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From Play to Concentration: The Effect of Digital Educational Games on Preschool Children's Attention Skills

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Abstract

The purpose of this study is to determine the effect of a digital educational game application on the attention skills of 5-6-year-old children. The research, planned with a quasi-experimental design and pretest posttest control groups, measured children's attention skills using the 'Concentration Test for Five-Year-Old Children' (Frankfurter Test Für Funjahrige Konzentration–FTF-K). The study used the MentalUp application, a digital educational game designed to improve the attention skills of preschool children. Sixteen different types of mini-games supporting 13 different attention skills were included in the study. A total of 40 children aged 5-6 years were divided into two groups based on gender. The preschool children were instructed to complete the application in a quiet classroom environment following a pre-posttest design. The results indicated that the digital educational game application significantly improved the children's attention skills. While there was no significant change from pre to posttest scores for the control group, the attention skills of the children in the experimental group were positively affected. The findings extend the current knowledge on attention skills in preschool children, highlighting the necessity of incorporating digital educational games into classroom practices to support attention skills at an early age. This study also provides valid evidence for the dissemination of digital educational games among preschool children.

Keywords: Preschool education, digital educational game, attention skills, concentration.

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Oyun Oynamaktan Odaklanmaya: Dijital Eğitsel Oyunların Okul Öncesi Çocukların Dikkat Becerilerine Etkisi

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Öz

Bu çalışmanın amacı dijital eğitsel oyun uygulamasının 5-6 yaş çocukların dikkat becerileri üzerine etkisini belirlemektir. Yarı deneysel desende ve ön test-son test kontrol gruplu olarak planlanan araştırmada çocukların dikkat becerileri "Beş Yaş Çocukların Dikkat Toplama Testi" (Frankfurter Test Für Funjahrige Konzentration–FTF-K) ile ölçülmüştür. Bu çalışmada okul öncesi çocukların dikkat becerilerini destekleyecek dijital eğitim oyunu olan MentalUp uygulaması kullanılmıştır. Okul öncesi çağındaki çocukların dikkat becerilerini geliştirmek için 13 farklı dikkat becerisini destekleyen 16 farklı türde mini oyun çalışmaya dahil edilmiştir. 5-6 yaş arası 40 çocuk cinsiyetlerine göre iki gruba ayrılmıştır. Okul öncesi çocukların önson test tasarımı doğrultusunda uygulamayı sınıfta sessiz bir ortamda tamamlamaları istenmiştir. Sonuçlar, dijital eğitsel oyun uygulamasının çocukların dikkat becerilerini önemli ölçüde geliştirdiğini göstermektedir. Kontrol grubunda yer alan çocukların öntest-sontest puanları arasında anlamlı bir değişiklik görülmezken, deney grubunda yer alan çocukların dikkat toplama becerileri olumlu etkilenmiştir. Elde edilen sonuçlar, okul öncesi çocuklarda dikkat becerileri ile ilgili mevcut bilgileri genişleterek, erken dönemde dikkat becerilerinin desteklenmesinde dijital eğitsel oyunları sınıf uygulamaları içerisine dahil etmenin gerekliliğini vurgulamaktadır. Bu çalışma aynı zamanda okul öncesi çocuklarda dijital eğitsel oyunların yaygınlaştırılması konusunda da geçerli kanıtlar sağlamaktadır.

Anahtar Sözcükler: Okul öncesi eğitim, dijital eğitici oyun, dikkat becerileri, dikkati toplama.

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Introduction

The rapid growth in information and communication technologies in the 21st century, along with digital transformation, has provided today's children with unprecedented access to information, individuals, and ideas (Arnott & Yelland, 2020; Marshall, 2016; Verenika et al., 2016). This swift development and changes in technology have significantly altered children's perceptions of play. Digital games have become among the most preferred types of games among children (Palfrey & Gasser, 2008). With the widespread adoption of touchscreen technology, children are now being introduced to screen-based media devices such as tablets, phones, and computers from a very young age. Many games, available under the name of "apps" on these technological devices, have become accessible to children of all age groups, starting from infancy (Hirsh-Pasek et al., 2015). Research indicating an increasing interest in digital games, with children spending more time in front of screens playing these games (Arnott, 2013; Kabali et al., 2015; Mustafaoğlu et al., 2018) documents the consequences of this trend.

