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Research Paper

Math Education for Gifted Individuals: Digital Gamification

Melike Şule Yıldız[a], Yavuz Yaman[*b]

[a](ORCID ID: 0000-0002-7901-1081), Phd Student, Istanbul University- Cerrahpaşa, Institute of Graduate Studies, Program in Education of Gifted Education, Turkey
melikesule.yildiz@ogr.iuc.edu.tr
[b](ORCID ID: 0000-0002-4837-9959), Assistant Professor, İstanbul University-Cerrahpaşa, Turkey, Hasan Ali Yücel Faculty of Education, Department of Special Education,
yyaman@iuc.edu.tr

[*]Corresponding author

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ABSTRACT

The aim of this study is to investigate the effect of digital gamification-based instruction on the attitudes towards mathematics and anxiety of seventh-grade gifted students in the "Equation and Equation" unit. In this study, pretest-posttest unbalanced group experimental design was used. The study was conducted in the 2022-2023 academic year with a total of 30 seventh-grade gifted students, 15 in the experimental group and 15 in the control group. During the study, the control group received a mathematics lesson based on traditional teaching and the experimental group received a mathematics lesson supported by digital gamification. In addition, the participants in the experimental group were asked to keep a diary throughout the implementation process to reflect their thoughts about digital gamification-based instruction. In the study, it was concluded that digital gamification-based instruction positively affected the attitudes of gifted students toward mathematics. It was observed that the anxiety levels of the students decreased after the application, but there was no statistically significant difference. In the study, students stated that mathematics lessons based on digital gamification were fun and their prejudices about the subject were broken.

INTRODUCTION

In the 21st century, the age of information, communication, and technology, advances in technology have led to socio-cultural changes worldwide. Technology, especially information technologies, has been widely used in every field of society for different purposes in the last ten years. The education system should aim to raise individuals with knowledge and skills compatible with advancing technology (Kert & Erkoç, 2017). For students to acquire these knowledge and skills, the teaching techniques, programs, and methods used in the education system should be restructured by the needs of the age (Alakoç, 2003).

Discussions on teaching mathematics date back 2500 years. From the very beginning of the 20th century, teaching maths has become a subject of frequent examination in terms of content and teaching methods (Peker, 1985). It has become compulsory to restructure teaching maths with technological tools brought by the changing age. The use of technology in maths lessons is not a new approach (Roblyer & Doering, 2013). Technology has been a tool in mathematics education since the 1980s. Teaching mathematics begins with normal calculators and continues with enriched dynamic geometry software, learning objects, and computer algebra systems with enriched developing technology (Karaarslan, Boz & Yıldırım, 2013).

Using technology in mathematics lessons can provide various benefits to students. The use of technology in the lessons is used as a tool to describe multiple situations by presenting algebraic, arithmetic, and geometric representations. Students can see concrete abstract concepts through multiple representations and technology helps students with the problem-solving process (Erbaş, 2005). Teachers who use technology in teaching mathematics can create an environment for in-depth discussions on mathematical concepts and problems. Technology can increase students' interest in mathematics and improve their problem-solving skills (Shi, 2009). Technology integration in mathematics lessons moves students away from memorization and enables them to create their projects, participate in problem-solving activities, and keep students active in the process (Güveli & Baki, 2000). Technology contributes to the concretization of the subjects in mathematics, to the understanding of concepts, and provides the opportunity to save time by increasing permanence (Tatar, Zengin, & Kağızmanlı, 2013). It reduces the teacher's course load and includes individual teaching. Technology contributes toward educating anxiety and fear in mathematics lessons, developing a positive attitude towards mathematics, and increasing success. It can also support the development of effective thinking habits such as analytical and critical thinking (Peker,1985). Studies have shown that technological software has had a positive impact on students' knowledge and understanding (Dikovic,2009), increases students' metacognitive awareness levels and performance (Tajuddin et al. 2009), and contributes to students developing positive attitudes toward mathematics (Aktümen & Kaçar, 2003; Machin & Rivero, 2002).

