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Mathematical Game Development Process From The Perspective of Gifted Students: The Concept of Relation

Üstün Yetenekli Öğrencilerin Perspektifinden Matematiksel Oyun Geliştirme Süreci: Bağıntı Kavramı

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Abstract

This qualitative case study aims to examine the Rock-Paper-Scissors game within the framework of the relation and to determine the experiences and opinions of gifted students in the game development process. The study was conducted with 45 students studying at Science-Art Center. In the study, activities related to relations and their properties were carried out by the students. Within the scope of the activities, the Rock-Paper-Scissors game was analyzed within the framework of the concept of relation and developing a game was carried out. The experiences and opinions of the participants were obtained with an opinion form. The data obtained in the research were analyzed via content analysis. As a result of the research, although gifted students thought that developing games in the process was confusing, they found the application parts of the activity fun. They preferred to carry out the activity as a group. In addition, the mathematical concepts that the students used the most while developing the rock-paper-scissors game were relation, probability, sets, cartesian product and relation properties. The results of this study show that gifted students want to participate in different game development processes in the context of mathematics because it offers them the opportunity to socialize with people similar to their own level.

Keywords: Rock - Paper - Scissors Game, Gifted Students, Relation, Mathematics in Games

Özet

Bu araştırmanın amacı Taş- Kağıt- Makas oyununun bağıntı çerçevesinde incelenmesi ve oyun geliştirme sürecinde üstün yetenekli öğrencilerin deneyim ve görüşlerinin belirlenmesidir. Çalışmada nitel araştırma yöntemlerinden durum çalışması deseni benimsenmiştir. Çalışma, Bilim ve Sanat Merkezine devam etmekte olan 45 öğrenci ile yürütülmüştür. Çalışmada öğrencilere bağıntı ve özellikleriyle ilgili etkinlikler gerçekleştirilmiştir. Etkinlikler kapsamında Taş-Kağıt-Makas oyunu bağıntı kavramı çerçevesinde incelenmiş ve oyun geliştirme çalışması yapılmıştır. Katılımcıların deneyim ve görüşleri görüş formu aracılığı ile toplanmıştır. Elde edilen veriler, içerik analizi kullanılarak analiz edilmiştir. Araştırma sonucunda üstün yetenekli öğrenciler süreçte oyun geliştirmenin kafa karıştırıcı olduğunu düşünmelerine rağmen etkinliğin uygulama bölümlerini eğlenceli bulmuşlardır. Etkinliği grup olarak gerçekleştirmeyi tercih etmektedirler. Süreçte öğrencilerin farklı beceri türlerinin gelişmesi sonucu ile beraber daha çok bilişsel becerilerin geliştiği sonucuna varılmıştır. Ayrıca Taş-kağıt-makas oyununu geliştirirken öğrencilerin en çok kullandıkları matematiksel kavramların, bağıntı, olasılık, kümeler, kartezyen çarpım ve bağıntı özellikleridir. Bu çalışmanın sonuçları, üstün yetenekli öğrencilerin kendi kendi seviyelerine benzer kişiler ile sosyalleşme imkanı sunduğu için matematik bağlamında farklı oyun geliştirme süreçlerine katılmak istediklerini göstermektedir.

Anahtar Kelimeler: Taş–Kağıt–Makas Oyunu, Üstün Yetenekli Öğrenciler, Bağıntı, Oyunlarda Matematik

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1. Introduction

The significance of education, a fundamental aspect of humanity, is progressively increasing due to the need for an information-based society. However, individuals differ from one another in terms of their abilities, intelligence, interests, learning styles, prior knowledge, and motivation. The success of human education depends on the extent to which these differences are considered and addressed with sensitivity (Aktepe, 2005). As a matter of fact, gifted students are one of the groups that need different and enriched education. These students, who get bored at school and lose their motivation due to their fast learning with the programmes of students with normal development (Ataman, 2003), need an appropriate education in order to realize themselves by using their potential at the highest level (Maker & Nielson, 1996; Tomlinson & Alan, 2000; Feldhusen & Jarwan 2000; Chan, 2001; VanTassel-Baska & Stambaugh, 2005). According to Reid & Boettger (2015), the programmes prepared for gifted students in European countries are prepared according to ambitious and talented students, some of the gifted students are unidentified and invisible, and the invisible gifted students need to be identified by experts in their field. These applications, which started with Enderun School in Türkiye, are now carried out in Science High Schools, Art High Schools and Science-Art Centres (BİLSEM) from younger age groups (Kaya, 2013). Enderun schools, where there was a talent-oriented selection, were similar to today's BİLSEMs, not only with the teaching of positive sciences, but also with the education of fine arts in line with their interests and with an educational approach that considers individual differences (Işık & Güneş, 2017; Kılıç, 2010; Kılıç, 2021). Science-Art Centres are educational institutions that provide remedial education to selected students under the Ministry of National Education, Directorate of Guidance and Special Education. The selection of BİLSEM students according to the Science and Art Centres Directive is as follows: Students in the 1st, 2nd and 3rd grades of primary schools selected by the School Guidance Commission take a pre-assessment test. Students who meet or exceed the criteria set by the Ministry are evaluated individually by the Provincial Diagnostic Commission (MoNE, 2015; MoNE, 2023).

When the related literature in terms of mathematics education is examined, giftedness is the ability to understand mathematical ideas and logic beyond high-level skills in performing arithmetic calculations (Dağlıoğlu, 2004). Krutetskii (1976) defines giftedness in mathematics as the ability to perform successfully in activities by combining mathematical information retrieval, processing and retention in an original way. These individuals are creative individuals who have conceptual generalisation, observation and strong questioning skills, can make quick judgements, and have extraordinary ability to comprehend cause and effect relationships (Krutetskii, 1976; Sheffield, 1994). Mathematically gifted students have different characteristics from regular education students. They can comprehend the regular curriculum quickly and are interested in more advanced mathematics subjects (Özyaprak, 2016; Şengil Akar, 2017; Yazgan Sağ, 2019). Therefore, enriched curriculum, individualised instruction, accelerated instruction and additional support and activities should be considered in the education of mathematically gifted students:

Enriched curriculum: Gifted students should be offered more complex and in-depth mathematics subjects that go beyond the regular curriculum (Özyaprak, 2016; Şengil Akar, 2017; .Yazgan Sağ, 2019) For example, they should be given the opportunity to start high school level mathematics subjects early (Şengil Akar, 2017).

Individualised Instruction: The individual needs and learning pace of students should be taken into account and appropriate teaching methods and materials should be used (Şengil Akar, 2017; Özdemir, 2018). In addition, opportunities should be provided to develop students' mathematical creativity (Şengil Akar, 2017).

Accelerated Instruction: Gifted students can complete the regular curriculum quickly, so they should be given the opportunity to start more advanced mathematics topics early (Özyaprak, 2016; Şengil Akar, 2017)

Additional Support and Activities: Gifted students should be offered opportunities for additional maths activities in and out of school, such as competitions, camps, etc. (Şengil Akar, 2017; Özdemir, 2018)

Consequently, the education of mathematically gifted students should be enriched, individualised and accelerated to meet their individual needs (Özyaprak, 2016; Şengil Akar, 2017; Özdemir, 2018, Yazgan Sağ, 2019).

Since gifted students' interest in learning, depth and speed of learning are different from their peers (Çetin & Ünsal, 2020), the teacher's task is to differentiate, accelerate and provide enriching experiences. For example, in mathematics education, activities should be planned to question the factors underlying causality, association and relationships (Özçelik, 2017). Mathematics education in BİLSEMs is delivered through a flexible curriculum that is prepared according to the activity-oriented student or group. The activities are based on skills such as problem solving and association, which also have interdisciplinary characteristics. Özyaprak (2016) emphasises that these students should be given the opportunity to become experts who produce knowledge rather than apply mathematics (Sheffeld, 2003) and stresses that gifted students should have high quality mathematics experiences with high-level questioning and learning by doing and living in their school life. Games that develop high-level skills such as questioning and provide opportunities for learning by doing (Şentürk, 2020) provide students with the opportunity to experience active learning by doing, constructing concepts and relationships between concepts by researching, exploring and questioning in realistic environments (Yang, 2012).

Games are activities in which students have fun, and channelling this activity into education is an important factor in increasing motivation. Motivation is an important power element (Akbaba, 2006) in achieving the desired goal in educational environments faster and more effectively. The fact that mathematics consists of abstract concepts makes it difficult to understand mathematics, which makes motivation for mathematics more important (Kesici, 2018). In mathematics education, as in any other field, it is important to associate the subject and its achievements with everyday life. This connection contributes to motivation. Games are a natural element of human beings (Sezgin et al., 2018) and have an important place in the formation of behaviours that shape our lives. According to Vankúš (2021), game-based mathematics education has a positive effect on the affective domain. Studies show that students with high mathematical achievement complete tasks in games by rising quickly and having strong motivation (Lee et al., 2023). Furthermore, Erdoğan et al. (2017) also show that intelligence games have the potential to teach various mathematical concepts. A classic game that is widely played around the world is rock-paper-scissors (Tekeli et al., 2016).