During the preschool period, children show great interest in digital educational games. However, research findings reveal that non-educational digital games, when engaged with for prolonged periods, negatively affect children's developmental areas (Bluemke et al., 2010; Gentile et al., 2012; Lillard & Peterson, 2011), while educational digital games encourage children to learn and create, thereby enhancing their motivation (Behnamnia et al., 2020; Castellar et al., 2015; Connolly et al., 2012; Fleer, 2014), improve cognitive thinking (Fitriyadi & Wuryandani, 2021; Johnson et al., 2011; Xiong et al., 2022), language development (Amorim, 2022; Blanchard & Moore, 2010; Neumann, 2018), fine motor skills development (Lee et al., 2013), concept acquisition (Scaife & Rogers, 2005; Zaranis & Alexandraki, 2019), and enhance academic and mathematical skills (Griffith et al., 2020). In this context, it is crucial to offer digital games to children that are age-appropriate and match their developmental needs (Bers, 2010; Bozkurt, 2014; Hamilton et al., 2020; Johnson & Dinger, 2012). It is also possible to talk about the effects of digital games that affect children's development areas positively or negatively on children's attention development.

Attention is a multifaceted feature that significantly influences all cognitive areas such as perception, memory, and learning (Posner & Patoine, 2009). Although basic attention skills start to develop during the first year of infancy, skills like directing attention and using strategies reach their peak at age six (Mulder et al., 2009). Experimental studies demonstrate how attention develops with age (Ruff et al., 1998; Steele et al., 2012). When children's achievements are below expectations, it is believed that they may have attentional difficulties (Wagner, 1991). Therefore, the observability of attentional problems during the school period highlights the importance of interventions aimed at developing attention from early stages (Rothbart & Posner, 2015). Research on attention training programs shows that they include a wide range of activities and practices such as focusing, perceptual constancy, figure-ground perception, visual scanning, alertness, selective attention, divided attention, and inhibitory control (Bıyıklı et al., 2020; Yavuz, 2014). Results indicate that attention training programs, supported by these activities and practices, improve children's attention skills (Bıyıklı et al., 2020; Ettrich, 1998; Lauster, 1999; Seçer & Özmen, 2015; Yavuz, 2014). Ettrich (1998) and Lauster (1999) mentioned that activities such as directing attention towards a target object or situation and answering questions related to the object or situation, as well as identifying similarities and differences between objects or situations, are also effective in enhancing attention.

The development of attention and overall cognitive capacity is possible through the training of neural networks, and the brain uses optimized pathways of neural networks for different functions while performing complex tasks (Rueda et al., 2005). These functions can be developed using activities such as computer-based interventions (Hitchcock & Noonan, 2000; Rueda et al., 2012) and digital educational games focusing on cognitive development (Connolly et al., 2012; Eichenbaum et al., 2014; Palaus et al., 2017; Ramos & Melo, 2018). Studies have indicated that computer-based tasks and digital educational game applications have the potential to support children's cognitive development (Boot et al., 2008; Diamond & Lee, 2011; Eichenbaum et al., 2014; Feng et al., 2007; Lieberman et al., 2009; Neumann & Neumann, 2013; Xiong et al., 2022).