Gifted students are a part of the digital population and have grown up using technology in various ways. Students who are accepted as *"digital natives"* (Prensky, 2001) or *"new millennium students"* (Pedro, 2006) use technology not only because it is digital, but as an integral part of life (Housand & Housand, 2012). According to Siegle (2004), one of the domains of talent encompasses giftedness in the field of technology. Students who demonstrate giftedness in technology integrate it into their homework, presentations, and creative projects. They exhibit positive attitudes towards the use of technology in educational settings, acquire technological skills at a faster rate than their peers, and actively assist others in problem-solving. Recognizing this specific talent is crucial for its development. These individuals require support from information technology experts (Siegle, 2004).

Gifted students require differentiation in the educational process due to their distinct abilities compared to their peers (Ataman, 2004). Standardization in mathematics education can present a risk for gifted students. A non-individualized mathematics curriculum that fails to address the unique needs of gifted learners may result in feelings of boredom, decreased academic performance, and even regression. To nurture the talents of gifted students, safeguard their potential for mathematical reasoning, and enhance the probability of their evolving into creative individuals capable of making valuable contributions to mathematical science, diversification in content, process, and production is imperative (Özyaprak, 2016). While accelerating, grouping, and enriching the education of gifted students, it is crucial to identify the teaching method that aligns most effectively with the unique needs of these students (Ataman, 2004). Digital technology-based applications can be adjusted to reveal the intellectual and creative abilities of gifted students and respond to their time, speed, and learning needs (Çubukçu & Tosuntaş, 2018).

Technology is a valuable tool that can support gifted individuals more actively, independently, and effectively by providing them with special educational opportunities (Kontostavlou & Drigas, 2019). Appropriate technologies can create an environment that stimulates the interests of gifted individuals (Jong & Shang, 2015). Technology supports the learning needs of gifted students, increases their participation and motivation in classes, and creates exciting environments (Heald, 2016). Appropriate use of technology integration puts the responsibility for learning in the hands of gifted students. When technology use is original or compatible with real-world applications, it can increase the motivation of gifted students (Housand & Housand, 2012).

The utilization of technology in gifted education enhances the quality of education and broadens the scope of educational services, thereby transforming education by opening up new avenues and possibilities. Through technology, access to gifted students and mentors in remote locations is facilitated, fostering project-based and inquiry-based learning opportunities. Additionally, technology offers a plethora of diverse learning resources, enabling the creation of communities of learners (Chen, Yun Dai & Zhou, 2013). Pyryt (2009) proposed that technology enhances the learning experiences of gifted students across five dimensions: individualized pacing, pursuit of personal interests, mental peer interaction, development of higher-order thinking skills, and the creation of diverse products. Cirak (2021) determined that technology-based enriched mathematics activities led to an improvement in the mathematics achievement of 5th-grade gifted students. However, these activities did not result in a significant difference in their attitudes. Likewise, findings from a study involving 8th-grade students who were not identified as gifted revealed that instruction supported by Geogebra significantly enhanced students' academic achievement and reduced their anxiety levels. However, it did not have a significant impact on their attitudes toward mathematics (Barçın,2019). Musan (2012) stated that dynamic mathematics software-supported teaching helps students develop positive attitudes toward mathematics, increases their interest in the course, contributes to the development of affective, psychomotor, and cognitive areas, and allows students to progress at an individual learning pace. Cengiz (2017) found that technology-based mathematics instruction increased the academic performance of 7th-grade students, but there was no significant difference in their anxiety levels. In addition, it was reported that the lessons were more fun, interesting, and conducive to permanent learning. Öztop (2023) concluded in his meta-analysis study that digital technologies may have a moderate effect on reducing mathematics anxiety. Aldemir and Tatar (2014) stated that educational games are mostly used in technology-supported mathematics teaching.

