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Evaluation of Educational Games Prepared by Mathematics Teacher Candidates According to Game Design Key Model

Gülçin OFLAZ[1]

Sivas Cumhuriyet University

Abstract

If chosen carefully according to teaching purposes and incorporated into the curriculum, games can enhance teaching and learning. The use of didactic games while teaching maths can support students' motivation and performance during the lesson. Therefore, educational games should be preferred in maths classes as an alternative teaching method. In this study, math teacher candidates' processes of developing educational games were observed, and the aim was to determine their opinions about the process. 52 teacher candidates form the participants of this research, which was conducted as a case study. Teacher candidates were informed about the properties of educational games, and they were asked to develop a mathematical game according to the Game Design Key Model developed by Özkan (2018). The research data was obtained using Game Design Key Model, structured interview forms, and daily plans. The obtained data was analyzed with descriptive and content analysis techniques. The games developed for the study were categorized according to their grade level, design purpose, learning area, game type, the way the game was developed, goal, the obstacle of the game, basic mechanics, feedback, and the number of players. Teacher candidates' views on the process were categorized as factors that make the process difficult and easier, and things that are enjoyed and disliked during the process.

Keywords: Educational games, Game Design Key Model, mathematics teacher candidates

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[1] Asst. Prof. Dr, Faculty of Education, Sivas Cumhuriyet University, Sivas, Turkey, ORCID: 0000-0002-5577-712X

Correspondence:erengulcin3@hotmail.com

Introduction

When mathematics is taught as memorized rules and manipulation of symbols with no meaning, it causes the child to fail in mathematics (Battista, 1986). This causes the child to learn mathematics, which is an intellectual subject, as a collection of symbols, signs, and formulas, and develop a fear and hatred towards the subject (Orim & Ekwueme, 2011). When mathematics is taught through memorization and algorithms mechanically within the "explain-apply-memorize" cycle, rather than understanding and reasoning, it also leads to the development of mathematics anxiety in students (Newstead, 1998). Teaching with traditional methods meets neither the expectations nor needs of the contemporary education system. Therefore, there are studies conducted concerning the re-structuring of learning environments. In this context, it is emphasized that education should be fun. Because when playing, the child is present both physically and mentally (Dienes, 1960). In the educational environment, children should be encouraged to learn by having fun, and such activities should be presented. Educational games serving this purpose make learning more interesting and attract the attention of the educators (Jong, Shang, Lee & Lee, 2008).

Games are closely related to people's desire for entertainment. As an innate personality trait, this element of entertainment may suggest that people have an instinct to "play." As a primordial human activity from childhood to adulthood, play is an integral aspect of life and culture (Campos & Moreira, 2016). Recently, it has been stated that entertainment and enjoyment are important in the learning process and should be included in the learning environment(Russo, Russo, & Bragg, 2018). Because learners are more comfortable, motivated, and willing to learn once the learning environment is rendered in an entertaining manner. Therefore, it is stated that we should consciously plan for "fun" in the classroom. In this way, the opportunity to learn through the pedagogical benefits of entertaining and adventurous experiences can be provided to students (Bisson & Luckner, 1996).

Mathematics and its learning should be designed as fun. This situation makes itself visible in many country's education policies. These countries emphasize attracting the attention of the child and creating positive emotions (MEB, 2018). Then, adding fun to the teaching of mathematics is not only a pleasant teaching method but also a way of achieving mathematical empowerment (Sumpter, 2015). Educational games are used to introduce new concepts in mathematics, reinforce mathematical ideas, solve problems in practice, and create an enthusiastic and avid classroom environment (Orim & Ekwueme, 2011). Putting a math skill into play helps students acquire it in a way better and faster than the traditional way they're accustomed to. It is remarked that in mathematics, most students are willing to learn the mathematical knowledge contained in a game through playing the game over the traditional method (Nejem & Muhanna, 2013). Children like playing games as playing games are fun. Elementary math teachers can take advantage of this situation, and they can design educational games

that would motivate children to learn. A well-designed math game can have both affective and cognitive effects on math learning (Lee, 1996).

The first and most striking advantage of supporting mathematics teaching with games is that it provides motivation (Ernest, 1986; Lee, 1996). Thanks to the game, students become motivated, and after a while they develop their attitudes as they immerse themselves in the game. In addition to being motivating, games add variety to the general mathematics curriculum by bringing a different approach to teaching the subject (Ernest, 1986). In some cases, classroom practices can remain insufficient. Thus, the mathematical concepts that students learn can sometimes hang in the air. Children who have the opportunity to practice with games can develop a deep understanding of concepts (Orim & Ekwueme, 2011). While children play, opportunities to develop mathematical skills arise, including attention, concentration, perception, memory, problem solving and strategy seeking, as well as having fun (Campos & Moreira, 2016). The students, who have the opportunity to apply formulas and rules, can enhance their understanding to a further level while solving problems. As they use their imaginations while playing, children who are given the chance to play can think of different ways of solving a problem. This improves their creativity and causes them to be more flexible in problem solving (Ompok, Teng & Sapirai, 2021). Additionally, they are suggested as a way for attaining such mathematical goals as acquiring and developing new concepts or practicing and reinforcing skills (Ernest, 1986; Jong, Shang, Lee & Lee, 2008; Orim& Ekwueme, 2011; Russo, Russo, & Bragg, 2018). The best part, on the other hand, is that the student experiences them through a very fun way, by playing games (Orim& Ekwueme, 2011)