The game of rock-paper-scissors dates back 2000 years to the Han Dynasty in China. This game, which is not just a children's game, is a model used to study decision-making mechanisms in interspecies competition and cycle modelling in economic markets (Zhou, 2016). İzgi and Özkaya (2019) analysed the fairness of the rock-paper-scissors game using the matrix. In the study, the researchers showed the fairness of the games with the norms of the payoff matrix using the newly introduced method of matrix games in the literature. Although the study was presented in the context of the rock-paper-scissors game, various matrix games were solved with the related method. The game of Rock-Paper-Scissors was extended in an episode of the television series The Big Bang Theory, with the addition of the characters Spock and the Lizard. Chamberland & Herman (2015) mentioned this television series in their study and analysed the Rock-Paper-Scissors game in the context of Borromean

Rings. In the study, Borromean Rings was modelled for the game with five, seven and more characters and the development of the game through intersecting relationships was mentioned. Tamborg et al. (2022) analysed resources related to programming and computational thinking in mathematics education developed around the game Rock-Paper-Scissors. The study concludes that this game is related to probability and statistics. While the focus is on estimating probabilities from data collected as the game is played repeatedly, it takes a Bayesian approach by recalculating probabilities as the game progresses. As a result, it involves the simulation of random realisations of a uniformly distributed discrete random variable such as rock, paper, scissors, which are equally likely outcomes. A review of the literature on the game of rock-paper-scissors shows that it is related to several mathematical concepts. In this study, the rock-paper-scissors game is analysed within the framework of the circular relationship.

Studies on game in relation to gifted students are limited (Genç & Dağlıoğlu, 2018). Due to their high creativity, maladaptive development and hypersensitivity (Genç & Dağlıoğlu, 2018), their interest in game that is different from their peers (Gross, 2009) and their preference to play alone (Karnes, 1983), gifted children have a higher rate of exclusion from play compared to normal children (Odom et al. 2002). Because of the leadership behaviour found in the majority of these children, they try to direct the games according to themselves and the strategies they decide (Karnes, 1983), and they generally want to invent complex games (Genç & Dağlıoğlu, 2018). Based on the above, it is important for the field of mathematics education to investigate the experiences of gifted students in game design processes and their opinions about the process, taking into account their creativity characteristics and their skills, interests and desires in games.

The aim of this study is to determine the views of gifted students on the process of game development within the framework of the rock-paper-scissors game using the concept of relation. For this purpose, the mathematical concepts in the rock-paper-scissors game were explored and the experiences of gifted students in the process of developing games using similar mathematical concepts, the difficulties in the process and the contributions of the process were examined.

2. Method

2.1. Research Method

This study was conducted using the holistic single case design, which is one of the case study designs of qualitative research methods which allows for a detailed examination of a single unit in all its dimensions over a period of time (Creswell, 2003; Yıldırım & Şimşek, 2008). The holistic single-case design is suitable for this study because individuals with unique characteristics, such as gifted students, provide direction and enlightening data for future research (Yıldırım & Şimşek, 2008; Yin, 2009).

2.2. Study Group

The study group of this research consists of 45 students, 27 students in the 7th grade and 18 students in the 8th grade, studying at Science-Art Centre. In order to conduct in-depth research in the selection of students, criterion sampling, one of the purposeful sampling methods that allows the selection of rich situations within the framework of the purpose of the study (Büyüköztürk et al., 2010), was used. Criterion sampling requires the inclusion of individuals who meet certain criteria for the sample in the study group (Büyüköztürk et al., 2010). In this study, the participants were selected from the students who took mathematics courses in BİLSEM programmes where the Special Talents Development (STD) programme was implemented.

2.3. Implementation of The Study

The research was applied in the mathematics course of the students studying at BİLSEM. The application was carried out in line with the relation acquisitions in the mathematics annual plan. The subject of relation was applied to students in groups of 4-8 students with activities during 4 lesson hours. The Rock-Paper-Scissors game was analysed within the framework of the concept of relation, and studies were carried out to improve the game during the lesson hours. The activity consisted of four open-ended questions developed by taking the opinions of field and field education experts:

- Write the rock-paper-scissors game as a relation defined in A={rock,paper,scissors} in such a way that the first component does not lose in ordered pairs.
- Show the relation defined on the set A on the figure.
- Can we improve the game by adding different elements? How?
- Calculate the probability in the improved game.

Example answers given by the students to the activity sheet are given in Appendix 1.

2.4. Data Collection Tools and Data Analysis

In the study, the data was collected by an opinion form developed by the researchers using the relevant literature and taking the opinions of two different experts. The opinion form consists of 11 questions regarding the students' previous gaming experiences, their gaming experiences in the process, the skills gained from game development study, and mathematical connections of the game (Appendix 2). While determining the themes in the study, firstly, it was subjected to descriptive analysis in line with the research questions and the questions in the interview form. This stage is carried out in order to exclude unnecessary data that are not related to the problem of the study in the process of data analysis and interpretation (Yıldırım & Şimşek, 2008; p.266). In the second step, in order to prevent data loss, the similar ones of the data that cannot be classified into existing themes was first be conceptualized and logically arranged according to the emerging concepts and brought together within the framework of the themes that explain the data. Content analysis was used, which allows the reader to interpret and organize the content in a way that they can understand (Yıldırım & Şimşek, 2008). In the content analysis process, Merriam (2009) data analysis process was followed: Firstly, all the documents obtained from the participants' opinions were read, and the codes were noted where they were found to be remarkable and important for the study by both researchers. The reason for preferring this coding rather than descriptive coding is the interpretation of meaning and coding that occurs from reflection (Richards, 2005). Then, the codes obtained were tried to be categorised under temporary common themes. In the construction of categories, inductive way was followed. In the conceptual coherence of the categories obtained, the same level was characterised by considering the previous experiences, the activity process, the game development process and the willingness to participate in different game development studies. In the naming of the categories, the researchers and the literature source was taken as a reference in order to be compatible with the purpose and theoretical framework of the study.

2.5. Validity, Reliability and Ethics

The Collaborative Constant Comparative Qualitative Analysis Process (Richards & Hemphill, 2018) guide was followed to ensure validity and reliability in determining the themes. The constant comparison method (Strauss & Corbin, 2015) was used in regular meetings to code the data. The reliability coefficient was calculated as 0.84 based on the consensus between the codes determined

by the researchers (Miles & Huberman, 1994). The results of the content analysis were presented in tables showing frequencies and percentages (Büyüköztürk et al., 2010).

For this study, an ethics committee permission certificate dated 17.05.2023 and numbered 2023/3 was approved by Balıkesir University Science and Engineering Sciences Ethics Commission. In addition, the necessary research application permission to carry out the study in the relevant schools was obtained with the approval dated 04/10/2023 and numbered 86143969 from the governorship.

3. Findings

In this section, the findings from the gifted students' opinions on the analysis of the game Rock-Paper-Scissors within the framework of the concept of relation and the game development process are presented.

The findings regarding the students' previous experience of developing games with mathematical concepts are presented in Table 1:

Table 1. *Findings Regarding Students' Previous Experiences of Developing Games with Mathematical Concepts*

	f	*%*
Experienced	6	13
Inexperienced	39	87
Total	45	100

An analysis of Table 1 shows that 87% of the students had never developed a game about mathematical concepts before. Three of the students who had developed a game before did not give any information about the game they had developed, while four students who had developed a game gave information about the game they had developed. They stated that the games they developed were related to probability.

Three themes, namely socialisation, calculation and pedagogical aspects, emerged from the analysis of the students' views on the situations they experienced during the game development process. The results are presented in Table 2.

Table 2. *Findings Related to the Situations Students Enjoy During the Game Development Process*

Theme	*Code*	*f*
Socialisation (f=27)	Fun	21
	Earning in practice	5
	Bringing the lesson to a boil (conversation)	1
Calculation (f=14)	Increased probability of winning	6
	Decreased chance of a draw	3
	Every move is equal	3
	Having too many elements	2
Pedagogical aspects (f=7)	Being instructive	4
	Mind development	1
	Creating a new perspective	1
	Be scientific	1
Total		48

When Table 2 is examined, it is seen that the students stated that they enjoyed the game development process mainly because it gave them the opportunity to socialise (f=27) during the game development process, and the students underlined this with the expressions of S11: *"I had fun and it was fun to make the signs."*, S31: *"It was a nice activity for us to socialise, I enjoyed it."*, S45: "*It was fun, we had a better, fun time with our friends and teacher, we mingled".* Another situation that students liked in the game development process was mathematical calculations (f=14). The student coded S16, who emphasised the increase in the probability of winning related to the calculation theme, stated: *"It is a good game if I win".* S19: *"Water beating fire (newly added characters) and me being champion twice".* S39: *"There are different alternatives"* and S13: *"There are many elements"*. As can be seen from Table 2, an important aspect that the students enjoyed the game development process was the educational aspect of the games (f=7). S1 one of the students explained this situation with the expression *"Developing the mind by bringing a new perspective to the game".*

Table 3 shows the findings obtained from the students who participated in the study regarding the situations they did not like during the game development process:

Table 3. *Findings Related to Students' Dislikes During the Game Development Process*

Theme	*Code*	f
Cognitive (f=14)	Mixed/Confusing	9
	Too much probability	4
	Difficult calculations	1
Calculation (f=8)	Increased probability of losing	6
	Draw	2
Social (f=5)	Losing in practice	4
	Lack of interest	1
Psychomotor / Physical (f=3)	Added elements are difficult to display manually	3
Total		30

Cognitive, calculation, social and psychomotor/physical themes were obtained from the students' views on the situations they disliked during the game development process (Table 3). Students expressed their opinions on cognitive (f=14) theme such as being mixed/confusing, involving too many possibilities, and difficult calculations during the game development process. The examples views on this theme are that S6: *"As the elements increase, it becomes more confusing."* S12: "*It was difficult for me. I had difficulty in remembering.*" S11: *"There are too many possibilities and I had difficulty in keeping in mind."* According to the students, the fact that the game process is mixed/confusing constitutes the basic structure of the situation they dislike. Calculation, which is one of the most admired aspects of the game development process, has become a disliked situation for some students due to the increased probability of losing and draw (f=8). Student coded S4 stated this situation as *"The possibility of losing also increased. That's why it was bad*." Students disliked the situations related to the social theme with 5 frequencies. This situation can be seen from the opinions of S29: *"Losing is a very bad thing."* S9: *"It is a subject that does not interest me."* In addition, the findings obtained show that the students had difficulty in performing unfamiliar movements (f=3).