In the digital age, games are one of the most important tools to motivate students and make learning fun (Kert & Erkoç, 2017). Games are an alternative tool that can be used by teachers to assess the progress of their students. Learning generally has three stages: instruction, practice, and evaluation. Games are an ideal environment to realize these three stages at the same time in a more natural way (Siegle, 2015). Computer and digital games create environments where students can analyze knowledge, structure knowledge, discover new knowledge, and creatively use learned knowledge (Kert & Erkoç, 2017). Through digital gamification, students understand a specific problem or challenge, complete a task, and receive feedback and suggestions for cognitive and metacognitive development (Kapp, 2012). Thanks to task-oriented digital gamification, the learning environment is transformed into a student-centered model, and students are motivated and become active participants in the learning processes (D'Aprile et al., 2015; Chan & Leung). Digital gamification increases student participation in decision-making, encourages self-assessment, and enhances mastery learning (Cooper, 2018). When implemented correctly in the classroom environment, games can provide social-emotional, cognitive, and motivational benefits to students. Games can be used to differentiate the educational curriculum for gifted students (Siegle, 2015). Cooper (2018) investigated the effect of digital game-based learning on sixth-grade mathematics achievement. It was concluded that between the groups that used digital game-based learning and those that did not, there was no significant difference in the percentages of mathematics achievement. Çankaya and Karamete (2008) found that the developed educational games did not significantly change students' attitudes towards mathematics. Tural-Sönmez (2012) found that web-based educational mathematics games help increase students' academic success, interest, and motivation. Özkan (2021) states that students are more active, collaborative, and participative in digital gamified courses compared to traditional courses. Digital games support students' problem-solving and creative thinking skills and can increase their motivation for learning (Poçan, 2023). Kara (2021) emphasized in the case study that there should be a meaningful connection between the subject area to be gamified and the process, that the levels of the mobile games designed should be presented from easy to difficult, and that the design and content of the games should match the students' expectations.

It is seen that studies analyzing technology integration in mathematics lessons in the education of gifted individuals are limited (Cooper, 2018; Çırak, 2021; Heald, 2016; Kontostavlou and Drigas, 2019). Teaching the subject of equations, which is difficult for students to understand, through digital gamification will also contribute to educators who want to differentiate the mathematics program in line with the needs of gifted students. This research aims to examine the effect of digital gamification-assisted instruction on the mathematics attitude and mathematics anxiety of gifted 7th-grade students. In line with this purpose, an attempt was made to seek answers to the following questions.

1. Did teaching mathematics through digital gamification significantly change the attitudes of gifted 7th graders towards mathematics?
2. Did teaching maths through digital gamification make a significant difference to gifted 7th graders' maths anxiety?
3. What are the views of gifted students on the use of digital gamification in mathematics education?

METHODOLOGY

Research Sequence

As this study investigates the effect of digital gamification-based instruction on gifted students' mathematics anxiety and attitude, it was designed as one of the weak experimental design types as a pretest-posttest unbalanced group design. In this design, a pre-test before the application and a post-test after the application using the same measurement tools are administered to the group of students formed without random assignment. The effect of the application is tested in the experimental group and no intervention is made in the control group (Büyüköztürk et al., 2022).

Research Process

In the digital gamification-supported teaching applied to gifted students, the subject of "Equality and Equations" in the 7th grade MEB curriculum was included. The subject of equations and inequality is one of the subjects that students make the most mistakes in the mathematics teaching process (Dede et al., 2002; Pomerantsev & Korosteleva, 2003; Şandır et al., 2007). Students stated that they could not find the solution of first-order equations with one variable and that they had difficulty understanding algebraic expressions (EARGED, 1996 as cited in Musan, 2012). Therefore, the subject of equations, which students struggled with, was taught to the experimental group using digital gamification-based instruction for 5 sessions (15 hours) and to the control group using traditional instruction. In the selection of the games, attention was paid to the student's ability to learn the subject by having fun. In addition, three teachers in the mathematics department were consulted in the selection of the games. For students to fully learn the subject of equality and equations and to increase their attitudes and interests towards the mathematics lesson different digital games were included in the program. Digital games were selected from "Mathnook", "Mathgames", "Math Playground", "Learningapps", "Wordwall", and "Geogebra" websites. Among these sites, "Learningapps" and "Wordwall" are used as gamification-based Web 2.0 tools. “Geogebra" is a software tool used in mathematics teaching and has been used in many studies. Other games are sites set up by enterprising teachers interested in mathematics to enable their students to learn mathematical topics by playing games. The activities were implemented for 5 sessions (15 lesson hours), and the students were asked to take part in the process and to solve the questions given in line with the rules of the game. A teaching environment suitable for digital games was prepared, and students were asked to bring their individual phone or tablet materials to the educational environment. Students actively participated in the process. For students who could not attend the lesson, the activities were shared with the students via Google Classroom. The implemented program was evaluated with pre-tests, post-tests, and diaries containing student opinions.