There are many studies evaluating the effectiveness of using games in the mathematics learning environments. These studies concluded that the inclusion of games in the mathematics teaching environment increased achievement in mathematics (Başün & Doğan, 2020; Boz, 2018; Dinçer, 2008; Divjak & Tomic, 2011; Köroğlu & Yeşildere, 2002; Tural, 2005), impacted positively the attitudes, motivations and interest (Afari, Aldridge & Fraser, 2012; Çankaya & Karamete, 2009; Dele-Ajayı, Strachan, Pıckard & Sanderson, 2019; Dinçer, 2008; Divjak & Tomic, 2011; Köroğlu & Yeşildere, 2002; Tural, 2005; Tüzün, Arkün, Bayırtepe, Kurt, & Yermeydan Uğur, 2006), and induced learners to teamwork and cooperation (Campos & Moreira, 2016; Dele-Ajayı, Strachan, Pıckard & Sanderson, 2019; Tüzün et al., 2006). There are also studies showing that using games in other lessons have positive effects for the students. With these studies, it was stated that the success, interest and motivation of the students increased with the use of games in the learning environment in the science course (Gürpınar, 2017; Yeşilyurt, 2004), social studies course (Altınbulak, Emir & Avcı, 2006; Savaş and Gülüm, 2014; Somen&Metin Göksu, 2020), Turkish course (Babayiğit & Gültekin, 2019; Boz, 2018). According to the results of all these studies, the use of games in the teaching environment increases the attitude towards the lesson, success, motivation, and interest. That is why

teachers are advised to use games in their lessons to create an interesting learning environment. There are also studies researching the opinions of teachers about the necessity of using games in the teaching environment (Ateş & Bozkurt, 2021; Doğan & Sönmez, 2019; Gürbüz, Gülburnu & Şahin 2017; Özata & Coşkuntuncel, 2019). In these studies, teachers stated that the games facilitated the learning and made it more permanent since they also made mathematics more concrete and comprehensible, that the fear of the mathematics lesson could be reduced thanks to an enjoyable learning environment, and that friendships would improve and team spirit would be supported. Therefore, a learning environment supported by games can enable students to associate mathematical concepts and applications more easily. In that case, games fill the gap between practical and theoretical knowledge. In this context, it is thought that it is crucial for teacher candidates, who will become the teachers of the future, to experience educational game design and that it is important to determine the reflections of this process. There are studies aiming to have teacher candidates design educational games and research their opinions about the process (Aykaç &Köğçe, 2019; Baran Kaya & Gökçek, 2021; Önen, Demir & Şahin, 2012; Saygı & Alkaş Ulusoy, 2019; Seçkin Kapucu & Çağlak, 2018; Usta, Işık, Şahan, Genç, Taş, Gülay, Diril, Demir & Küçük, 2017). Baran Kaya and Gökçek (2021) classified the types of the games designed by primary school mathematics teacher candidates in terms of the place where the game is played, class level, learning area, purpose, and number of players. Different from this study, the current study asked mathematics teacher candidates were asked to develop a mathematical game according to the Game Design Key Model developed by Özkan (2018) and determined their opinions about the process. For this purpose, answers to the sub-problems below were searched.

1. How are the educational games prepared by the teacher candidates evaluated according to the grade level, purpose of the design, learning area, game type, way the game is developed, goal, obstacles of the game, game's basic mechanics, feedbacks of the game, and number of players?
2. What are the opinions of the teacher candidates about the game design process?

Method

Research design

This study used case study as one of the qualitative research designs. In-depth analysis of the process is conducted during case studies, in which the factors related to a certain situation are evaluated with a holistic approach (Yıldırım & Şimşek, 2005). In the study, on the other hand, the aim was to evaluate the educational games developed by teacher candidates in mathematics and determine their opinions about the process.

Determination of the participants

The participants of the research consist of 52 teacher candidates who study at a primary school mathematics teaching program at a state university in the Central Anatolia Region. These students are in their their year and take the course Teaching Mathematics with Games 38 of the participants were female and 14 were male teacher candidates. The teacher candidates were briefed that the information and visuals of the games they designed would be shared as part of the study, and all of them volunteered to participate in it.

Data Collection Tool

The data used in the research was obtained through the game design key model about the games developed by the students, a structured interview form in which students' opinions were taken at the end of the design process, and a lesson plan in which they could use the game they developed.

Game Design Key Model

Game design key model was developed by Özkan (2018) for teachers who want to prepare educational games. The game design key model consists of two main parts as the general features of the game and the selection of game mechanics and elements. The game elements and mechanics, which are described as the building block of the game design, were determined as the character, rule, target, obstacle, feedback, environment, and story of the game (Özkan, 2018). The elements and mechanics that are mentioned as part of this research are explained below.

Purpose of the game: It is defined as the performance standard, task, and problem and that the players have to perform, which can be grasped by the players as tangible, accessible, and appropriate for their level.

The rule of the game: The rules of the game are the most basic elements that make the game a game, and they define what the player can and cannot do.

The obstacle in the game: It is defined as the physical elements included in the game that prevents the player through rules or procedures, does not allow her to achieve her goals, makes the progress and development of the game difficult, and limits or brings it to a halt.

The game feedback: They can be defined as the rewards, punishment, badge, or success status suitable for the purpose, which enable the player to remain in the game flow.

The game environment: The game environment, which is determined by the game location, time, purpose, and the player's duty, can also be determined according to the game type.

Game mechanics: They are the elements that make the game entertaining and match the players' abilities so that the players eagerly continue playing the game.

Within the study's scope, the teacher candidates are separated into groups. Thus, 12 games developed by 12 groups were examined within this study's scope. The game design key model filled by the teacher candidates about the 12 games form the data in this study.

Structured interview form

From the questions used by Özkan (2018) to evaluate the educational game development processes of the teacher candidates and obtain their opinions, in accordance with this study, they were asked to express the challenges encountered in the process and the factors that facilitated the process, as well as the points they enjoyed or disliked in the game development process. Each teacher candidate responded to the structured interview forms individually. Therefore, 52 structured interview forms were used as a data collection tool as part of this study.

