



The Relationship Between Academic Achievement in Mathematics Course, Academic Procrastination, Digital Game Playing Motivation and Problem-Solving Skill of Middle School Students

Ortaokul Öğrencilerinin Matematik Dersi Akademik Başarıları ile Akademik Erteleme Davranışı, Dijital Oyun Oynama Motivasyonları ve Problem Çözme Becerileri Arasındaki İlişki

Saghar Nabdell, Nuri Can Aksoy, Cengiz Çınar

ABSTRACT

The aim of this study is to examine the predictive levels of middle school students' academic achievements in mathematics in relation to their problem-solving skills, academic procrastination behaviors, and motivation for playing digital games. In this research, a quantitative research method, specifically the correlational survey model, was employed. A total of 1074 participants continuing their education in middle school were reached within the scope of the study. Data collection tools included scales for digital game playing motivation, academic procrastination, and problem-solving skills. Report card grades were evaluated for students' academic achievements. The findings of the research indicate that success is directly predicted by problem-solving skills and that academic procrastination and motivation for playing digital games mediate the effect on success.

ÖZ

Bu araştırmanın amacı ortaokul öğrencilerinin matematik dersindeki akademik başarılarının, problem çözme becerileri, akademik erteleme davranışları ve dijital oyun oynama motivasyonları ile yordama düzeylerinin incelenmesidir. Bu çalışmada, nicel araştırma yöntemlerinden ilişkisel tarama modeli kullanılmıştır. Araştırma kapsamında ortaokulda öğrenimine devam eden 1074 katılımcıya ulaşılmıştır. Veri toplama araçları dijital oyun oynama motivasyonu, akademik erteleme ve problem çözme becerilerine yönelik ölçekler kullanılmıştır. Öğrencilerin akademik başarıları için karne notları değerlendirilmiştir. Araştırmanın bulguları başarının problem çözme becerisi tarafından doğrudan yordama etkisine sahip olduğunu, akademik erteleme ile dijital oyun oynama motivasyonunun başarıya aracılık etkisi olduğunu göstermektedir.

Author Information

Saghar Nabdell

Ph.D. Student, Gazi University,
Ankara, Türkiye
saghar.nabdell@gmail.com

Nuri Can Aksoy

Assoc. Prof. Dr., Hasan Kalyoncu
University, Gaziantep, Türkiye
ncan.aksoy@hku.edu.tr

Cengiz Çınar

Prof. Dr., Gazi University, Ankara,
Türkiye ccinar2525@gmail.com

Article Information

Keywords

Digital game
Motivation
Problem solving
Academic Procrastination
Middle school students

Anahtar Kelimeler

Dijital oyun
Motivasyon
Problem çözme
Akademik erteleme
Ortaokul öğrencileri

Makale Geçmişi

Arrival : 10/11/2023

Editing : 03/12/2023

Acceptance : 18/12/2023

For Attribution: Nabdell, S., Aksoy, N. C. & Çınar, C. (2023): Ortaokul öğrencilerinin matematik dersi akademik başarıları ile akademik erteleme davranışı, dijital oyun oynama motivasyonları ve problem çözme becerileri arasındaki ilişki. *JRES*, 10(2), 224-236. <https://doi.org/10.51725/etad.1383827>

Etik Bildirim: Çalışmanın etik kurul izni Gazi Üniversitesi Eğitim Bilimleri Enstitüsü etiği kurulu, 25.01.2022 tarih ve 02 sayılı kararı ile alınmıştır.

Introduction

Mathematics is perceived as a challenge for students throughout their educational lives. (Gürbüz, Toprak, Yapıcı & Doğan, 2011). Many studies have been conducted to identify the source of this perceive (Baker, 1996; Baki & Kutluca, 2009; Dikici & İşleyen, 2004; Durmuş, 2004; Tatar, Okur & Tuna, 2008; Tall & Razali, 1993; Zachariades, Christou & Papageorgiou, 2002). For instance, Tall and Razali (1993) conducted studies to identify learning difficulties in mathematics. They concluded that individuals who perceive learning conceptually face fewer learning difficulties compared to those who perceive it operationally. In mathematics education, mathematics is considered a discipline that inherently involves abstract concepts, and generalizations, yet it also encompasses real-world examples that can be related to, emphasizing analytical thinking. When considering this discipline from a student's perspective, it is evident that there are some difficulties encountered in the learning process, understanding abstract concepts, and working with these concepts (Umay, 1996; Zafran, 2010). To overcome these challenges, especially in primary and middle school, various teaching methods and techniques should be diversified to visualize and concretize the concepts. One of these methods and techniques is using games.