Working Sample Group

The research was initiated with the approval of Istanbul University-Cerrahpaşa Social and Human Sciences Ethics Committee No. 595744 dated 17.01.2023 and approved by the ethics committee. In this study, 30 7th-grade gifted students studying at the Science and Art Centre affiliated with the Ministry of National Education in Istanbul in the 2022-2023 academic year participated. Experimental and control groups were formed by convenience sampling. Convenient sampling method is defined as collecting data from a sample that the researcher can easily reach (Büyüköztürk et al., 2022). Personal information of the study group is given in Table 1.

Table 1. Demographic Information of the Study Group

		Control group		**Experimental group**	
		n	**%**	**n**	**%**
Gender	Female	5	33,3	10	66,7
	Male	10	66,7	5	33,3
Purpose of using technology	Lesson- Education-Teaching	4	26,7	2	13,3
	Information and research	-	-	1	6,7
	Play a game	7	46,7	3	20,0
	Communication	3	20,0	3	20,0

	Social media	-	-	2	13,3
	For fun	1	6,7	4	26,7
Time of daily use of technology for teaching and learning purposes	None	-	-		
	Less than 1 hour	4	26,7	4	26,7
	1-3 hours	11	73,3	11	73,3
	4 hours or more	-	-	-	-

Looking at the answers to the multiple responses in the personal information form, it was concluded that all of the students had an internet connection at home, the majority of the students (76.7%) had a smartphone with internet access, and they mostly used YouTube, Kahoot, and Eba among the technological applications for learning purposes. It has been found that Geogebra, Phet, Math Playground, Cabri Geometry, and Learning Apps are among the least used technological applications for learning purposes. Apart from these, students stated that they use Schoolistic, Morpha Campus, Duolingo, Tinkercard, Mentalup technological applications for teaching purposes.

Data collection tools

Personal information form, mathematics attitude scale, and mathematics anxiety scale were used as data collection tools in the study.

Mathematics Anxiety Scale: It is a valid and reliable measurement tool developed to determine the mathematics anxiety of 2nd-level primary school students. The Cronbach Alpha coefficient of the scale for this study is .81. The higher the score obtained from the scale consisting of 13 positive and 7 negative items, the higher the mathematics anxiety level of the students (Özdemir & Gür, 2011).

Mathematics Attitude Scale: The mathematics attitude scale developed by Önal (2013) consists of 22 items. The Cronbach Alpha coefficient of the scale for this study is .79.

DATA ANALYSIS

The normality of the maths anxiety and attitude scores was first tested when analyzing the data. As the distribution was not normal and the number of participants was less than 50, non-parametric tests were used to analyze the data. The level of significance was set at $p<.05$ in this study. If the pre-and post-test scores were significant, the effect size was checked. The effect size is evaluated regardless of the sign. If the r (effect size) coefficient of the effect value is between 0.2 and 0.5 it is considered a small effect, between 0.5 and 0.8 it is considered a medium effect and if it is greater than 0.8 it is considered a large effect (Cohen, 1988). The square of the r-effect value represents the proportion explained by the total variance. The r^2 value indicates how much of the effect of the independent variable is on the dependent variable (Cohen, 1992). The journals in which the students wrote their opinions about digital gamification-supported teaching were analyzed by content analysis. During the analysis of the data, the students' opinions about the application were presented with direct quotations.

FINDINGS

Findings related to pre-test and post-test scores

Table 2. Mann Whitney U test results of pre-test scores by group

Pre-Test	Group	n	Mean Rank	Sum of Ranks	U	p
Anxiety total	Control	15	13.07	196	76	.129
	Experimental	15	17.93	269		
Attitude total	Control	15	18.73	281	64	.044
	Experimental	15	12.27	184		
Attitude-Interest	Control	15	18.97	284.50	60.50	.030
	Experimental	15	12.03	180.50		
Attitude-study	Control	15	19.13	287	58	.022
	Experimental	15	11,87	178		
Attitude-necessity	Control	15	16	240	105	.751
	Experimental	15	15	225		

There is no significant difference ($U=76$, $p>.05$) between the groups' pre-test scores for maths anxiety according to Table 2. There is a significant difference in favor of the control group ($U=64$, $p<.05$) between the pre-test scores of the mathematics attitude and interest and study sub-dimensions.