Daily Plans

Teacher candidates were asked to plan a lesson environment in which they could use the educational game they developed. Thus, the 12-day plan, which was prepared as a group, is the data of this research. The reason for the preparation of these plans is to determine whether the educational game is prepared according to the game design purpose specified in the game design key model. Once the specified game design purpose and daily plans were evaluated together, it was determined that all of the games developed were designed according to the design purpose.

Data Collection Process

This study was carried out during spring semester of 2021-2022 academic year as part of the course Teaching Mathematics with Games for 3rd grade students by primary school mathematics teaching. The content of the course was planned to inform about games and their types, mathematical games, the significance of games in teaching mathematics, and theoretical approaches to games. As this content was completed, information about the game design key model was delivered for 2 weeks, game mechanics and elements were introduced, and the points that should be considered while developing the game according to this model were highlighted. In the class, 12 groups were formed, and each group was asked to develop an educational game according to the model. Then they were asked to prepare as a form the information about the game they developed and found in the game design key. Thus, 12 forms were obtained. Following the preparation of the games, structured forms in which the teacher candidates were asked about their opinions about the process were administered individually. Additionally, the teacher candidates were asked to plan and execute a lesson environment in which they could use the educational game that they developed. Thus, for 6 weeks, each group introduced the game they developed and presented it to the class with a lesson plan. At the

end of each presentation, the whole class and the lecturer assessed the game and expressed their opinions about it. The study was thus completed in 14 weeks.

Data analysis

Descriptive analysis was used for analyzing the game design keys of the educational games developed by the teacher candidates, and the structured forms in which the opinions about the process were determined were analyzed via content analysis technique. The teacher candidates were asked to create lesson plans in order to determine the suitability of the game they developed for the game design purpose. It was found that all the educational games presented by the teacher candidates according to their lesson plans were suitable for the game design purpose specified in the key.

Findings

The findings regarding the evaluation of the games developed in the study according to the game design model and the opinions of the teacher candidates about the game development process are considered.

How are the educational games prepared by the teacher candidates evaluated according to the grade level, purpose of the design, learning area, game type, way the game is developed, goal, obstacles of the game, game's basic mechanics, feedbacks of the game, and number of players?

The analysis of the developed games according to grade levels can be seen in the table.

Table 1. Analysis of the developed games according to the grade level

Grade level	n
5th grade	2
6th grade	4
7th grade	3
8th grade	3

As it can be seen, two of the games were on the 5th grade level, 4 of them on the 6th grade level, and 3 of them are 7th and 8th grade level. One of the games designed for 8th grade is seen below.

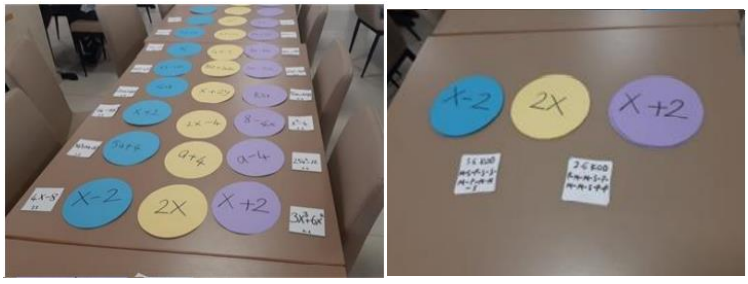

Figure 1. A Game Sample Designed For the 8th Grade

Played by the whole class, the game aims to reinforce the factorization of algebraic expressions. Students line up before a racetrack and jump to the question's correct answer. The next player has to jump to the card her previous friend has jumped, and then she jumps to the answer of her own question. The team that reaches to the end of the racetrack will be the game's winner.

The developed game's analysis according to the design purpose can be seen.

Table 2. Analysis of the developed game according to the design purpose

Design Purpose	n
To enhance operations skill	6
Reinforcement	5
To determine preparedness	1
To eliminate misconceptions	1
To use it for evaluation	1

In the majority of the games developed (n=6), it was aimed to improve the students' operation skills and to consolidate the knowledge (n=5). In addition, determining the students' preparedness, eliminating misconceptions, and using the game for course evaluation is among other purposes. In the game Guess What, which was developed for 5th grade students, the aim was to improve the students' skills in operations.

Figure 2. Visual From The Game Guess What

The class separates into groups of 4. The presenter asks the questions written on the question cards to the players. Players solve the question on the answer sheets, and the first one to solve says the answer after pressing the button. Then the next player takes the turn.

The analysis of the developed games according to learning and sub-learning areas is seen.

Table 3. The analysis of the developed games according to learning and sub-learning areas

Learning area	Sub-learning area	n
Numbers and operations	Natural numbers	6
	Operations with natural numbers	
	Fractions	
	Operations with fractions	
	Exponential Expressions	
	Square-root expressions	
	Multipliers and Multiples	
Algebra	Algebraic Expressions	5
	Equality and Equation	
	Linear Equations	
Geometry and measurement	Polygons	1

As it is seen, games were developed in the learning areas of numbers and operations (n=6), algebra (n=5), and geometry and measurement (n=1). In the field of numbers and operations, games on natural numbers, operations with natural numbers, fractions, operations with fractions, exponential expressions, square root expressions, multipliers and multiples sublearning areas have been developed. On the other hand, while algebraic expressions, equality and equations, and linear equations were central in the area of algebra learning, the only game in the field of geometry and measurement learning was developed on polygons. The visual of the Find Polygon game can be seen, which is a game aiming students to find the polygon suitable for the given property and reach the correct polygon as soon as possible.