The findings obtained from the students' opinions about the factors that positively affect the game development process are presented in Table 4:

Table 4. *Findings Related to the Factors that Positively Affect Students' Game Development Process*

Theme	*Code*	*f*
Factors related to the game (f=28)	Being a well-known game	22
	It's fun	3
	Newly added elements	3
Factors related to what is used in the game (f=11)	Use of maths topics	9
	Understanding the logic	2
Factors related to the implementer of the activity (f=6)	Teacher tips	6
Factors related to game developers/players (f=2)	Being a group	1
	Few people in the group	1
Total		47

When Table 4 is analysed, the factors related to the game (f=28) positively affected the game development process of the students the most. The students who stated that the game facilitated the process because it was a well-known game (f=22) emphasised this situation with the statements of S6: *"If it was a game we did not know, we would have learnt it more difficult".* S9: "*It is a slightly different version of a game I already know, it is easy".* S11: *"Because it is a game I have been playing since the past."* S19: "*I do not know and do not like rock, paper, scissors very much".* The factors related to the factors related to what is used in the game positively affected the game development process of the students with 11 frequencies. The students stated this situation with the expressions of S24: *"Using the rules of mathematics and trying in a loop."* S14: "*Understanding the logic of the game".* As a matter of fact, mathematical concepts positively affected the game development process for these mathematically gifted students who can quickly perceive the rules of mathematics and have developed reasoning skills. Another factor affecting the process was related to the implementer of the activity (f=6). The students who underlined that the teacher's recommendations facilitated the process stated this with the expressions S3: *"The help of our teacher"*, S35: *"helping as a guide*", S45: "*The activity sheets given by the teacher"*. In addition, the factors related to game developers/players affected the students positively with 2 frequencies. The students stated this situation with the expressions S21: *"Developing it with many people".*

Table 5 shows the findings obtained from the students' opinions on the factors that negatively affect the game development process.

Table 5. *Findings Related to the Factors That Negatively Affect Students' Game Development Process*

Theme	*Code*	*f*
Factors related to the game (f=23)	Mixed / confusing	17
	Too many elements	4
	Incompatibility between elements	2
Factors related to game developers/players (f=5)	Difficulty in performing the movement representing the elements	4
	Physical fatigue	1
Factors related to what is used in the game (f=3)	Constructing a relation	2
	Mathematical calculation	1

Factors related to the implementer of the activity (f=1)	Insufficient support from the teacher	1
Total		32

The factors negatively affecting the game development process of the students were related to the game, the game developers/players, what is used in the game and the implementer of the activity. The factors related to the game (f=23) affected the students negatively the most. The situation that affected the students negatively the most was that the game was complicated (mixed/confusing). The students described this situation as follows: S20: "*Decreased retention in the mind*" S24: "*Our right to choose increases and the game is more complicated*." S25: "*It was complicated but then I got used to it."* S26: "*My brain burns because it is too complicated*." S36: "*It is very suitable for confusing and making attention mistakes*." Another was the factors related to the game developers/players (f=5). The students stated this situation with S16: *''I do not have difficulty because I am not used to movement".* The game development process of the students was negatively affected by the factors related to what is used in the game with 3 frequencies. The students stated this situation with S13*: "I cannot create the star".* In addition to the students who stated that the game development process became easier (f=6) (Table 4) because the implementer provided sufficient support, 1 student was negatively affected by the factors related to the activity implementer.

Three themes: cognitive skills, affective skills and psychomotor skills; were obtained from the opinions of gifted students about the skills improved by the game development process within the framework of the relation concept of the rock - paper - scissors game (Table 6):

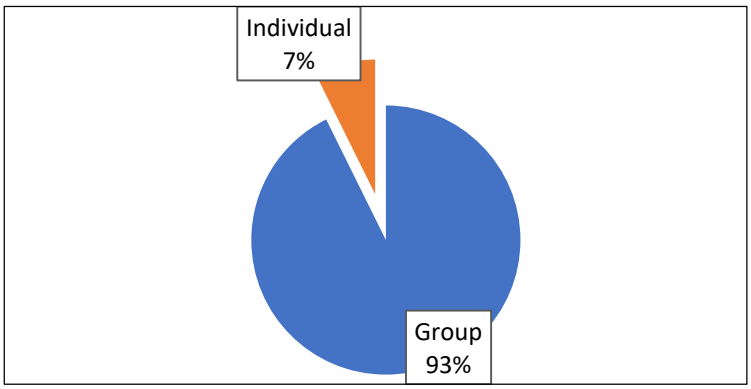
Table 6. *Findings About the Skills Improved by the Game Development Process*

Theme	*Code*	*f*
Cognitive Skills (f=24)	Mind / Memory	15
	Logic	5
	Maths Skills	2
	Visual Intelligence	1
	Analytical Thinking	1
Affective Skills (f=16)	Creativity	12
	Productivity	3
	Imagination	1
Psychomotor Skills (f=6)	Development of reflexes	6
Total		46

When Table 6 is analysed, it is seen that the students think that the game development study improves cognitive skills with a frequency of 34. The students stated this with the expressions S15: *"It improved our thinking skills."* S32: *"I think I developed mentally".* S40: *"Creativity and effective thinking".* S26: *"reasoning".* The students stated that the game development study generally improved the skills related to the mind/memory code. In addition, the students who stated that it developed affective skills such as creativity, productivity and imagination (f=16) thought that this implementation also developed psychomotor skills (f=6) in terms of the development of reflexes. The students stated these skills as S3: *"reflexes, manual skills*" and S32: *"My hands improved".*

Figure 1 shows the findings related to the students' preferences for studying individually/in groups in the game development process.

Figure 1. *Students' Game Development Preferences for Studying with Someone*



When Figure 1 is analysed, 93% of the students stated that they prefer to develop games as a group. On the other hand, 7% of the students stated that they prefer to develop games alone. The findings obtained from the opinions of the students regarding the reasons for these preferences are given in Table 7:

Table 7. *Findings Related to the Reasons for Preferences of Studying in Groups/Individually*

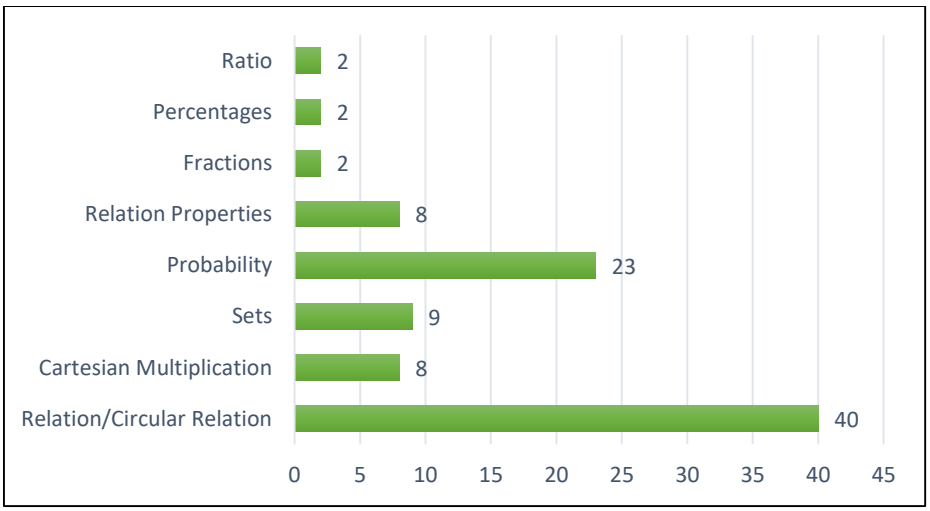
	Theme	*Code*	*f*
Group (f=38)	Social (f=21)	More fun	11
		Easier	9
		Defeating others	1
	Thinking (f=13)	Development of different ideas	13
	Game (f=4)	The nature of the game	4
Individual (f=3)	Social (f=2)	Non-interference by others	1
		Upsetting others	1
	Personal (f=1)	Ownership of the game idea	1
Total			41

When Table 7 is analysed, it is seen that the students who preferred the game development study as a group stated that they chose to be a group because of the situations related to the social theme with a frequency of 21. The students stated this situation as S18: *"As a group because it is more funny."* S20: *"as a group because it is more enjoyable."* S5: *"It is easier as a group."* S17: *"It is easier with the distribution of tasks."* In addition, the number of students who prefer to be in a group because different ideas develop (f=13) is also at a considerable level. The students expressed this situation as S11: "*As a group because I am curious about the ideas and thoughts of my other friends*." S12: *"Different ideas can come out*." S33: "*As a group because it is more fun with different ideas when we are together*." S35: *"Studying as a group because the game can be better with different ideas*." The students emphasised the nature of the game (f=4) while stating another reason for preferring to study in groups with the expressions S3: *"It cannot be played alone*." S26: *"It is a game played with many people*." Those who preferred to work individually stated that they made this choice for social and

personal themes. S38: *"I am alone because everyone will present an idea but we have to choose two. I would like everyone to be alone so that others would not be offended."*

Figure 2 shows the findings related to the mathematical concepts used in the game development process.