Table 3. Mann Whitney U test results of post-test scores by groups

Post-test	Group	n	Mean Rank	Sum of Ranks	U	p
Anxiety total	Control	15	13.20	198.00	78	.151
	Experimental	15	17.80	267.00		
Attitude total	Control	15	16.80	252.00	93	.418
	Experimental	15	14.20	213.00		
Attitude-Interest	Control	15	15.70	235.50	109.50	.901
	Experimental	15	15.30	229.50		
Attitude-study	Control	15	17,13	257.00	88	.302
	Experimental	15	13,87	208.00		
Attitude-necessity	Control	15	14,43	216.50	96.50	.493
	Experimental	15	16.57	248.50		

Table 3 shows that students in the experimental group had higher post-test scores for anxiety and lower post-test scores for attitude than students in the control group, but the difference between the post-test scores was not significant (p>.05).

Findings related to the comparison of pre-test and post-test scores of the groups

Table 4. Wilcoxon signed-rank test results regarding the pre-test and post-test scores of the experimental group

Test	n	Mean	ss	Negative Mean rank	Pozitive Mean rank	Negative sum of ranks	Pozitive sum of ranks	z	p
Anxiety pre-test	15	35.33	10.86	6	6	48	18	-1.341	.180
Anxiety post-test	15	33.80	9.10						
Attitude pre-test	15	88.46	9.42	0.00	5.50	0.00	55	-2.807	.005
Attitude post-test	15	95.46	7.11						
İnterest pre-test	15	39.46	7.27	5.13	9.05	20.50	99.50	-2.249	.025
İnterest post-test	15	43.73	5.16						
Study pre-test	15	14.86	2.97	5.67	7.40	17.00	74.00	-2.030	.042
Study post-test	15	16.33	2.60						
Necessity pre-test	15	12.33	2.43	4.83	6.44	14.50	51.50	-1.653	.098
Necessity post-test	15	13.46	1.55						

Negative rank= Post-test< Pre-test
Pozitive rank= Post-test >Pre-test

According to Table 4, it can be seen that the difference between the mathematics anxiety scores of the students in the experimental group before and after the application is not significant (z= -1.341 p>.05). However, the student's anxiety level in mathematics class decreased after the application ($Mean_{pre-test}$=35.33; $Mean_{post-test}$=33.80). It was concluded that the difference between the mathematics attitude scores and the interest and study sub-dimensions scores was significant (z=-2.807, p<.05). The effect size of the significant results was calculated. (Cohen $d_{attitude}$ = .71; Cohen $d_{interest}$ =.57; Cohen d_{study}= .52). Looking at the total and average ranks, we can see that this significant difference is in favour of positive ranks. In other words, it can be said that the attitude, interest and study level of the students in the experimental group towards mathematics lessons increased after the application. It can be said that the effect of digital gamification on this significant increase is moderate.

Table 5. Control Group Pre-Test and Post-Test scores Wilcoxon Signed Ranks Test Results

Test	n	Mean	ss	Negative Mean rank	Pozitive Mean rank	Negative sum of ranks	Pozitive sum of ranks	z	p
Anxiety pre-test	15	29.13	4.91	6.67	7.29	40	50	-.387	.699
Anxiety post-test	15	29.46	6.59						
Attitude pre-test	15	96.40	9.92	7.19	8.93	57.50	62.50	-.143	.887
Attitude post-test	15	96.80	9.77						
İnterest pre-test	15	44.80	4.90	7.25	5.75	43.50	34.50	-.354	.723
İnterest post-test	15	44.26	4.54						
Study pre-test	15	17.06	2.08	5.58	6.50	33.50	32.50	-.045	.964
Study post-test	15	17.20	1.14						
Necessity pre-test	15	12.60	2.44	4.88	4.13	19.50	16.50	-.212	.832
Necessity post-test	15	12.53	2.61						

According to Table 5, the difference between the levels of anxiety and attitude of the students in the control group before and after the application was not significant ($p > 0.5$). After the traditional education, an increase in the students' anxiety and attitude levels was observed.