Games, which are a source of entertainment for children, have a significant impact on the educational and instructional process. In the education of children, the most suitable method and technique in terms of age and developmental level is the game, which represents learning through enjoyment (Toraman, Çelik & Çakmak, 2018). Educational games are games that reinforce learned knowledge and enhance mental abilities, enabling the review of what has been learned in cheerful and relaxed environments, bringing a change to classroom activities (Demirel, 1999). Game-based learning environments offer significant advantages to both educators and learners. Educators can utilize the intrinsic motivation to play games, which is especially dominant in children but present in individuals of all age groups, as a means to achieve educational goals (Taşdemir, 2007). Such a learning environment not only enhances students' skills but also provides them with the opportunity to have a good time (Akin & Atıcı, 2015).

It can be stated that digital games have various positive effects on mental and psychological aspects such as acquiring computer literacy, perception, attention, spatial abilities, hand-eye coordination, imagination, quick problem-solving, explaining the causes of shapes, visualizing objects related to chemistry and physics, and integrating shapes in space (Cesarone, 1994; Horzum et al., 2008). Digital game-based learning (DGBL) emerged in the early 1990s with the integration of educational technology into learning environments. DGBL began to be used as a method for enhancing instructional practices while increasing student engagement in the use of educational technology (Asmundis et al., 2015). The introduction of digital games into our lives has been met with both positive reactions and concerns.

Academic Procrastination Behavior and Mathematical Skills

Spending too much time on digital games, a decrease in the time allocated for studying, and exhibiting extreme reactions when interrupted during gameplay pose various bio-psycho-social risks for children (Taylan, Kara & Durğun, 2017). Parents and teachers, in particular, may have concerns that playing digital games could lead students to exhibit academic procrastination behavior. Due to this concern, parents do not want elementary and middle school students to engage in play, especially digital gaming. In particular starting from the 6th grade, due to the high school entrance exams held in Turkey, students are encouraged by their parents and teachers to study for exams outside of school as

well. Therefore, parents do not deem it appropriate for students to engage in play. Parents and teachers may have the belief that when children play, their academic achievements may decline due to academic procrastination. Academic procrastination behavior is typically defined as an irrational tendency to postpone the initiation or completion of academic tasks until the next day (Senecal et al., 2003). The academic procrastination, identified as the most significant factor negatively impacting a student's success, reduces the efficiency of learning and lays the groundwork for academic failure (Ferrari et al., 1995). It can be thought that individuals displaying procrastination behavior may also be distant from deliberate, goal-oriented exploration in problem-solving.

Problem-solving is generally defined as a conscious exploration conducted to reach a clearly designed but not immediately attainable goal in a scientific matter (Özsoy, 2005). In mathematics, problem-solving is the process of eliminating a problem, inherent in the structure of mathematics, through mental processes (reasoning) by utilizing the necessary information and performing operations (Altun, 1995, p.3). Problem-solving can contribute to the development of cognitive strategies in a child while learning mathematics (Yıldızlar, 1999, p.36). In his study, Yang (2012) emphasizes that DGBL is clearly effective in improving students' problem-solving skills.

Digital game

A digital game is a system consisting of computer software that interacts with interfaces such as a monitor, mouse, keyboard, or joystick, and it has rules and objectives (Kayalı, 2011). A digital game is a game that is programmed with various technologies and allows users to make user inputs along with a visual environment (Çetin, 2013). These games, programmed with various software and utilizing different technologies, are classified into digital console games, computer games, and online games depending on the technology used (Gökçearslan & Durakoğlu, 2014).

Game-based learning

According to Piaget, play is a tool that allows a child to develop their existing abilities and provides a foundation for acquiring many skills (Çakırcı, 2017). Game-based learning environments have a structure that helps students improve their skills and contain domain-specific knowledge patterns related to the subject matter they are designed for. In addition to providing students with an opportunity for enjoyable experiences, game-based learning environments also have an instructive and reinforcing feature within the activities that occur in the game.