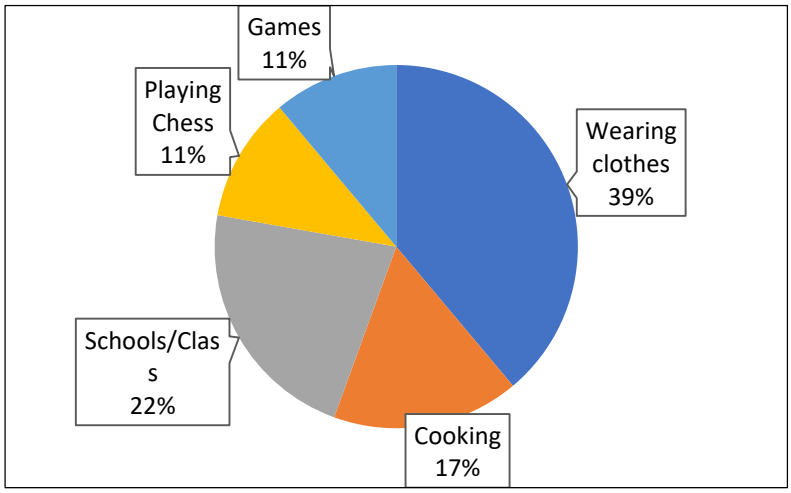
Figure 2. *Mathematical Concepts Used by Students in Game Development Process*



When Figure 2 is analysed, students stated that they used the concepts of relation (f=40), probability (f=23), sets (f=9), relation properties (f=8), cartesian multiplication (f=8), fraction (f=2), percentage (f=2) and ratio (f=2) in the game development activity.

The findings obtained from the question asked to the students about the place of the concept of relation in daily life show that a great majority of the students (39%) use it in wearing clothes. This situation was expressed by S10: *"When looking at which clothes to combine with which clothes"*. 17% of the students stated that they used it in cooking, 22% in class/school, 11% in chess, 11% in games (Figure 3).

Figure 3. *Places Where Students Use the Concept of Relationship in Everyday Life*



The situations in which students had difficulties in the game development process were categorised under the themes of theory, practice and connection (Table 8):

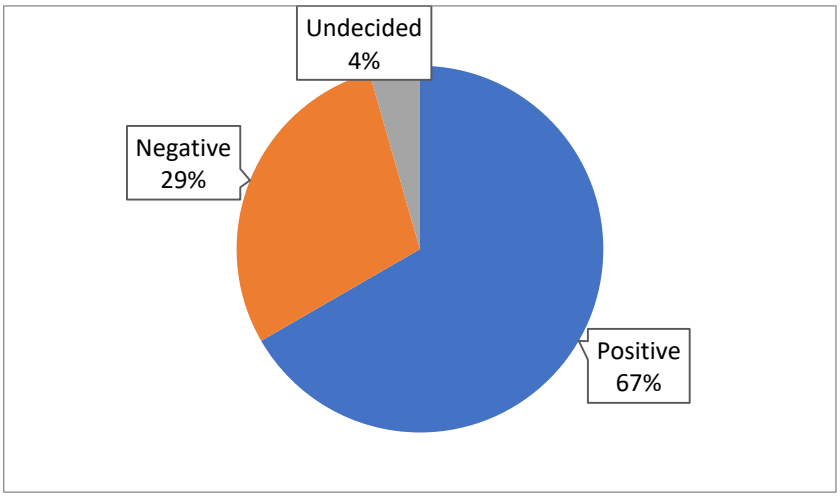
Table 8. *Findings Related to the Difficulties in Game Development*

Theme	*Code*	*f*
Theory (f=18)	Matching / Excess items	9
	Mixed	6
	Calculation of probabilities	1
	Creating a relation	1
	Learning new concepts	1
Practice (f=7)	Determining who wins at the time of game execution	4
	Difficulty in performing movements	3
Connection (f=6)	Connection with real life	6
Total		31

When Table 8 is analysed, it is seen that in the game development study, students experienced difficulties in situations related to theory with a frequency of 18. S11: *"I had difficulty in matching the relations."* S26: *"There are many factors. It is complicated."* S33: *"There were too many options, I got confused."* Students had difficulty with 7 frequencies in situations related to the practice. S7: *"I had difficulty in finding out who beat whom because there were too many elements"* S15: *"Movements were difficult. I corrected it by practising".* Students had difficulty in situations related to connection (f=6). This was stated by S37: "*It was difficult to connect the logic in the game with real life".* S40: *"In real life, not all of them can beat each other, reasoning".*

In Figure 4, findings about whether the students would like to develop new game in the context of mathematics is given:

Figure 4. *Students' Preferences for Participation in New Game Development Studies in the Context of Mathematics*



When Figure 4 is analysed, 67% of the students stated that they wanted to participate in a new game development study in the context of mathematics, 29% stated that they did not want to participate in a new game development study in the context of mathematics and 4% stated that they were undecided. The findings obtained regarding the reasons for students' preferences for participation in new game studies are given in Table 9:

Table 9. *Findings on the Reasons for the Desire to Participate in Other Game Development Studies in the Context of Mathematics*

	Theme	*Code*	*f*
Positive (f=22)	Socialisation (f=17)	Funny	17
	Affective (f=3)	Enjoying maths	2
		Making maths popular	1
	Self-development (f=2)	Enjoying the challenge	1
		Contribution	1
Negative (f=9)	Cognitive (f=6)	Difficult/Complicated	6
	Personal (f=3)	Not wanting to change the usual game	2
		No need	1
Total			31

When Table 9 is examined, it is seen that the students stated that they wanted the new game development study for socialisation (f=17). The students stated this as S8: *"Yes, it is fun."* S17: *"Yes, it was quite enjoyable.*" S37: *"Yes. Because it helps to learn new things while having fun. I believe that I can learn different things about mathematics from such activities."* The students stated that they wanted to do a new study from the situations related to the affective theme with 3 frequencies. The students stated this with S36: *"Yes, I like to do studies about mathematics".* The students stated that they wanted to do a new study with 2 frequencies due to situations for self-improvement. The students did not want to make a new game development study with 6 frequencies due to the situations related to the cognitive theme. The students stated this situation with the expressions S5: *"No, it was difficult".* S11: "*No, it is too labour intensive and I am lazy*". Students stated that they did not want to do a new game development study due to the situations related to the personal theme with 3 frequencies. This situation was stated by S1: *"It is not nice to renew the games that have been put into a mould*".

4. Conclusion, Discussion and Recommendation

In this study, the rock-paper-scissors game was analysed and a game development study was carried out with gifted students. In this process, the analysis of the data on the opinions of the students is reported in the findings section. In this section, the results obtained in line with the aim of the research are presented by evaluating the relevant literature studies.

It was concluded that the majority of the students had no experience in developing games related to the concept of mathematics before the activity. This situation reveals that they have always encountered the abstract form of mathematics concepts. Kesici (2018) states in his study that mathematics is difficult to learn because it consists of abstract concepts, so motivation has an important place for mathematics. Students who had previously studied the concept of mathematics stated that their studies were in the form of playing games and designing games in the context of mathematics. It was stated that the games were generally related to the subject of probability and they had an effective experience at the point of associating with daily life.

The results obtained regarding the situations that the students liked shows that the most important situation that comes to the fore is that they find this process fun. They evaluated it as a good opportunity for socialisation. The necessity of motivation in realising mathematics acquisitions effectively (Akbaba, 2006) is emphasised in literature. The fact that the process was described as fun by the students emphasised the effect of the game on the affective domain. Vankúš (2021) similarly

stated that most of the game-based mathematics studies were effective in the affective domain. For the students, the prominent cognitive theme in the situations that they disliked in the development of the game is the situation of being complicated / confusing. As a result of the difficulty of some students in the theoretical part of the game, situations related to the cognitive field emerged at the beginning of the situations that students did not like in the process. Due to the nature of the mathematics course, it is a course in which cognitive features are at the forefront. Similarly, in their study, Memnun and Akkaya (2010) stated the situations related to the theme of being confusing among the disliked aspects of the mathematics course. Among the situations that the students disliked during the game development process was that it was difficult to show the newly added items manually in terms of psychomotor aspects. The students experienced mistakes while performing movements that they were not used to, and this situation took its place among the disliked situations because it negatively affected the flow rate of the game. In addition, students stated that losing in the application belonging to the social theme, not being interesting and increasing the probability of losing in the calculation theme were unpleasant situations. Although students disliked losing in practice, Ateş and Bozkurt (2021) stated in their study that students learnt to be leaders, to take responsibility and most importantly, to lose through games.