Figure 3. Visual From The Game Find The Polygon

In this game, the class is divided into groups. For each question, a different member is selected from the groups in turn. The selected students go to the center of the game carpet. The teacher asks a question to the students, and the students are expected to go within the given time to the polygon containing the answer. Each student plays in turn, and the group scores are determined according to the correct/wrong answers. The group with the highest score wins the game.

The analysis of the developed games according their type can be seen.

Table 4. The analysis of the developed games according to game types

Game type	n
Card game	7
Racetrack	5
Material-supported game	2
Digital	1
Board game	1

While only one of the developed games was digital, all of the remaining games were physical games. It was seen that the games coded as physical were card games (n=7), racetrack games (n=5), material-supported games (n=2) and board games (n=1) according to the material used in the game. When the game types are evaluated, it is seen that some games consist of stages.

From these games developed as a card game, in Unomath, 8 cards are distributed to each person. After each player receives their cards, a person selected randomly starts the game throwing a question card. If the player does not have a question card in her hand at the beginning, he/she draws a card from the card deck in the middle a question comes, and then throws the question card. It is now the player in the right's turn and he/she tries to throw the answer. The game continues in this manner. The game also includes handover, joker, direction change, pass, and ban cards. In this way, the game enhances the student's mathematical skills.

Figure 4. A Visual From The Game Unomath

One of the developed games has a digital dimension as well as a racetrack. Designed for 7th grade students, the students must complete the ground racetrack in the first place. The questions about equality and equations with answers either 1,2, or 3 are directed to the students. Students act as pawns on the ground racetrack; they first say the answer to the question and then proceed as far as the

answer they say. The one who complete the racetrack first wins. Then they move on to the Fish Grabber game, which was developed using the Scratch program. The game begins with the instruction to start. The crab character informs about the game. When the game starts, a shark waiting for small fish appears. The small fish asks questions and expect their answers. These questions must be answered until they go near the shark. The groups receive points according to their correct/wrong answers, and the group with the highest score wins the game.

Figure 5. A Game Sample Designed For 7th Grade

The distribution of the games according to the way they are developed can be seen.

Table 5. The analysis of the way the game is developed

The way the game is developed	n
Original	8
Adaptation	4

8 of the developed games are original, while 4 of them are adaptations. Ludo, which is an adapted game, was developed for the 6th grade level.

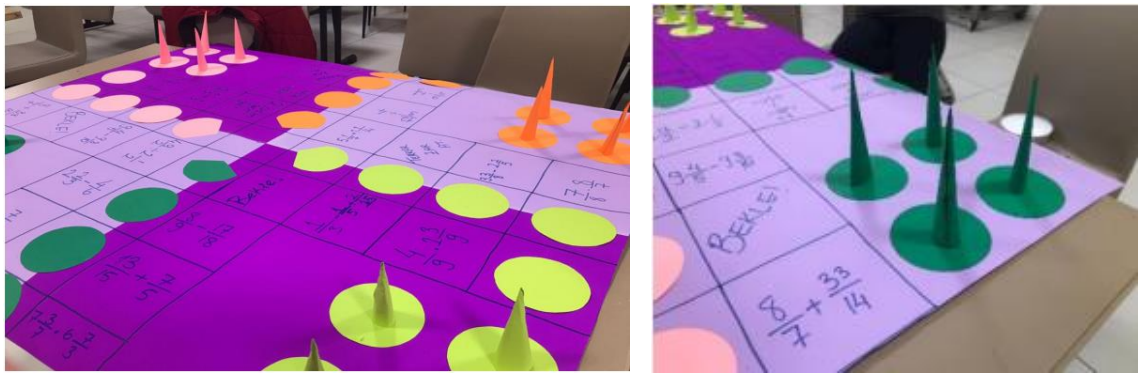

Figure 6. A Visual From Ludo Game

Each player or group is represented by a pawn in the game that can be played individually or in groups. The dice is thrown to decide which pawn will begin. The pawn moves forward as the dice shows, and does the operation in the square it arrived. The turn is in the next pawn, and so the game continues. The one who completes the game first wins.

The distribution of the games according to purposes can be seen.

Table 6. The analysis of the developed games according to their purposes

Purpose	n
Duty (answering the right answer, memorizing the previous friend's answer, reaching the target first, writing the answer on the board, finishing the cards, modeling, matching)	12
Passing stages	4

While in 12 of the developed games the student is expected to fulfill a task (giving the correct answer, remembering the answer of the previous player, being the first to reach a target, writing the answer on board, finishing the cards, modeling, matching), in 4 games the aim was to pass the stages. A game designed to reinforce the topic of operations with fractions is composed of two stages as matching cards and a Tarsia puzzle.

Figure 7. Visual From The Game Matching Cards And Tarsia Puzzle

In the card-matching game, the prepared cards are placed as their upward-facing side is closed. Then the group members randomly open the cards. Those cards whose fraction and modeled state correspond are left out. It continues until the cards are finished in this way. The first group to finish the cards start the Tarsia puzzle completion task. At this stage, the groups fit the triangular cards and the questions and answers given in a scattered manner into the puzzle, and as a group they try to complete the puzzle, the outline of which they already know. The first group to finish wins the contest.

The student is required to both take quick action and model it in a game that is developed for reinforcing the subjects of equality and equations and that consists of stages.

Figure 8. Visual From A Game Developed For Reinforcing The Topic Of Equality And Equation

In this game played as groups, 2 students draw cards and try to solve the question on the solution board while 2 other students try to model this question on a weighing scale. Therefore, the aim is the active participation of all group members. Among the groups that are scored separately for the problem solving and modeling on the weighing scales, the group with the highest score wins the game.

The distribution of the games according to their obstacles can be seen.

Table 7. Analysis of the games according to their obstacles

The obstacle of the game	n
Time	8
Rival	6
Tasks becoming more difficult	3
Individual game	2
Group game	1

As it can be seen, the players will compete against time (n=8), against a rival (n=6), against tasks becoming more difficult (n=3), against individual player obstacle (n=2), and against group game obstacle (n=1).