Game-based math learning

Some topics and concepts can be quite challenging for students to learn, so new approaches and various theories (behavioral, and cognitive approaches) play an important role in making learning easier and ensuring retention in this field. In addition to these theories, another method that can facilitate learning, enhance the permanence of teaching, and make learning more enjoyable in education is games (Altun, 2005). Game-supported mathematics instruction is particularly useful, engaging, and beneficial for elementary and middle school students, given their age-related interest in games (Çakmak, 2000).

Digital game-based learning

According to Çetin (2013), Educational digital games are defined as games prepared with the help of technological tools, possessing cognitive, social, behavioral, and emotional dimensions, and designed to facilitate learning for a specific objective. The use of educational digital games in

educational environments has many benefits for students (Erekmekçi & Fidan, 2012; Kula & Erdem 2005; Prensky, 2001; Yağız 2007). It has been observed that digital games contribute to individuals' higher-level cognitive development, and problem-solving skills when faced with challenges, as well as enhancing advanced learning and empathy abilities (Yıldırım, 2016). Cömert (2020) suggested that problem-solving activities designed and implemented through the digital game-based learning method led to increased student motivation in class, aided learning, and made the process more enjoyable.

The Aim of Study

The general aim of this research is to examine the predictive levels of middle school students' academic achievements in mathematics based on their problem-solving skill, academic procrastination behaviors, and motivation to play digital games. In accordance with this main objective, answers have been sought to the following questions:

1. What is the level of achievement, problem-solving skill, academic procrastination, and motivation for playing digital games among middle school students?
2. Is there a mediating effect of academic procrastination and motivation for playing digital games in the prediction of middle school students' achievements by their problem-solving skills?

Method

Research Model

This research, which examines the impact of game-based learning on students' academic achievements, problem solving skill, academic procrastination behaviors, and gaming motivation, is based on a quantitative research approach, specifically utilizing a correlational survey model. The correlational survey model is used to reveal the relationship or effect between two different quantitative variables through a correlation coefficient (Fraenkel et al., 2012). Relational survey model, one of the quantitative research methods, was used in the study. The correlational survey model is a model designed to determine and examine the correlation between two or more variables.

Participants

This research was conducted with 1074 students enrolled in middle schools under the Ankara Provincial Directorate of National Education during the 2022-2023 academic year.

The distribution of participants according to certain demographic characteristics is provided in Table 1.

Table 1. Distribution of Participants According to Some Demographic Characteristics

Demographic Characteristics	n	%
Grade		
5	200	18.6
6	240	22.3
7	337	31.4
8	297	27.7
Digital Game Playing		
Yes	843	78.2

Frequency of Digital Game Playing	No	231	21.5
	Every day	83	7.7
	A few days a week	128	11.9
	Once a week	402	37.4
	A few days a month	261	24.3

According to Table 1 is examined, it can be seen that 18.6% of the participants are in the fifth grade, 22.3% are in the sixth grade, 31.4% are in the seventh grade, and 27.7% are eighth-grade students. Regarding the participants' digital game playing status, 78.2% answered 'Yes,' while 21.5% answered 'No.' Regarding the frequency of digital game playing, 7.5% of the participants play every day, 11.9% play several days a week, 37.4% play once a week, and 24.3% play several days a month.

Ethical Statement

This study was conducted in accordance with the approval of Gazi University Ethics Committee on 25.01.2022, with reference number 02.