In these studies' results the factors related to the game are remarkable positively affected the game development process of the students. The fact that the game is a well-known game that the students have played before has positively affected the students in this process. The Rock-Paper-Scissors game, which is applied at the point of decision-making in daily life, is known and applied by a wide audience. In his study, Zhou (2016) mentioned that the Rock-Paper-Scissors game is not only a children's game but also used as decision-making mechanisms in different fields. In the process, associating mathematics activities with daily life had a positive effect on students. Çenberci and Özgen (2021) stated in their study that associating with daily life has positive effects such as easier learning, interest in the lesson, and concretisation. Another remarkable situation that positively affected the game development process was the factor related to the implementer of the activity. The support and guidance of the teacher positively affected the students in this process.

The factors that negatively affect the game development process are related to the game. Students were negatively affected by situations such as the complexity of the game and the presence of too many elements in the process. The situations that negatively affected the students were similar to the data obtained in the situations they did not like. Therefore, the situations that the students did not like also affected them negatively. Another situation related to the game in which the students were negatively affected during the development process was the incompatibility between the elements. The students wanted to create a logic between the newly added elements, as in the logic of the stone being eaten by breaking the scissors, and the mismatches described as incompatible by the students negatively affected them in this process. The difficulty of making the movements that were handled in unpleasant situations was also included in the factors that negatively affected the students.

The results about the skills improved by the game development process shows that cognitive theme was mostly emphasised. Gelen and Özer (2010) stated in their study that gamification developed problem solving skills. They emphasised creativity skills in the process in which students identify new items and associate them with each other. Students also mentioned that psychomotor skills developed. The majority of the students prefer to study as a group in the game development process. Sociability is at the forefront in these preferences. Ergül and Erşen (2023) stated in their study that well-designed games would contribute to the socialisation of students. The development of different ideas for studying as a group was an important reason for preference. Students stated that

stuying as a group brings together different ideas and creates a strong thinking structure. Another reason for studying grouply is that the nature of the game is suitable for this. Since there should be more than one option for decision making, they stated that the game should be played mutually. Unlike the results found in this study, Karnes (1983) shows that gifted children prefer to play alone because they have different skills compared to their peers regarding the types of games they prefer. The difference between the two studies may be due to the fact that all participants in this study were gifted. In other words, it is thought that children with similar potential prefer to play games and socialise together. As a matter of fact, it is emphasised in the related literature that these children choose as friends those who have similarities and parallels in their interests and intelligence at their level (Çağlar, 2019), and that they develop a sense of self-confidence and relax emotionally when they are with them (Ersoy & Avcı, 2004).

Analysing the mathematical concepts used in the game development process shows that the concepts stated by the students in parallel with the activity were compatible. This situation revealed that the students had a high level of awareness in examining the activity in the context of mathematics. Almost all of the students mentioned the concept of relation and circular relation. They also mentioned the concept of probability used in the calculation of winning and losing situations, and the concepts of sets and Cartesian multiplication used in explaining the concept of relation. The fact that the probability is a ratio enabled the students to mention concepts such as fraction and percentage. Furthermore, in this study, it is reached that the concept of relation used by the student in daily life are related to matching were stated. Students stated that they used the concept of correlation in clothing selection, cooking, class branches, chess and games. They stated that they used it in situations such as creating a combination in choosing clothes, for instance matching a black sweater with black shoes. As a matter of fact, the results in the literature reveal that games increase the level of comprehension of mathematical concepts and academic achievement (Gürbüz, 2007; Kebritchi et al., 2010; Polaki, 2002; Pratt, 2000; Ragasa, 2008).

From the results of the difficulties in the game development study, it is possible to say that codes similar to the disliked situations and negatively affected situations emerged. The most difficult point was experienced in the theory part of the study. The students stated that the theoretical part of the study was cognitively challenging and confusing and mentioned the difficulties experienced in this part. In the application phase of the study, they expressed the difficulties related to physical aspects. The process of getting used to the newly added movements and lack of practice were among the physical difficulties. Nevertheless, despite the difficulties experienced by the majority of these gifted children were willing to develop other games in the context of mathematics. Those who are willing want to do studies mostly because of social aspects. When we consider the situations that the students like and the aspects that affect them positively, the reasons for the students' desire to participate in other game development studies similarly emerge. Students stated that they wanted to participate in other studies because it was a fun process, because it contributed to them and because they liked mathematics. Those who said no stated that they did not want to participate due to cognitive and personal aspects. The students stated that they did not want to participate in other studies because the study was difficult and complex.

In summary, as a result of the study, the students evaluated the process as a fun and social activity in which they improved themselves in the context of mathematics. In this process, it was concluded that some students had difficulty because they evaluated the study as complicated. Especially the implementation phase created an impressive situation for the students. While evaluating the process, the students mostly mentioned the situations related to the application phase.

Hava et al. (2020) concluded that a systematic game development process enabled gifted students to gain awareness about professional game development activities such as identifying the target audience, prototyping and evaluation. In addition, this game design model enabled the game development activity to be implemented more systematically and faster. The results of the study also showed that the game development activity provided important educational outputs in terms of students gaining skills in problem solving and transferring their feelings/thoughts to artefacts through the design process experience. Another study by Bozan and Taşlıdere (2024) concluded that the game digital game designs of gifted BİLSEM students with Scratch programme positively affected their success and self-efficacy in coding.

In this study, the rock-paper-scissors game was included in the activities in its classical form. Considering that gifted students' digital games expand their imagination and are fun (Sevgili Koçak, 2019), examining their views on the design process of the game in the digital environment will contribute to the field. In addition, since games are an important opportunity in teaching mathematical concepts (Erdoğan et al., 2017), the use of games in mathematics teaching and the effect of game development processes on academic achievement can be examined in different studies. In this study, it was concluded that students enjoyed the socialisation and mathematical calculations during the game development process. Further studies can be conducted to examine the effect of the mathematical concepts learnt by students from this process on their long-term academic achievement. In this study, students' experiences related to the game development process were revealed. Different studies can be conducted to investigate how it affects students' mathematical thinking skills or problem-solving skills. This study was conducted with gifted students. The process of gifted students can be compared with the studies to be conducted with normal students.

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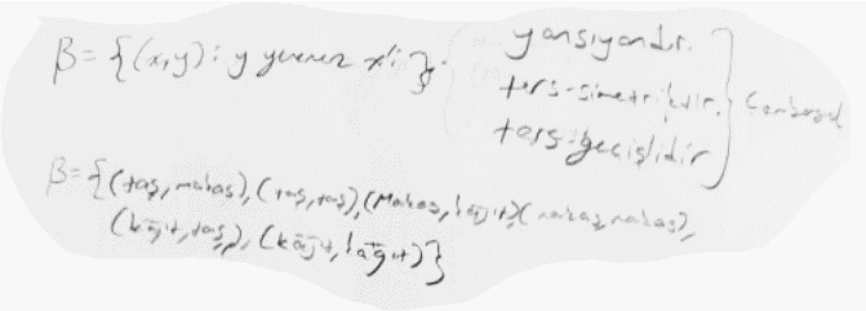
Appendix 1. Example Answers of Students

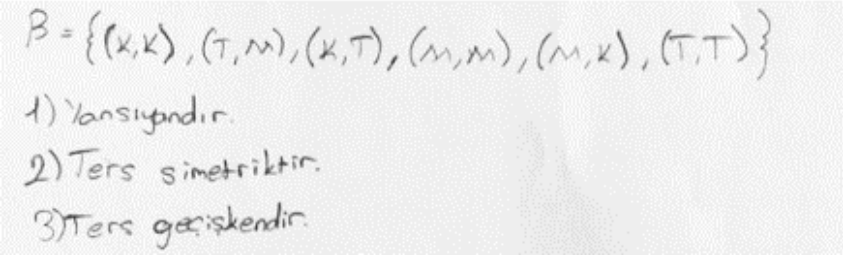
Activity

- Write the rock-paper-scissors game as a relation defined in $A = \{rock, paper, scissors\}$ in such a way that the first component does not lose in ordered pairs

Example Answer 1

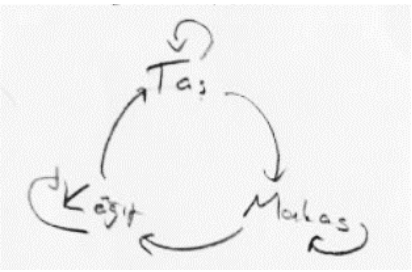


Example Answer 2

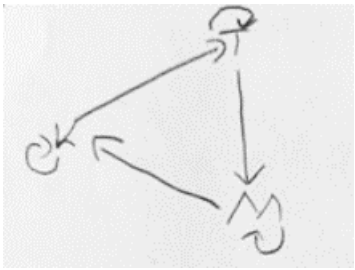


- Show the relation defined on the set A on the figure.