The distribution of the developed games according to their basic mechanics can be seen.

Table 8. Analysis of the developed games according their basic mechanics

Basic mechanics	n
Knowledge	7
Running	5
Pressing a button/bell	4
Speech	4
Matching	3
Selecting card	3
Progress	3
Carrying a bottle	2
Jumping	2

Finishing the cards at hand	2
Toppling glasses	1
Finishing the puzzle	1
Modeling	1
Entering the right answer on keyboard	1
Reading	1
Writing the answer on board	1
Rolling a dice	1

The basic mechanics of the developed games were determined as knowledge, running, pressing a button/bell, telling , matching, selecting a card, moving forward, carrying a bottle, jumping, finishing the cards in one's hand, tipping the glasses, completing a puzzle, modeling, entering the correct answer on the keyboard, reading, writing the answer on board and rolling dice. The basic mechanics of a game developed for 7th grade level were determined as knowledge speech, choosing cards, writing the answer on board.

Figure 9. A Game Sample Designed For the 7th Grade

As the visual explains, the game is composed of cards and joker cards. The questions, determined as easy, normal, and difficult, are arranged according to colors. 3 questions must be correctly answered to pass to the next level. Afterwards, it proceeds to the next level once the critical question on the gray card is solved. The group that accomplishes all the stages win the game.

The distribution of the developed games according to their feedbacks can be seen.

Table 9. The analysis of the developed games according to their feedbacks.

Feedback	n
Progress/No Progress	4
Win/lose points	3
Eliminate/Level up	3
Award/penalty	2
Winning jokers/losing hearts	2
Increasing/decreasing the card at hand	2

It is seen that the feedback type most preferred by the teacher candidates is progress/fail to progress, gain/lose points, eliminate/level up, win a prize/penalty, gain a joker/lose lives, and increase or decrease the card in their hand.

The distribution of the developed games according to the number of player can be seen.

Table 10. The analysis of the developed games according to the number of player

Number of players	n
As a team	7
The whole class as a team	5
Individual	4

It is seen that the games developed are played as a team (n=7), as a team with the participation of the whole class (n=5), and individually (n=4).

What are the opinions of teacher candidates about the game design process?

This section gives the views of teacher candidates about the game development process. The answers given by the teacher candidates about the process were categorized as factors that make the process difficult or easier and things that are enjoyed or disliked in the process. In the game development process, the most challenging factors for prospective teachers were determined as difficulties about the game properties, about the game preparation stage, and about working as a group. Prospective teachers stated that they had difficulty in developing original and instructive games in which the whole class would participate, that must be fun, and that are suitable for all levels. At the same time, they had difficulty in developing a game that is up to standards, that the game is in accordance with ethical values, that the chance factor is low, that it must be popularize mathematics and include. Some student statements mentioning these difficulties are presented below.

"We tried to design a game ensuring that the student does not get bored and the game also provides complete learning. As we progressed in this direction, factors such as enabling the participation of whole class was a little challenging for us."

"It was trying to include the whole class in the game. Since there will be students from all levels in a classroom, considering this situation and preparing questions for all their levels and designing a game that would include the whole class was truly a thought-provoking and challenging process."

Table 11. Students' views on the factors that make the game development process challenging

Category	Theme
Challenges related to game properties	Fun Attendance of the entire class Original Suitable for all levels Educative Low luck factor Suitable to ethical values Competitive Making mathematics more lovable

Challenges related to the game preparation phase	Deciding the game Designing the game Determining the rules Working with game material Determining the questions
Difficulty of working as a group	Communication with group friends Arranging a suitable time Consensus on a common idea

The challenges encountered by the teacher candidates during the game preparation stage were found as deciding on the game, designing the game, determining the rules, working with game material, and determining the questions. Some expressions in this category were determined as follows:

"We had some concerns about out imagined game's adaptability to real life."

"The most difficult part of the game design process was determining the suitability of the game to the class level. On the other hand, another issue that I was challenged with was preparing the question cards. While preparing these question cards, it was necessary to pay attention to details such as them being suitable for the learning outcomes, for the level of the student, for the topic, and for modeling on a weighing scale."

"It was challenging to cut the cartons we used because they were rather hard"

Teacher candidates, who talked about the difficulty of working as a group, remarked that they had difficulty in communicating with their group friends, arranging a suitable time, and building consensus around a common idea. The expressions evaluated in this category are as follows.

"The game design process was actually fun, but it was also rather tiring. The most tiring part was coordination with group friends. "

"Preparing as a group and gathering during the school process pushed us a little. I mean, we had difficulty in coming together with our group friends. "

The student opinions regarding the factors that facilitated the game development process are categorized as the characteristics of group members, individual, and design process. It can be stated that the group members being individuals who do division of labor, are at work, are in solidarity, respect different ideas, make an effort, and exchange ideas facilitates the game development process. The evaluated answers from the students in this context are as follows:

"Sharing tasks in the game design process made it easier for all of us. After sharing tasks, we helped each other in cases where we couldn't make on our own. And while designing the game, we all researched what kind of game it should be; so it became easier for me to come up with new ideas for the game."

"It made our task easier for us that we were in constant communication about the game and everyone had logical ideas. In addition, that my group friends truly put an effort for the assignment made the task easier."