The literature highlights a lack of research focusing on the role of digital games in supporting children's learning processes (Papadakis & Kalogiannakis, 2020). Current literature shows that studies

evaluating the impact of digital educational games on the development of children and adolescents are generally focused on elementary, middle, and high school levels (Ağırgöl et al., 2022; Bilgin, 2021; Chen & Wu, 2023; Efendi, 2022; Homer et al., 2018; Hussein et al., 2019). Contrary to previous academic studies, research on the effects of digital educational games on the attention skills of preschool children is quite limited (Gözüm & Kandır, 2020; Liu et al., 2021). Considering the importance of attention skills at early ages, understanding the potential contributions of digital educational game applications to children's development during this period is critical. Therefore, this study aims to examine the impact of digital educational game applications on the attention skills of children in the preschool period. In line with this objective, the following questions have been addressed:

1. Do digital educational games have a positive effect on the attention skills of preschool children?

2. Is there a change in the attention skills of children in the control group, who do not play digital educational games, during the educational program?

Method

Research Design

This study utilized a quasi-experimental design with pretest-posttest control groups to investigate the influence of digital educational game applications on the attention development of children. This design involves dividing the groups to be included in the study into two, experiment and control groups, through an unbiased assignment (Büyüköztürk et al., 2017). Before the application, the data collection tool for the dependent variable was applied to both groups. Then, while the experimental procedure was applied to the experiment group, no intervention was made to the control group. Finally, measurements related to the dependent variable were obtained again from both groups, using the same data collection tool (Büyüköztürk et al., 2017; Creswell, 2003).

The research design is visualized in Table 1.

Table 1. *Pretest-posttest control group quasi-experimental design*

	Group	Pretest	Intervention	Posttest
40 randomly selected children	**Experimental**	**O_1**	**X**	**O_3**
	20 children	(FTF-T)		(FTF-K)
	Control	**O_2**		**O_4**
	20 children	(FTF-K)		(FTF-K)

In evaluating the attention skills of children in both the experimental and control groups, the FTF-K was used as a pretest, followed by playing attention games through the digital educational game application with the children in the experimental group. After the application, the data collection tool used in the pretest was reapplied as a posttest, and test scores were evaluated to determine the effect of the training.

Research Sample

The study included two classes of children aged 5-6, who were attending an independent kindergarten in the Konyaaltı district of Antalya during the 2023-2024 academic year. As the research was designed with a quasi-experimental design, the classes were determined and the equivalence of the groups was controlled. The results of the Mann-Whitney U test analysis, conducted to evaluate the equivalence between the groups, are presented in Table 2.

Table 2. *Results of the Mann-Whitney U test for the pretest scores of the FTF-K*

Groups	n	Mean rank	Sum of ranks	u	Z	p
A	20	17.00	340.00	130.00	-1.904	.057
B	20	24.00	480.00			

Table 2 shows that the difference in average scores obtained from the pretest by the classes included in the study group (Z= -1.904, $p > .05$) is not significant, indicating that the groups are homogeneous, meaning they can be considered equivalent. Group A was randomly designated as the experimental group and Group B as the control group. The gender distribution in the experimental and control groups was equalized to 10 girls and 10 boys in both groups and the experimental group, 40.9% of the children were 5 years old (M_{age}=5.55, SD=0.51); 27.3% of the children in the control group (M_{age}=5.7, SD=0.47). were 5 years old.

Research Instruments

Demographic Information Form

This form, prepared by researchers, contains identifying questions regarding the children's names, gender, and chronological ages.

Concentration Test for Five-Year-Old Children' (Frankfurter Test Für Funjahrige Konzentration–FTF-K)

The test was developed by Raatz & Möhling (1971) and is designed to measure the attention skills of children aged 5-6 years. In this individually administered test, children are presented with a mix of apples and pears, and the total number of pears drawn within 90 seconds determines the raw score of the test. The test includes a 'corrected score' table based on the child's chronological age and gender, from which the test score is derived.

A reliability study of the test was conducted in 1969 with 100 children from 20 nurseries, and the reliability coefficient was determined as .79 using the test-retest method. In 1971, to determine the reliability of the test, a study was conducted over a three-week period with 29 children in two nurseries, resulting in a reliability coefficient of .85 using the 'test-retest' method (Raatz & Möhling, 1971). Between 1970-1971, a standardization study of the test was conducted with 1170 children in various provinces of West Germany. In 2018, a study conducted on Turkish children confirmed the test's reliability and validity (Gözüm & Kandır, 2018).