Example Answer 1

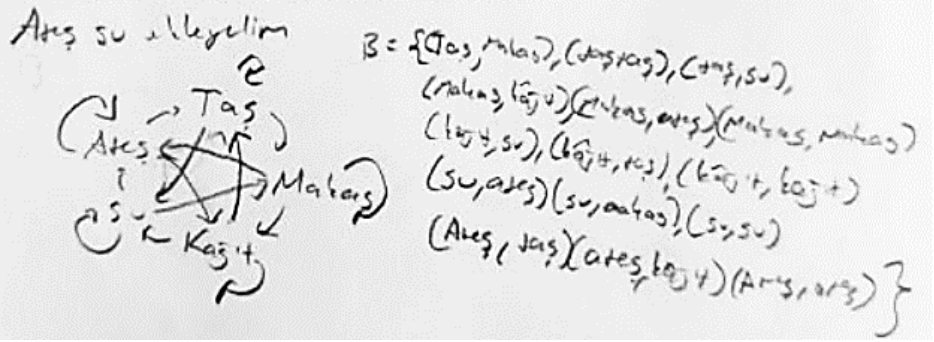


Example Answer 2

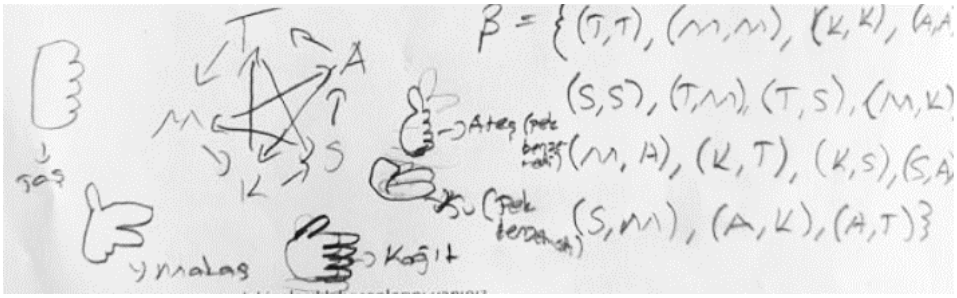


- Can we improve the game by adding different elements? How?

Example Answer 1

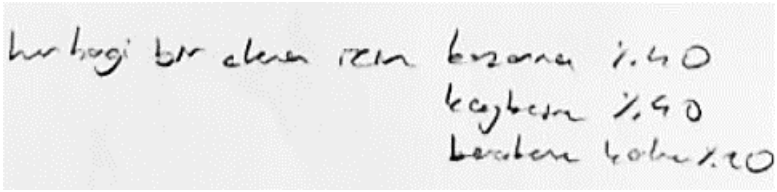


Example Answer 2

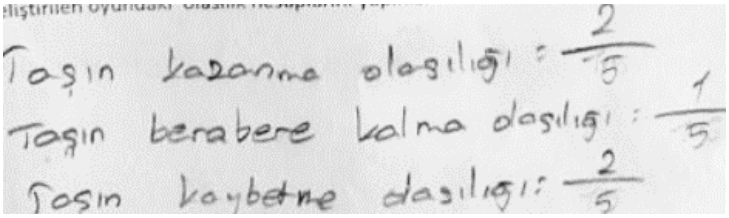


- Calculate the probability in the improved game.

Example Answer 1



Example Answer 2



Appendix 2. Opinion Form

1-Have you developed a game with mathematical concepts before this lesson? If yes, can you explain the relationship between the game and mathematics?
2- What are the situations you like when the game is analysed in terms of mathematics?
3- What are the situations that you dislike in analysing the game in terms of mathematics?
4- What are the factors that positively affect your game development process?
5- What are the factors that negatively affect your game development process?
6- Which skills do you think the game development work improved? Can you give some examples?
7- Would you prefer to work alone or as a group while developing the game? Why would you do this?
8- Which mathematical concepts did you use while developing the game?
9- What were the difficulties you had during the game development process?
- What do you think could be the reasons for these problems?
- If you did, what did you do to overcome these difficulties?

10-Do you use relations in daily life? How? Can you give an example?
11- Would you like to do other studies on game development and analysis in the context of mathematics? Why?

Geniş Özet

Giriş

Her birey yetenekleri, zekâsı, ilgisi, öğrenme biçimleri, ön bilgileri ve motivasyonları ile birbirinden farklıdır. Eğitimde bu farklılıklar dikkate alındığı ve duyarlı olunabildiği ölçüde başarılı olunabilmektedir (Aktepe, 2005). Nitekim farklı ve zenginleştirilmiş eğitime ihtiyaç duyan gruplardan biri de üstün yetenekli öğrencilerdir. Normal gelişim gösteren öğrencilerin programlarıyla birlikte hızlı öğrenmeleri nedeniyle okulda sıkılan ve motivasyonlarını kaybeden (Ataman, 2003) bu öğrencilerin potansiyellerini en üst düzeyde kullanarak kendini gerçekleştirmeleri için uygun bir eğitime ihtiyaçları vardır (Maker & Nielson, 1996; Tomlinson & Alan, 2000; Feldhusen & Jarwan 2000; Chan, 2001; VanTassel-Baska & Stambaugh, 2005). Matematik eğitimi açısından üstün yetenek, aritmetik hesaplamaları yaparken üst düzey becerinin ötesinde matematiksel fikirleri ve mantığı anlamada yüksek yetenektir (Dağlıoğlu, 2004). Bu bireyler, kavramsal genelleme, gözlem ve güçlü sorgulama becerisine sahip, hızlı muhakeme yapabilen, sebep sonuç ilişkilerini kavrayabilmede olağanüstü becerisi olan, yaratıcı bireylerdir (Krutetskii, 1976; Sheffield, 1994). Özyaprak (2016), üstün yetenekli öğrenciler için okul hayatlarında üst düzey sorgulamalar ve yaparak-yaşayarak öğrenme ile kaliteli matematik yaşantıları deneyimlemesi gerektiğinin altını çizmektedir. Sorgulama gibi üst düzey becerileri geliştiren ve yaparak-yaşayarak öğrenme imkânı sunan oyunlar (Şentürk, 2020), öğrencilerin yaparak-yaşayarak aktif bir şekilde öğrenmeyi deneyimlemelerini, gerçekçi ortamlarda araştırmaları, keşfetmeleri ve sorgulamaları ile kavramları ve kavramlar arası ilişkileri yapılandırmalarını mümkün kılmaktadır (Yang, 2012). Dünya çapında sıklıkla oynanan klasikleşmiş bir oyun da Taş-Kağıt-Makas oyunudur (Tekel vd., 2016).

Üstün yetenekli öğrenciler açısından oyunla ilgili çalışmalar sınırlıdır (Genç & Dağlıoğlu, 2018). Yüksek yaratıcılıkları, uyumsuz gelişimleri ve aşırı duyarlıkları (Genç & Dağlıoğlu, 2018), oyun ilgilerinin akranlarından farklı olması (Gross, 2009), tek başına oynamayı tercih etmeleri (Karnes, 1983) nedeniyle, normal çocuklara kıyasla üstün yetenekli çocukların oyundan dışlanma oranı daha yüksektir (Odom, vd. 2002). Oyunları kendilerine ve belirledikleri stratejilere göre yönlendirmeye çalışan (Karnes, 1983) üstün yetenekli çocuklar; genellikle karmaşık oyunlar icat etmek istemektedirler (Genç & Dağlıoğlu, 2018). Yukarıdakilerden hareketle bu çalışmanın amacı, üstün yetenekli öğrencilerin bağıntı kavramı kullanarak taş–kâğıt–makas oyununu çerçevesinde oyun geliştirme sürecine ilişkin görüşlerinin belirlenmesidir. Amaç doğrultusunda taş-kâğıt-makas oyunundaki matematiksel kavramların keşfedilmesi ve üstün yetenekli öğrencilerin benzer matematiksel kavramlar kullanarak oyun geliştirme sürecindeki deneyimleri, süreçteki zorluklar ve sürecin katkıları incelenmiştir.

,

Yöntem

Çalışmada bir nitel araştırma yöntemi olan durum çalışmasının bütüncül tek durum deseni (Creswell, 2003; Yıldırım & Şimşek, 2008) benimsenmiştir. Çalışma grubunu amaçlı örnekleme yöntemlerinden ölçüt örnekleme kullanılarak (Büyüköztürk ve diğerleri, 2010) seçilen 7. Sınıfta öğrenim gören 27, 8. Sınıfta öğrenim gören 18 olmak üzere toplam 45 Bilim ve Sanat Merkezi öğrencisi oluşturmaktadır. Öğrencilerin seçiminde kullanılan ölçüt, BİLSEM programlarından Özel Yetenekleri Geliştirme (ÖYG) programı uygulanan matematik dersi seçmeleridir. Çalışmada matematik yıllık planında yer alan bağıntı kazanımları doğrultusunda 4 ders saati süresince 4-8 kişilik gruplar halinde öğrencilere bir etkinlik uygulanmış, Taş-Kağıt-Makas oyunu bağıntı kavramı çerçevesinde incelenmiştir.

Ayrıca, ders saatleri içerisinde öğrencilerle oyunu geliştirmek için çalışmalar yürütülmüştür. Etkinlik alan ve alan eğitimi uzmanı görüşü alınarak geliştirilmiş, dört açık uçlu sorudan oluşmaktadır:

- Taş-kağıt-makas oyununu sıralı ikililerde ilk bileşen kaybetmeyecek şekilde A={taş,kağıt,makas} da tanımlı bir bağıntı olarak yazınız.
- A kümesinde tanımlanan bağıntıyı şekil üzerinde gösteriniz.
- Oyuna farklı elemanlar ekleyerek geliştirebilir miyiz? Nasıl?
- Geliştirilen oyundaki olasılık hesaplarını yapınız.