Table 12. Students' views on the factors that make the game development process facilitated

Characteristics of group members	Does division of labor Groups at work Groups in solidarity Respectful of different ideas Making an effort Exchanging ideas
Individualistic	Having field and field education knowledge Observing secondary school youth Researching Loving mathematics
Design process	Expert guidance Conducting research on the subject Being inspired by similar games

The students stated that the game development process was easy due to their individual characteristics. The evaluated answers in this context were gathered under the themes of having field and field education knowledge, conducting research, observing secondary school youth, and loving mathematics. The evaluated statements in this context are given as follows:

"Designing a structure and a game on my favorite subject was very enjoyable process... In addition, since we know the outcomes, we did not have difficulty in question preparation. "

"The point that made my job easier in game design is that I examined the secondary school youth around me in the past and recently. In addition, I have seen after some research online that there are many studies about the topics we want. "

The points that facilitated the students' work during the game design process are determined as expert guidance, research on the subject, and inspiration from similar games. The evaluated statements in this context are as follows:

"The point that contributed to us was that we designed a new game by combining some other games. The games helped us a lot. "

"The things that facilitated and contributed to my progress in the game design process are my love for mathematics, collective action with group friends, the information given by our teacher about this course, and other articles and theses on this subject in the literature."

During the game development process, the things that teacher candidates enjoyed were categorized as group work, game determination stage, and design stage. Working in harmony within groups, collective decision-making and exchanging ideas, and increasing intimacy with friends were determined as the things they liked the most. The statements evaluated in this context are as follows:

"The place I enjoyed about the game design process was my research on the specification of the materials and presenting my findings to my group friends. Besides, what I liked the most is that the developing friendships in the group were new, and the teammates supported each other in communication. "

"Although the work of preparing the materials and the game seemed challenging, it enabled us to act as a team, and I understood the value of the saying that two heads are better than one. Once the thrill of designing a new game was added to it, happiness hormones were released. "

Table 13. Students' opinions about the points they enjoyed during the game development process

Working with the group	Making decisions together Working in harmony Exchanging ideas Increased sincerity with friends
The stage of determining the game	Conducting research Associating with mathematics Determining the rules Writing the questions
Game design phase	Preparing the material Painting, cutting, folding, gluing Being able to design digital games Producing a new game Playing

During determining the game phase, the most enjoyable points for the teacher candidates were determined as doing research, associating with mathematics, determining the rules, and writing the questions. The statements of the teacher candidates in this regard are as follows:

"Following the preparation of the game, the best part was determining the rules. Because we usually play a game with certain rules. This time, we were the ones who made the rules. I enjoyed determining the rules of the game and them being unique to us. "

"It was very fun to prepare questions, arrange cards, and define the rules of the game by discussing with friends. My favorite part was to associate the game with the mathematics lesson after determining the game."

During the game design phase, the most enjoyed things were found as preparing the material, painting, cutting, folding, pasting, being able to design a digital game, producing a new game, and playing. The student responses evaluated in this context are as follows:

"After designing the game, I enjoyed handling cardboards in the process of designing materials. Preparing colorful materials was fun. "

"The part I liked doing during the game design process was to be able to design Scratch Fish Snatching game. It was a very fun and enjoyable process. "

"During the game design process, I liked the point when we prepared materials with our group friends using objects such as cardboard, scissors, or glue. After preparing the game, I also liked that we presented and played it in the class."

The points that the students did not like about the game development process were categorized as the preparation for the game stage and the game preparation stage. Regarding the preparation for the game stage, they stated that they did not like being affiliated with the group and determining the game. The students expressed this situation as follows:

"Thinking about what the game will be during the design process has put me under a lot of stress. In other words, the process of deciding what the game would be was the most troubling part for me. "

"There was no part that I did not enjoy except that I could not make completely autonomous and original decisions, since the task was accomplished with the group."

Table 14. Students' opinions about the points they did not like during the game development process

Preparation for the game stage	Being bound by the group Determining the game
Preparing the game stage	Editing document Preparing question Working with the computer Not enjoying drawing and cutting

The things they disliked about the game preparation phase were expressed as document editing, question preparation, working with the computer, and not liking drawing and cutting. The evaluated responses in this context are as the following:

"What I did not like about the game design process was that I could not perform my duties on time due to the lack of important materials such as computers and thus my participation remained weak."

"What I did not like doing was to write questions with similar answers (such as 4a, 4x). To ensure competition, we had to choose questions that students could answer incorrectly. "

"What I didn't like doing during the game design process was to fill out forms. Because it was a long and difficult process. "

Discussion Conclusion and Recommendations

Learning mathematics is one of the most difficult lessons for many children due to its difficult and abstract nature. Thanks to educational games, mathematics learning and attitudes are positively affected by minimizing these difficulties (Afari, Aldridge & Fraser, 2012). Educational game is understood as a student and teacher activity that pursues certain instructional goals. In this process, students usually engage in such activities as the motivation and joy of playing the game,

competitiveness, the opportunity to work as a team, and self-actualization. Therefore, they do not become aware of learning goals. The educational game also has rules that regulate student activities and help achieve the game's educational goals. Thanks to an educational game, students enjoy having accomplished an activity with high participation, motivation, and fun(Vankúš, 2008). The games can be used as an icebreaker to create a positive and enthusiastic atmosphere. It is also used to introduce new concepts and reinforce ideas (Orim & Ekwueme, 2011). Students learn mathematics for outcomes such as enjoyment or encouraging cooperation and discussion, besides achieving the specified mathematical goals. These mathematical goals were determined as acquiring and developing new concepts, applying and reinforcing skills, and developing a problem-solving strategy (Ernest, 1986). Within this study's scope, the aim to improve the processing skills of secondary school students and consolidate their knowledge through games developed by teacher candidates. In addition, determining preparedness, eliminating misconceptions, and usage of the game in lesson evaluation are among other purposes. Baran Kaya and Gökçek (2021) stated that the games developed by teacher candidates were for reinforcement purposes, and only one game was for teaching the subject.