Data collection

The measurement instruments used to collect data in the research have been addressed in the quantitative dimension of the study. The research collected data based on four variables. Middle school students' report card grades were used in the academic achievement variable of mathematics course. Data collection instruments for these variables included the Digital Game Motivation Scale, Academic Procrastination Behavior Scale, and one scale aimed at measuring Problem-Solving skill. Reliability and validity studies of the scales were conducted. The Digital Game Motivation Scale's construct validity was analyzed using the SPSS 23 software package, including KMO, Item-Total Test Correlation, EFA, and Cronbach Alpha analyses. Another analysis conducted to provide evidence for the construct validity of the scale is the Confirmatory Factor Analysis (CFA) performed using the Lisrel 8.8 program. The results of the analysis revealed that the scale items were grouped under three sub-factors. Furthermore, it is observed that the results obtained from the CFA analysis of the scale have sufficient fit indices. Based on the analyses conducted, it can be stated that digital game-based learning, consisting of 19 items and showing a three-factor structure, is a valid and reliable scale (Demir & Hazar, 2018). The Academic Procrastination Behavior Scale consists of 19 items developed in a 5-point Likert scale format, with items 15, 16, 17, 18, and 19 reverse-coded. The developed scale's Cronbach's alpha coefficients for its factors were calculated as 0.866 and 0.935, respectively, and the Cronbach's alpha coefficient for the overall scale was calculated as 0.946, indicating that the scale is reliable. According to the results of the confirmatory factor analysis, the goodness of fit was found to be $\chi^2/df = 1.926$, which is less than 3 (indicating excellent fit), and the RMSEA value was 0.056, which is less than 0.08 (indicating good fit) (Gürbüz & Karataş, 2019). Exploratory and Confirmatory Factor Analyses were conducted for PS, C, R, and Co scales to establish their construct validity, resulting in the emergence of PSBS consisting of 18 items and three factors; CSBS consisting of 15 items and three factors; RSBS consisting of a single factor with 19 items; and CoSBS consisting of 8 items grouped under two factors (Özpinar, 2012).

Data collection process

The study has been approved by the Gazi University Ethics Committee. The classification, duplication, and collection of the scales to be used in the research were carried out by the researcher. The prepared scales were implemented in all grade levels of the specified middle schools, where research was permitted, in a face-to-face manner during the 2022-2023 academic year. Data was collected over an approximately 6-month period.

Data analysis

1074 participants were reached in the scope of the study. In order to decide which statistical techniques would be used to answer the research questions, missing values and outliers were first examined. The negative items (DOM15, DOM16, DOM17, DOM18, and DOM19) were reverse-coded. It was observed that there were missing values in the dataset. Mean imputation was performed. An outlier examination was conducted. For univariate outliers, the scores on the scale were converted to Z-scores, and values from 23 individuals that fell outside the range of -3 to +3 were removed from the dataset. Mahalanobis scores were calculated for multivariate outliers, and it was observed that there were no values below 0.01. After removing the outliers, the analysis continued with data from 1074 individuals.

To decide which statistical techniques would be used to answer the research questions, a Kolmogorov-Smirnov test was conducted to assess the normality of the data. Histogram plots and skewness and kurtosis values were examined.

Findings

1. Examining the levels of middle school students' achievement, problem-solving skill, academic procrastination behaviors, and digital game playing motivations.

The levels of middle school students' achievement, problem-solving skill, academic procrastination behaviors, and digital game playing motivations are presented in Table 2.

Table 2. The levels of middle school students' achievement, problem-solving skill, academic procrastination behaviors, and digital game playing motivations

Scale/ Dimension	n	\bar{X}	S	k	\bar{X}/k	Decision
<i>Achievement</i>	1074	6.46	2.15			
<i>Academic Procrastination</i>	1074	30.33	12.37	19	1.60	Very Low
<i>Irresponsibility and Choice</i>	1074	9.98	4.25	6	1.66	Very Low
<i>Environment and Feelings</i>	1074	20.35	8.76	13	1.57	Very Low
<i>Digital Game Playing Motivation</i>	1074	54.57	14.44	19	2.87	Intermediate
<i>Success and Revival</i>	1074	13.91	4.71	5	2.78	Intermediate
<i>Curiosity and Social Acceptance</i>	1074	26.15	9.91	9	2.91	Intermediate
<i>Uncertainty in Game Request</i>	1074	14.16	5.70	5	2.83	Intermediate

<i>Problem Solving Skill</i>	1074	46.79	13.15	18	2.60	Low
Understanding	1074	10.56	3.32	4	2.64	Intermediate
Application	1074	15.56	4.68	6	2.59	Low
Evaluation	1074	20.68	5.57	8	2.59	Low

When Table 2 is examined, it can be stated that the participants' levels of Academic Procrastination are very low, while their levels of Problem-Solving Skills, Digital Game Playing Motivation, Achievement, Communication Skills, and Correlation Skills are moderate.

2. Is there a mediating effect of academic procrastination and digital game playing motivations in predicting middle school students' achievements by problem-solving skill?"