Comparison of post-test scores of gifted students in the experimental group in terms of duration of instructional technology use

Table 6. Comparison of post-test scores in terms of duration of using technology for course-educational purpose

Post-test		n	Mean rank	Sum of ranks	U	p
Anxiety	less than 1 hour	4	8.75	35.00	19	.753
	1-3 hours	11	7.73	85.00		
Attitude	less than 1 hour	4	6.75	27.00	17	.571
	1-3 hours	11	8.45	93.00		
Attitude-Study	less than 1 hour	4	6.25	25.00	15	.412
	1-3 hours	11	8.64	95.00		
Attitude-Necessity	less than 1 hour	4	7.25	29.00	19	.753
	1-3 hours	11	8.27	91.00		
Attitude -İnterest	less than 1 hour	4	6.75	27.00	17	.571
	1-3 hours	11	8.45	93.00		

According to Table 6, the students' attitude scores after the application did not show a significant difference according to the duration of using technology for educational purposes ($p>.05$). However, it can be said that the attitudes towards mathematics, interest, study and necessity scores of the gifted students who used technology for instructional purposes between 1-3 hours were higher than those who used technology for less than 1 hour.

Students' views on digital gamification

In the study, it was aimed to determine the opinions of the students in the experimental group about digital gamification-based mathematics teaching. For this purpose, students were asked to write a diary at the end of the lesson. In line with the diary records obtained, the opinions of the students were analyzed according to the following themes.

Table 7. Qualitative analysis of diary records

Theme	Sub-theme	Codes
The effect of digital gamification on the teaching process	Positive aspects	Efficient, useful, faster learning
		Be fun, enjoyable
		generalizability
		Breaking the prejudice to the subject, liking the subject
	Limitations	Game content (Some games are long, boring, easy, difficult)
		Technological trouble - charging problem
		Insufficient course time
		Limitation due to student (late to class)

Some of the student's views on the positive aspects of the applied program are given below:

K4: I definitely think that I learned the equations faster thanks to the activities we have done so far. If we had tried to learn normally, it would have taken me longer to learn.

K1: I understood the equation very well in the subjects we covered so far, my favorite game so far was candy jars. In my opinion, maths is more effective with games and activities.

K14: I had difficulties in the first research, but towards the end, I immediately started to solve it. Even if I had a lot of shortcomings, I solved them immediately. I liked the game "True and False" the most. It helped me a lot today.

K7: The lesson was very productive. I was biased towards equations, but I realized that it was not difficult. Teaching the lesson with an instructive game provided both fun and more efficient learning. It was one of the classes I enjoyed the most.

Participants stated that the digital gamification-based course is efficient, effective, beneficial, makes learning easier and faster, the lessons are fun and enjoyable, and the prejudice against the subject is broken and they love the subject.

Identifying the limited aspects of the implemented program will be a guide for future similar studies. Some of the student's views on the limited aspects of the applied program are as follows:

K11: Some games were long so I got bored. My favorite games are barking dog, candy jars

K8: There were two games that I liked in today's lesson, these are the barking dog and the 2-step equation-solving game. But most of the other games were unfinished, the time was not enough. What we covered in the lesson was difficult but fun.
K3: The lesson was fun, but I had trouble at the beginning of the lesson because I ran out of battery. Some people had to wait as most people had the same problem. But when we use technology, lessons are a lot of fun. Especially the last 2 tests were a lot of fun. I didn't understand the equations last year, it seems so easy this year.

Students' views on the limitations of the program were reported as limitations on the content of the games, technology-based experiences, and limitations on time.

The results showed that making the content enjoyable had an impact on breaking down students' preconceptions about the subject.

DISCUSSION, CONCLUSION AND RECOMMENDATIONS

In this study, the effect of digital gamification-supported instruction on attitudes and anxiety levels towards mathematics courses was investigated. The research found that the program had a positive effect on the gifted students' attitude scores, but not on their anxiety scores. As a result of the research, an increase was observed in students' interest and study scores towards mathematics. According to the meta-analysis study of Fadda et al. (2022), teaching based on digital games was found to be effective tools compared to traditional teaching. This research result is similar to the result of Musan (2012) mentioned in the literature. In the studies, it was concluded that digital technologies increased the attitude scores towards mathematics, but no significant difference was observed (Çankaya & Karamete, 2008; Şataf, 2010; Karakış, 2014; Yemen, 2009). The reason why the results of the research differ may be due to the differences in the selected digital technologies, subjects, measurement tools and research methods. Digital gamification was found to have a moderate effect on attitudes as a result of this research. Furthermore, digital gamification was effective in reducing gifted students' equation bias. Similarly, the meta-analysis study of Öztop (2023) shows compatibility with this research result. Mathematics success percentages did not differ significantly according to the groups. In the studies, it was concluded that digital-based applications in the education of gifted students support students' high-level thinking skills, prepare an environment that enables students with mathematical abilities to progress at their own pace, motivate them, and increase their mathematical success (Tosunoğlu, 2021).