While the developed games are mostly in the areas of learning numbers and operations and algebra, only 1 game is in the area of learning geometry and measurement. Along with this, no game was developed in the areas of data processing and probability. Mathematics, which is generally described as unpopular, is one of the subjects that students fail the most due to its abstract and unrelated nature. Among mathematics topics, the learning areas with which the students say to have the most difficulty with are numbers and algebra (Baki & Kutluca, 2009). Therefore, this may be the reason why teacher candidates also turn to numbers and algebra and develop more games in these learning areas. In the field of numbers and operations, games on natural numbers, operations with natural numbers, fractions, operations with fractions, exponential expressions, square root expressions, multipliers and multiples sublearning areas have been developed. In algebra learning, algebraic expressions, equality and equations, and linear equations were central while the only game in geometry was developed on polygons. Ateş and Bozkurt (2021) determined in their study that primary school teachers mostly need to teach with games about four operations and fractions in mathematics. Additionally, they expressed that they need teaching with games in the topics on measurement. Similarly , Baran Kaya and Gökçek (2021) stated that while the games developed by teacher candidates in mathematics were mostly in the fields of numbers and operations learning, they also developed games in the fields of geometry and measurement, algebra and data processing, but no games in probabilities. No additional game about data processing has been developed in this study. Although probability, permutation, and combination are very critical in mathematics and in daily life, they are among the subjects that students have the most difficulty in understanding. Therefore, it is possible for students to learn these concepts, which they have difficulty in learning, by making them more fun thanks to the game (Çelikler, Demir Kaçan&Yenikalaycı, 2021; Gün, Işık & Şahin, 2021).

From this perspective, that teacher candidates do not think about developing games in this learning area is an interesting result.

The physical games developed within the scope of this study were determined as card game, racetrack game, material supported game, and board game. When the game types are evaluated, it is seen that some of the games are composed of stages. Games and activities are expressed as special educational structures in which diverse teaching methods, techniques, and tools can be applied in various combinations. Knowledge of different game types and properties can be beneficial for teachers in mathematics teaching planning, game development and application (Demir, 2016). The types of educational games that can be used in the lessons can be categorized as card games, racetrack games, material-supported games, and board games. Which game type is more effective in maths classes varies depending on the purpose of using the game (Lee, 1996). Additionally, the class level to be taught with the game and the characteristics of the students are also important in determining the game. The important thing is that these games are presented to students according to the purpose of teaching. It is stated that the educational games used in teaching should be determined according to the objectives and should be prepared with concrete materials by addressing the students' age groups (Usta et al., 2017). Baran Kaya and Gökçek (2021) stated that the majority of teacher candidates in mathematics preferred using board/card games in their lessons. Some of them have preferred to adapt well-known board/card games for the mathematics lesson. On the other hand, some of the developed games are original. Within the scope of this study, while most of the games developed by teacher candidates in mathematics are original games, some are adaptations.

With the contemporary developments in mathematics teaching, integration of technology into mathematics teaching increases day by day. The rapid development of technology also elicits new opportunities for meaningful and permanent teaching in mathematics (MEB, 2018). Computer use in teaching mathematics enables students to acquire high-level mathematical skills and allows them to create their own knowledge (Cengiz, 2017). Educational math games in which computers are deployed are reported to have positive effect on students' achievement, motivation, and attitudes (Korkmaz, 2018; Uğurel & Moralı, 2008). In this context, it is remarked that educational computer games, in addition to being motivating and entertaining, can be used as a complementary and supplementary activity (Çankaya & Karamete, 2008). Within this study's scope, only one of the games developed by the candidate mathematics teachers is determined as a digital game, while the others are considered as physical games. This situation is interesting. Because the computer games started to supersede the traditional games with the latest technological developments. Therefore, there is a transition from traditional to digital in games as well (Taylan, Kara & Durğun, 2017) However, that only one group developed a digital game can be explained by the fact that teacher candidates do not have sufficient knowledge to design a computer game. Sarıgöz (2019) determined that teacher

candidates avoided playing digital games, hesitated. They also feared that if they face with a problem when using digital games, they would not solve it. A similar condition is seen in the study by Baran Kaya and Gökçek (2021), and the candidate teachers' lack of computer knowledge is given as the reason.

We see that education and competition have been employed together since the past. Some researchers believe that competition should be included in education for students to get accustomed to it for their later lives. The aim of these competitions is for students to compete successfully without appearing to be competing (Verhoeff, 1997). This situation can be provided through games. Hence, it can be seen that the types of feedback preferred by teacher candidates in the games they developed are progress/no progress, gaining/losing points, elimination/level up, reward/penalty, winning joker/losing lives, and increasing /decreasing the card in the player's hand. The aim with these types of feedback is that the students succeed in a given task and get ahead of their competitors. However, in order to prevent the negative feelings and tension that this competitive environment will create on children, measures should be produced and the teacher should manage the process (Tural, 2005). From this perspective, it should be secured that students focus on the game rather than focusing merely on winning or losing. Therefore, mathematical games are meaningful learning tasks in which the aim is to achieve certain mechanics and dynamics that require contending with a task or an opponent. It was determined in Özkan's (2018) study that the objectives of the games developed was to accomplish the tasks, and the obstacle of that game was various elements such as playing individually or as a team, playing against time, non-player characters, and levels in increasing difficulty. The goal of the games developed in this study can be explained as giving the right answer, being the first to reach a target, modeling, matching, or passing the stages in some other games. Additionally, players in these games will compete against time, an opponent, tasks that become more difficult, the obstacle of playing individually or in groups. It is seen that these games are played as a team, with the whole class as a team, and individually. Similarly, Baran Kaya and Gökçek (2021) stated that the games developed by the teacher candidates were designed as games for the whole class, for a few people, or for a single person.