Çalışmada veriler araştırmacılar tarafından ilgili literatür ve iki farklı uzmanın görüşü alınarak geliştirilen görüş formu ile toplanmıştır. Görüş formunda öğrencilerin önceki oyun deneyimleri, süreçteki oyun deneyimleri, oyun geliştirme çalışmasının kazandırdığı becerileri ve ilişkilere yönelik 11 sorudan oluşmaktadır. Elde edilen veriler, öncelikle ilgili literatürdeki araştırmalar sonucu elde edilen temalar doğrultusunda betimsel analize tabi tutulmuş; daha sonra veri kaybını önlemek amacıyla var olan temalara sınıflandırılamayan verilerin, birbirine benzeyenlerinin önce kavramsallaştırılması ve ortaya çıkan kavramlara göre mantıklı bir şekilde düzenlenmesi ve veriyi açıklayan temaların çerçevesinde bir araya getirerek bunları okuyucunun anlayabileceği şekilde yorumlayarak düzenlemesini sağlayan (Yıldırım & Şimşek, 2008) içerik analizi ile analiz edilmiştir. Temaların belirlenmesinde geçerlilik ve güvenilirliği sağlamak ve araştırmacı yanlılığını azaltmak için İşbirliğine Dayalı Sürekli Karşılaştırmalı Nitel Analiz Süreci (Richards & Hemphill, 2018) kılavuzu takip edilmiştir. Haftalık toplantılarda sürekli karşılaştırma yöntemi (Strauss & Corbin, 2015) aracılığıyla gerçekleştirilen kodlama sürecinde ve kodlayıcılar fikir birliğine varana kadar anlaşmazlıklar tartışılarak son şekli verilmiştir. Araştırmacılar tarafından belirlenen kodlar arası görüş birliğine dayalı olarak güvenirlik katsayısı 0,84 olarak hesaplanmıştır (Miles & Huberman,1994). İçerik analizi sonucu elde edilen veriler, frekans ve yüzdeler cinsinden tablolar şeklinde sunularak yorumlanmıştır (Büyüköztürk, vd. 2010) Ayrıca temalar, katılımcı görüşlerinden doğrudan alıntılarla desteklenmiştir.

Bu çalışma için Balıkesir Üniversitesi Fen ve Mühendislik Bilimleri Etik Komisyonu'ndan 17.05.2023 tarih ve 2023/3 sayılı etik kurul izin belgesi alınmıştır. Ayrıca çalışmanın ilgili okullarda yürütülebilmesi için gerekli araştırma uygulama izni Valilik makamının 04/10/2023 tarih ve 86143969 sayılı onayı ile alınmıştır.

Sonuç, Tartışma ve Öneriler

Çalışmanın sonuçları, çalışmaya katılan üstün yetenekli öğrencilerin büyük çoğunluğunun etkinlik öncesi matematik kavramı bağlamında oyun geliştirme deneyimi yaşamadığını göstermektedir. Deneyim sahibi öğrenciler, bu konuda olasılık konusunu örnek gösterirken, günlük yaşamla ilişkilendirme noktasında etkili bir deneyim geçirdikleri söylenebilir. Birçok öğrencinin bu konudaki deneyim eksikliği, matematik kavramlarının soyut hali ile hep karşılaştıkları sonucunu gün yüzüne çıkarmaktadır. Nitekim Kesici (2018)'ye göre, matematik soyut kavramlardan oluştuğu için öğrenimi zordur, bu yüzden motivasyon matematik için önemli bir yere sahiptir. Matematik kazanımlarını etkili bir şekilde gerçekleştirmede motivasyon gereklidir (Akbaba, 2006). Süreçte hoşlanılan durumlara ilişkin öne çıkan durum, sürecin eğlenceli oluşudur. Sürecin öğrenciler tarafından eğlenceli olarak nitelendirilmesi oyunun duyuşsal alan üzerindeki etkisini vurgulamaktadır. Bu sonuç; Vankúš'ın (2021) oyun temelli matematik çalışmalarının büyük kısmının duyuşsal alanda etkili olduğu sonucunu destekler niteliktedir. Mevcut çalışmada, öğrencilerin büyük bir çoğunluğunun oyunun geliştirilmesinde hoşlanmadığı durum ise bilişsel açıdan karışık/kafa karıştırıcı olduğu sonucuna ulaşılmıştır. Oyunun teorik kısmında bazı öğrencilerin zorlanması sonucunda, öğrencilerin süreçte hoşlanmadıkları durumların başında bilişsel alana yönelik durumlar ortaya çıkmıştır. Matematik doğası

gereği bilişsel özelliklerin ön planda olduğu bir derstir. Memnun ve Akkaya (2010) çalışması da benzer şekilde matematik dersinin sevilmeyen yönlerinin arasında kafa karıştırıcı olduğunu belirtmektedir. Elde edilen bir diğer sonuç da öğrencilere süreçte psikomotor açıdan yeni eklenen öğelerin elle gösterilmesi zor gelmesidir. Öğrenciler alışık olmadıkları hareketleri yaparken yanılmalar yaşamış ve bu durum oyunun akış hızını olumsuz etkilediği için hoşlanılmayan durumlar arasında yerini almıştır. Ayrıca öğrenciler sosyallikle ilgili uygulamada kaybetmek, ilgi çekici olmaması ve hesaplamayla ilgili kaybetme olasılığının artması durumlarını hoşlanılmayan durumlar olarak bildirmişlerdir. Her ne kadar öğrenciler uygulamada kaybetmekten hoşlanmasalar da Ateş ve Bozkurt (2021) çalışması, oyunlar ile öğrencilerin lider olmayı, sorumluluk almayı en önemlisi olarak da kaybetmeyi öğrendiklerini göstermektedir.

Elde edilen sonuçlar, süreci olumlu etkileyen faktörlerin büyük bir çoğunluğunun oyun ile ilgili olduğunu göstermektedir. Oyunun bilindik, öğrencilerin tarafından daha önceden oynadıkları bir oyun oluşu öğrencileri bu süreçte olumlu etkilemiştir. Günlük yaşamda karar verme noktasında başvurulan Taş-kağıt-makas oyunu geniş bir kitle tarafından bilinmekte ve oynanmaktadır. Zhou'a (2016) göre Taş-Kağıt-Makas oyununun sadece bir çocuk oyunu değildir, farklı alanlarda karar verme mekanizmaları olarak da kullanılmaktadır. Çalışmada, oyun geliştirme sürecinde matematiğin günlük hayatla ilişkilendirilmesinin öğrenciler üzerinde olumlu etki oluşturduğu sonucuna ulaşılmıştır. Günlük hayatla ilişkilendirme; daha kolay öğrenme, derse yönelik ilgi duyma, somutlaştırma gibi olumlu etkileri (Çenberci & Özgen, 2021) göz önüne alındığında oyun geliştirme süreçlerine öğrenme ortamlarında daha fazla yer verilmesinin matematik eğitimi açısından önemli bir yere sahip olduğu söylenebilir.

Bu çalışma kapsamında gerçekleştirilen oyun geliştirme sürecini; oyunun karışık ve fazla öğe olması gibi durumlar olumsuz etkilemiştir. Öğrencileri olumsuz etkileyen durumlar ile hoşlanmadıkları durumlara ilişkin elde edilen sonuçlar benzerlik göstermektedir. Dolayısıyla öğrencilerin hoşlanmadıkları durumlar aynı zamanda onları olumsuz etkilemektedir. Öğrencilerin geliştirme sürecinde olumsuz etkilendikleri oyun ile ilgili bir diğer durum öğeler arası uyumsuzluktur. Öğrencilerin taşın makası kırarak yenmesi mantığında olduğu gibi yeni eklenen öğeler arasında da bir mantık oluşturmak istememesi ve öğrenciler tarafından uyumsuz olarak nitelendirilen eşleştirmeler bu süreçte onları negatif tesir etmektedir. Hoşlanılmayan durumlarda ele alınan hareketlerin yapımının zor oluşu öğrencileri olumsuz etkileyen faktörlerde de yer almıştır. Bu olumsuzluklara rağmen öğrencilerin bu süreçte geliştirdikleri beceriler incelendiğinde daha çok bilişsel olarak nitelendirilen becerilere vurgu yapılmıştır. Nitekim Gelen ve Özer (2010) oyunlaştırmanın problem çözme becerisi geliştirdiğini belirtmektedir. Bu çalışmanın sonuçlarından görüldüğü üzere süreçte öğrencilerin yeni öğeler belirleyip birbirleri ile ilişkilendirdiklerinde yaratıcılık ve psikomotor becerilerin gelişimini de ön plana çıkmaktadır.