In order to answer the research question, structural equation model mediation analysis was conducted. The schematic representation of the model is provided in Figure 1.

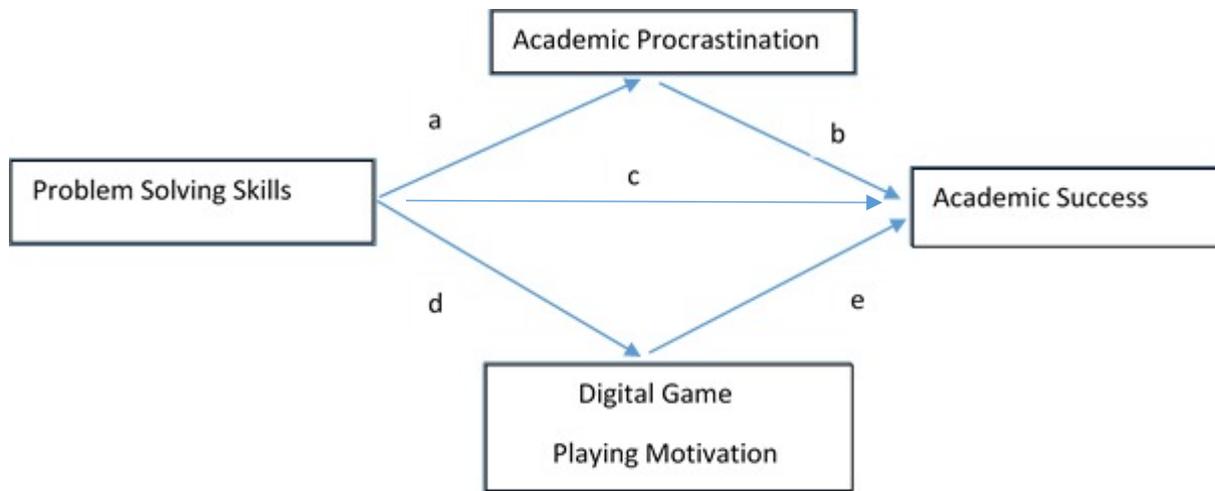


Figure 1. Model of the Mediating Effect of Academic Procrastination and Digital Game Playing Motivation in Predicting Achievement by Problem-Solving Skill.

As seen in figure 1, "c" represents the direct effect in predicting achievement by problem-solving skill. "a" represents the prediction of problem-solving skill by academic procrastination, and "b" represents the prediction of achievement by academic procrastination.

In addition, $a*b$ represents the mediating effect of academic procrastination in predicting achievement by problem-solving skills. "d" represents the prediction of problem-solving skills by digital game playing motivation, and "e" represents the prediction of achievement by digital game playing motivation. Additionally, $d*e$ represents the mediating effect of digital game playing motivation in predicting achievement by problem-solving skills.

Regression models are provided in Table 3.

Table 3. Regression Model

Way	Guess	Error	z Value	p
c	0.074	0.005	16.096	0.000
a	-0.256	0.028	-9.277	0.000
b	-0.011	0.005	-2.302	0.021
d	-0.162	0.033	-4.895	0.000
e	-0.008	0.004	-2.036	0.042

$R^2 = 0.234$ (Model), $R^2 = 0.074$ (Academic procrastination), $R^2 = 0.022$ (Digital game playing motivation)

When Table 3 is examined, it can be seen that all paths are significant predictors. When the model is evaluated as a whole, approximately 23.4% of the variance in achievement is explained by the model. Problem-solving skills explain 7.4% of the variance in academic procrastination, and problem-solving skills explain 2.2% of the variance in digital game playing motivation. The significance of the mediation effects is provided in Table 4.

Table 4. Mediation Effect Test Results

Way	Guess	Error	z Value	p
a*b	0.003	0.001	2.234	0.025
d*e	0.001	0.001	1.880	0.060

When examining Table 4, it can be observed that "a*b" is significant ($p < .05$), while the "d*e" path is not significant ($p > .05$). According to this, in predicting achievement through problem-solving skills, academic procrastination shows a significant mediating effect, while digital game playing motivation does not show a significant mediating effect.