Working as a group and division of labor during the game development process made the teacher candidates' work easier. When working as a group, individuals support each other because they feel that they are on the same side. This enables the development of the skills of being a part of a group, which is a function of social skills (Johnson & Johnson, 1999). Emotional and social development of children should be supported as well as their relationships with others (Aksoy, 2020). In this study, too, teacher candidates stated that the solidarity of the group members and division of labor in a way that respects different ideas facilitated the game development process. Working as a group and sharing responsibilities were also determined as conditions that teacher candidates liked

most about the game development process. About the design process, they remarked that receiving expert guidance when needed and being inspired by similar games facilitated the process.

The success of teaching maths is primarily dependent on the student's active participation. Children learn mathematics by practice and forming mathematical concepts and skills themselves. Therefore, the child has to be active during the process of knowledge-formation. Similarly, the child is physically and mentally active as she plays a game. Therefore, games encourage children's active participation, make them open to learning, and increase their motivation (Ernest, 1986). When involved in an entertaining situation, the child learns the logical structure of the game while at the same time assimilating the existing mathematical structure (Campos & Moreira, 2016). It is also stated that the attitudes of the students towards the lesson improve as the use of games in the learning environment increases the motivation. Considering that attitudes activate the mental activities essential for learning, educational games also help develop attitudes towards mathematics and its teaching (Vankúš, 2008). Therefore, games add variety to the standard mathematics curriculum by bringing a different approach to teaching the subject (Ernest, 1986). Therefore, teachers should try to include games in their mathematics lessons (Lee, 1996). Opinions of the teacher candidates about the game development process were categorized as factors that make the process difficult or easier and things that are enjoyed or disliked in the process. Prospective teachers stated that they had difficulty in developing original and instructive games in which the whole class would participate, that must be fun, and that are suitable for all levels. At the same time, they had difficulty in developing a game that is up to standards, that the game is in accordance with ethical values, that the chance factor is low, that it must be popularize mathematics and include. Önen, Demir, and Şahin (2012) also stated that teacher candidates in sciences should use games in the learning environment as they make the lesson fun and contribute to the subject's learning. However, regarding the game development process, they also stated that they had difficulty in preparing questions suitable for the grade level. Similarly, Usta et al. (2017) also found in their study that teacher candidates thought that using games in mathematics lessons was necessary and beneficial, that the fear of mathematics could be reduced in a fun learning environment, thus making mathematics more concrete and comprehensible. However, teacher candidates expressed that they had difficulty in preparing games suitable for the subject and grade level. The game that will be used in the learning environment should be suitable for the age, interests, and abilities of the students. This game should have content that matches the educational learning outcomes. Only a game with these properties can actually lead to more effective teaching and the elimination of some learning barriers (Tüzün et al., 2006; Vankúš, 2005). The difficulties in the game preparation phase are deciding on the game, designing the game, determining the rules, working with the game material and determining the questions. Similar challenges are remarked in other studies as well (Seçkin Kapucu & Çağlak, 2018; Usta et al., 2017). These challenges experienced by the teacher candidates can be explained by their lack of experience in game development. Therefore, support can

be provided to the environments where teacher candidates can practice educational game development.

Teacher candidates stated that they enjoyed producing mathematical games in which they determined the rules themselves while designing the game. Producing a new game is a situation about which teacher candidates are happy both in this study and in the study of Özkan (2018). During the game preparation stage, producing a new game by dealing with the material is a situation that some students enjoyed and some students disliked. In addition, preparing the design key about the game they developed and a lesson plan were determined as the points they did not like. A similar result was concluded in Özkan's study (2018). In this study, teacher candidates stated that writing the details and preparing a lesson plan while designing the game was a waste of time. As technology has recently been taking a large space in our lives, the work of writing has been replaced by such devices as computers or smartphones. For this reason, in Özkan (2018), teacher candidates proposed to digitize the documents and prepare the documents about the game with the aid of computers and phones.

In this study, teacher candidates in mathematics designed educational games using the game design key. This study revealed that the key developed by Özkan (2018) is suitable for developing a mathematical game. Similar game design processes can be carried out for different courses with the help of this key. In addition, the developed games can be applied to the target audience and improvements can be made in the game. Thus, these games can be created as resources that teachers, who are the practitioners of the course, can benefit from. Mathematics teaching can be enriched by applying to the students the games developed within the scope of the study. It was observed that only one of the developed games was digital. Considering that its reason may be the teacher candidates' lacking computer use, it can be recommended to increase the knowledge and experience of teacher candidates in using computers during their undergraduate courses.

Policy Implications

When games are carefully selected on the basis of instructional objectives and incorporated into the curriculum, they enhance teaching and learning. The use of didactic games during the teaching of mathematics supports the motivation and performance of the students during the lesson. For this reason, educational games should be preferred in mathematics classes as an alternative teaching method. When mathematics is traditionally taught with an understanding that is far from reasoning, a meaningful understanding does not occur for students. It is also known that traditional teaching methods develop anxiety and fear towards mathematics in students. Therefore, teaching with traditional methods does not meet the expectations and needs of the education system today. In order to meet these expectations, studies are carried out on the restructuring of learning environments. In the educational environment, children should be encouraged to learn by having fun and such activities should be offered. Mathematics and its teaching should be designed as fun. For this reason, it is

important to include educational games in learning environments. This situation shows itself in the education policy of most countries. From this point of view, it can be suggested that the program makers make arrangements in the teaching environment by taking into account the "ice breaker" effect of the games. Because, studies show that teachers and teacher candidates also think that using games in teaching environments contributes to students. In their undergraduate education, prospective mathematics teachers take the course of Teaching Mathematics with Games. This course should also be offered to prospective teachers studying in other departments. Thus, pre-service teachers are informed and experienced about teaching with games as an alternative teaching method.

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