Öğrenme öğretme sürecinin önemli bir öğesi de birlikte çalışma becerisidir. Bu çalışmanın sonuçları oyun geliştirme sürecinde öğrencilerin büyük çoğunluğunun grup olarak çalışmayı tercih ettiklerini göstermektedir. Bu tercihlerinde sosyallik ön plandadır. Ergül ve Erşen (2023) çalışmasında iyi tasarlanmış oyunlar ile öğrencilerin sosyalleşmesine katkı sunacağını belirtmiştir. Grup olarak çalışma için farklı fikirlerin gelişmesi durumu önemli bir tercih sebebi olmuştur. Öğrenciler grup olarak çalışmayı farklı fikirlerin bir araya gelip güçlü bir düşünme yapısı oluşturması nedeniyle tercih ettiklerini belirtmektedir. Bir diğer grup olarak çalışma nedeni oyunun doğasının buna uygun oluşudur. Karar verme için birden fazla seçenek olması gerektiği için oyunun karşılıklı oynanması gerektiğini belirtmişlerdir. Bu çalışmada bulunan sonuçlardan farklı olarak Karnes (1983) üstün yetenekli çocukların tercih ettikleri oyun türlerine ilişkin diğer akranlarına oranla farklı becerilere sahip olmaları nedeniyle tek başına oynamayı tercih ettiklerini göstermektedir. İki çalışma arasındaki farklılık bu çalışmadaki tüm katılımcıların üstün yetenekli olmasından kaynaklanıyor olabilir. Diğer bir deyişle

benzer potansiyele sahip çocukların, birlikte oyun oynamayı ve sosyalleşmeyi tercih ettikleri düşünülmektedir. Nitekim bu çocukların arkadaş olarak kendileri seviyesindeki zekâya sahip, ilgilerinde benzerlik ve paralellik olan kimseleri seçtikleri (Çağlar, 2019), onlarla birlikteyken kendine güven duygusunun geliştiği ve duygusal açıdan rahatladığı (Ersoy & Avcı, 2004) ilgili alan yazında vurgulanmaktadır.

Süreçte geliştirilen oyunlarda kullanılan matematiksel kavramlar, etkinlikteki kavramlarla paralellik göstermektedir. Bu durum öğrencilerin etkinliği matematik bağlamında incelenmesinde farkındalık düzeyinin yüksek olduğunu göstermektedir. Öğrencilerin neredeyse tamamı bağıntı ve çembersel bağıntı kavramlarını, oyunlarını geliştirmekte kullanmışlardır. Ayrıca kazanma ve kaybetme durumlarının hesabında kullanılan olasılık kavramını, bağıntı kavramının açıklanmasında kümeler ve Kartezyen çarpım kavramlarını ve olasılık ifadesinin oran oluşu nedeniyle kesir, yüzde gibi kavramları kullandıklarını belirtmişlerdir. Bağıntı konusunun ön plana çıkışı günlük hayatta bağıntıyı nasıl ilişkilendirdikleri sorusunu ön plana çıkarmaktadır. Öğrencilerin günlük hayatta bağıntı kavramını kullanmalarına yönelik sonuçlar, eşleştirme ile ilgili durumları örneğin, kıyafet seçimi, yemek yapımı, sınıf şubeleri, satranç ve oyunları bağıntıyla ilişkilendirdiklerini göstermektedir. Nitekim literatürdeki sonuçlar, oyunların matematiksel kavramları kavrama düzeylerini ve akademik başarıyı arttırdığını ortaya koymaktadır (Pratt, 2000; Polaki, 2002; Gürbüz, 2007; Ragasa, 2008; Kebritchi vd., 2010).

Öğrencilerin oyun geliştirme çalışmasında zorlandıkları durumlara ilişkin sonuçların, hoşlanılmayan ve olumsuz etkilenen durumlara benzer olduğunu söylemek mümkündür. En çok zorlanılan nokta çalışmanın teori kısmında yaşanmıştır. Öğrenciler çalışmanın teorik kısmının bilişsel açıdan zorlayıcı ve kafa karıştırıcı olduğunu belirterek bu bölümde yaşanılan zorluklardan bahsetmişlerdir. Çalışmanın uygulama aşamasında fiziksel yönlere ait sıkıntıları dile getirmişlerdir. Yeni eklenen hareketlere alışma süreci ve pratik eksikliği fiziksel açıdan zorlanılan durumlardan olmuştur. Ancak bu zorluklara rağmen, öğrencilerin büyük bir çoğunluğu matematik bağlamında başka oyunlar geliştirme çalışmaları için istekli olduğu sonucuna ulaşılmıştır. İstekli olanlar daha çok sosyal yönlerden dolayı çalışma yapmak istemektedir. Öğrencilerin hoşlandıkları durumlar, onları olumlu etkileyen yönler de göz önüne alındığında öğrenciler benzer oyun geliştirme çalışmalarına katılma isteğinin nedenleri ortaya çıkmaktadır. Öğrenciler eğlenceli bir süreç olduğu, kendilerine katkı sağladığı, matematiği sevdiği için başka çalışmalarına katılmak istediklerini belirtmektedirler. Olumsuz görüş bildirenler ise bilişsel ve kişisel yönlerden dolayı katılmak istemediklerini ifade etmektedirler. Öğrencilerin çalışmanın zor ve karmaşık olmasından dolayı başka çalışmalara katılmak istemedikleri görülmektedir.

Özetle çalışma sonucunda, öğrenciler süreci; eğlenceli, matematik bağlamında kendilerini geliştirdiği, sosyal anlamda dolu bir etkinlik olarak değerlendirmişlerdir. Bu süreçte bazı öğrencilerin çalışmayı karışık olarak değerlendirdiği için zorlandıkları sonucu ortaya çıkmıştır. Özellikle uygulama aşaması öğrenciler için etkileyici bir durum oluşturmuştur. Öğrenciler süreci değerlendirirken daha çok uygulama aşamasına yönelik durumlardan bahsetmişlerdir. Hava ve diğerlerinin (2020) sonuçları, sistematik bir oyun geliştirme sürecinin üstün yetenekli öğrencilerin hedef kitleyi belirleme, prototip oluşturma ve değerlendirme gibi profesyonel oyun geliştirme faaliyetleri konusunda farkındalık kazanmalarına, öğrencilerin problem çözmede becerine ve tasarım süreci deneyimi yoluyla duygu/düşüncelerini eserlere aktarabilmelerine olumlu katkı sağladığını göstermektedir. Ayrıca Bozan ve Taşlıdere (2024) sonuçları üstün yetenekli öğrencilerin Scratch programı ile gerçekleştirdikleri oyun dijital oyun tasarımlarının kodlamadaki başarı ve öz yeterliklerini olumlu etkilediğini göstermektedir.

Bu çalışmada, Taş-kağıt-makas oyunu klasikleşmiş haliyle etkinliklere dâhil edilmiştir. Dijital oyunların üstün yetenekli öğrencilerin hayal dünyalarını genişlettiği ve eğlenceli olduğu (Sevgili Koçak,

2019) göz önüne alındığında, bu öğrencilerle gerçekleştirilecek dijital ortamda oyunun tasarlanma sürecine ilişkin görüşlerinin incelenmesi alana katkı sağlayacaktır. Ayrıca oyunların matematiksel kavramların öğretiminde önemli bir fırsat olması (Erdoğan, vd., 2017) nedeniyle yapılacak farklı çalışmalarla oyunların matematik öğretiminde kullanılması ve oyun geliştirme süreçlerinin akademik başarılarına etkisi incelenebilir. Bu çalışmada, oyun geliştirme sürecindeki sosyalleşme ve matematiksel hesaplamalardan keyif alındığı sonuçlarına ulaşılmıştır. Yapılacak ileri çalışmalarla öğrencilerin bu süreçten öğrendikleri matematik kavramlarının uzun vadeli akademik başarıları üzerindeki etkisi araştırılabilir. Mevcut çalışmada öğrencilerin oyun geliştirme sürecine ilişkin deneyimleri ortaya koyulmuştur. Yapılacak farklı çalışmalar ile öğrencilerin matematiksel düşünme becerilerine veya problem çözme yeteneklerine nasıl etki ettiği incelenebilir. Ayrıca normal gelişim gösteren öğrencilerle yapılacak çalışmalar ile üstün yetenekli öğrencilerin süreci karşılaştırılabilir.

Yayın Etiği Beyanı

Bu araştırmanın, Balıkesir Üniversitesi Fen ve Mühendislik Bilimleri Etik Komisyonu tarafından 17.05.2023 tarihinde 2023/3 sayılı kararıyla verilen etik kurul izni bulunmaktadır. Ayrıca araştırmanın ilgili öğrencilerle gerçekleştirilebilmesi için gerekli uygulama izni, Valilik Makamının 04/10/2023 tarih ve 86143969 sayılı onayı ile alınmıştır.

Bu araştırmanın planlanmasından, uygulanmasına, verilerin toplanmasından verilerin analizine kadar olan tüm süreçte "Yükseköğretim Kurumları Bilimsel Araştırma ve Yayın Etiği Yönergesi" kapsamında uyulması belirtilen tüm kurallara uyulmuştur. Yönergenin ikinci bölümü olan "Bilimsel Araştırma ve Yayın Etiğine Aykırı Eylemler" başlığı altında belirtilen eylemlerden hiçbiri gerçekleştirilmemiştir. Bu araştırmanın yazım sürecinde bilimsel, etik ve alıntı kurallarına uyulmuş; toplanan veriler üzerinde herhangi bir tahrifat yapılmamıştır. Bu çalışma herhangi başka bir akademik yayın ortamına değerlendirme için gönderilmemiştir.

Araştırmacıların Katkı Oranı Beyanı

Bu çalışmada her iki yazarın da çalışmaya katkı oranı eşittir. Birinci yazar %50, ikinci yazar %50 oranında katkı sağlamıştır.

Çatışma Beyanı

Araştırmanın yazarları olarak çalışma kapsamında raporlanan araştırmada sonuçlarda ya da görüşlerde dolaylı/dolaysız herhangi mali çıkar ya da bağlantı olmadığı, çıkar çatışması yaşanmadığını ve yanlılık bulunmadığını beyan ederiz.