According to the Wilcoxon test analysis, no significant difference was found in the pre-test and post-test scores of students' anxiety towards mathematics courses. Although there was no significant difference between the students' pre-and post-test results after the digital gamification-based program, it was observed that their anxiety levels about the maths course were reduced. The result of this study is in parallel with Barçın (2019) and Cengiz (2017) in the literature. It can be said that maths anxiety, which is an affective trait, depends on many factors, and observing its change through digital gamification requires a longer period of time. In their diary entries, students reported that the lessons were productive, fun and enjoyable, that they learned faster, and that their preconceptions about the subject were broken down. In the lessons where digital gamification was used, it was observed that some of the students in the experimental group were more enthusiastic about the lesson, asked more questions, collaborated more with their peers in the game and were more willing to learn the subject. Therefore, this situation may be one of the reasons that positively influences the students' attitude towards the subject and reduces their anxiety.

After the traditional instruction, it was observed that the mathematical anxiety scores of the students in the control group increased. The reason for this situation can be explained by the fact that the subject of equations in the literature is difficult to understand and frequently made mistakes (Dede et al, 2002; Pomerantsev & Korosteleva, 2003; Şandır et al, 2007). Daily records of the experimental group are also in support of this information. For this reason, and based on the literature, there is a need for a differentiated and enriched educational program that meets the interests and needs of gifted students (Ataman, 2004; Özyaprak, 2016). In teaching this subject, technology-based applications and digital gamification-based teaching can be used.

There was no statistically significant difference between the attitudes towards mathematics and anxiety posttest scores of the experimental and control groups (p>.05). It was observed that the anxiety scores of the experimental group were higher and attitude scores were lower than the control group. The fact that there was no random assignment while forming the groups and the groups were not matched may have affected the emergence of this result. Due to the weak experimental design of the study, the differences between the groups are not expected to show a strong cause-effect relationship (Büyüköztürk et al., 2022). It is seen that the groups were different in terms of anxiety and attitude scores before the application. The difference in post-test scores may be due to the inhomogeneity of the groups. The fact that the groups are not homogenous makes it difficult to interpret the attitude and anxiety scores between the groups after the application.

Students' post-test scores in the experimental group showed no significant difference according to the duration of technology use in teaching (p>.05). The attitude and interest scores of the students who used 1-3 hours were higher than the students who used less than 1 hour. A game is a system in which players engage in an abstract challenge that involves rules, interaction, challenge, and feedback, resulting in measurable outcomes and often evoking an emotional response (Kapp, 2012). It has been concluded that feedback from digital gamification components attracts students' interest, and components such as awards and badges make students more fun and happy (Çağlar & Kocadere, 2015; Meşe & Dursun, 2018). These components in the game system can be effective in students' continuation of the game. In addition, due to the content of technological applications and games, it takes a certain amount of time to understand the task, find the rule, and get used to the gamification method. The fact that the post-test scores of the students who used 1-3 hours were higher can be explained by the fact that the applied program was carried out for 3 lesson hours (120 minutes) per week.

This research is limited to 15 lesson hours based on digital gamification and digital games used in the teaching process. By eliminating the limitations of this research, research can be conducted in accordance with the experimental method by using mathematics software tools in teaching mathematics subjects. Sample applications, digital games, high-level thinking skills, and problem situations in which mathematics is associated with other disciplines can be presented to gifted students in mathematics teaching. According to the results of this research, teaching based on digital gamification had a significant positive effect on children's attitudes towards mathematics and helped to break their prejudices towards the subject. Teachers should prepare enriched programs on subjects that can be taught based on digital gamification in mathematics and digital. It can be suggested that they participate in seminars, and in-service training and improve themselves in order to complete their deficiencies in applications. It can be suggested to include courses for the applied teaching of technological tools that will enrich the mathematics course in the undergraduate mathematics education program.

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