Discussion, Conclusion and Recommendation

The main objective of this research was to examine the relationships between middle school students' academic achievements, problem-solving skills, academic procrastination behaviors, and digital gaming motivations. According to this research, the participants' levels of academic procrastination are very low, their problem-solving skills are low, and their levels of digital gaming motivation and academic achievement are at a moderate level. In the literature, there are studies indicating positive outcomes of digital games on mathematics education. Öndeş (2022), in their study, found a positive relationship between the math achievement and math motivation of 3rd and 4th-grade elementary school students. However, they also identified a negative relationship between digital game addiction and math motivation and math achievement. Similarly, Go et al. (2022) conducted a study with university students and found that digital games improved students' fundamental math skills. On the other hand, in game-based environments, students often create their own problems and gather the necessary information to solve them (Bottino et, 2006; Ebner & Holzinger, 2007). In contrast to these studies, Ağırçöl (2020) found in her research that the use of educational digital games in science classes had a positive impact on students' academic success and also positively influenced retention. However, she also pointed out concerns that students might experience academic procrastination due to their desire for more visuals and a continuous desire to play. Additionally, according to Yalçın (2023), there

are positive and significant relationships between academic procrastination, digital game addiction, and academic motivationlessness variables. Furthermore, digital game addiction has a positive direct impact on academic procrastination, and it is also a significant predictor of academic procrastination. It is evident in this study that success is directly predicted by problem-solving skills. In this study that academic procrastination mediates the relationship between success and problem-solving skills. Furthermore, digital game-playing motivation serves as a mediator in predicting success based on problem-solving skills. The direct prediction of success by problem-solving skills is indeed one of the key findings of this research. Also, there is an indirect effect of academic procrastination and digital gaming motivation on the prediction of middle school students' success through their problem-solving skills. When the literature in the field is reviewed, it can be observed that the results of this study are in line with previous findings, providing qualitative support for the conclusions drawn in this research. Özsoy (2005) found a significant and positive relationship between the mathematics achievement and problem-solving skills of 5th-grade primary school students. İlhan, Gemcioğlu and Poçan (2021) found a significant positive relationship between middle school students' perceptions of problem-solving skills, mathematics attitudes, and mathematics achievement in their study. While no research explaining the relationship between digital game-playing motivation, problem-solving, and academic achievement has been encountered, Çetinkaya (2019) found in their study that mobile-based applications, when used as assistive technology in education, had a positive impact on increasing student achievement and developing positive attitudes after problem-based learning processes. In contrast to this study, Demir and Kutlu (2017) discussed internet addiction, and they found that as internet addiction increased among adolescents, academic procrastination also increased, and as academic procrastination increased, academic achievement decreased. Another study that supports this research is by Mohd et al. (2011), which reflects a significant relationship between attitude towards problem solving (patience, confidence, and willingness) and mathematics achievement. Kuş (2023) found in their study that digital game addiction is influenced by achievement and revitalization motivation as well as curiosity and social acceptance motivation. They concluded that both intrinsic and extrinsic motivations have a direct impact on digital game addiction. The results of this research, which aimed to investigate the relationship between middle school students' motivation to play digital games in mathematics class and their academic achievement, academic procrastination behavior, and skills, are provided below:

1. In light of the results obtained, it can be observed that academic procrastination levels are very low, problem-solving skills are low, digital game-playing motivation and achievement levels are at a moderate level.

2. Another result of the research is that mathematics achievement is directly predicted by problem-solving skills, and academic procrastination and digital game-playing motivation mediate the effect on achievement.

Researchers can further investigate whether the digital games, which are highly popular among today's digital natives, have an impact on their mathematics achievements. Studies examining the relationship between digital gaming motivation and mathematical achievement prediction can also be recommended.

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Yazarların Katkı Oranı Beyanı

Bu araştırmanın planlanması, yürütülmesi ve yazılı hale getirilmesinde yazarların katkıları eşit orandadır.

Destek ve Teşekkür Beyanı

Bu çalışmada hiçbir kurumdan destek alınmamıştır.

Çatışma Beyanı

Araştırmacıların araştırma ile ilgili diğer kişi ve kurumlarla yaşanabilecek herhangi bir çıkar çatışması bulunmamaktadır.

Etik Bildirim

Bu çalışma Gazi Üniversitesi Etik Kurulu'nun 25.01.2022 tarih ve 02 sayılı onayı doğrultusunda gerçekleştirilmiştir.