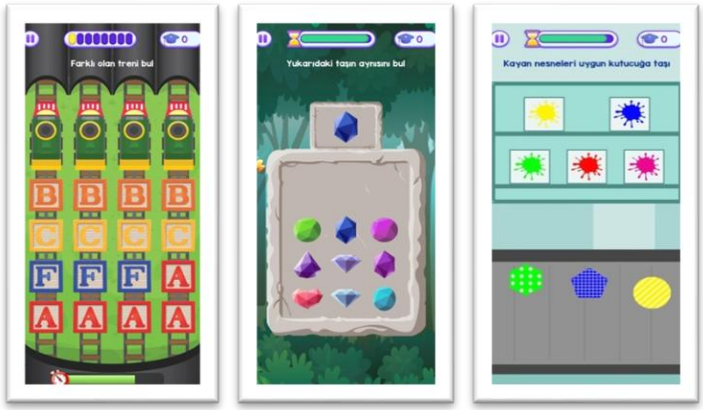
Research Process and Implementation

Pretest Application

FTF-K for five-year-old children was administered as a preliminary test to the children in the study group. Before proceeding with the test application, an introduction was made with the children to ensure they felt comfortable, engaging in conversation for this purpose. The test was conducted individually with the children, seated side by side, in a quiet environment that would not distract their attention.

Digital Educational Game Application

Following the preliminary test application, children in the experimental group were engaged with attention games available in the 5-6 age category on the MentalUp application. Supported by the Scientific and Technological Research Council of Turkey (TUBITAK) and Yıldız Technical University, the MentalUp application is a ganified educational program and includes intelligence games for early childhood. The app includes hundreds of games that improve children's skills such as attention, visual attention, focused attention, concentration, reaction control, problem solving, visual perception, mathematics, planning and organization. All games in the category of "attention games" in the app were selected. The game applications were scheduled twice a week, with two games played in each session. A total of 16 different game applications were carried out over four weeks. In order not to exceed the screen exposure time of children and to prevent possible negativities such as digital addiction, the application period was planned to be twice a week for 4 weeks. In addition, it was limited to 4 weeks in order to observe the short-term effect of the application. Sample screenshots from the game application are indicated in Figure 1.



Freight Trains Diamond Hunter Spot the Difference

Figure 1. *Sample screenshots from the games*

Figure 2 shows the implementation process of the attention games selected through the application according to the weeks and the skills that the games are based on.

Week	Application	Game	Skills											
			Visual Attention	Sustained Attention	Short-Term Memory	Visual Memory	Visual Scanning	Speed	Spatial Perception	Visual Tracking	Planning	Comparison	Focusing	Conceptualization
1. Week	1. Application	Chain Shot	✓				✓		✓					
		Flying Balloon	✓					✓			✓			
	2. Application	Freight Trains	✓				✓					✓		
		Catch Before Falling	✓									✓	✓	
2. Week	3. Application	Messy Room	✓			✓	✓							
		Hopping Frog		✓		✓				✓				
	4. Application	Spot the Difference	✓				✓					✓		
		Diamond Hunter	✓				✓					✓		
3. Week	5. Application	End of the Rope	✓							✓		✓		
		Lost Objects	✓			✓	✓							
	6. Application	Missed Balls	✓	✓									✓	
		Moving Conveyor Belt	✓	✓										✓
4. Week	7. Application	Space Warden	✓				✓					✓		
		Fire the Rocket	✓				✓					✓		
	8. Application	Find the Suspect	✓		✓		✓							
		Cat Family	✓	✓									✓	

Figure 2. *Implementation process of the games in practice and the skills based on the games*

The game interventions were carried out individually with the children and the children played games for 20-25 minutes in each application, 40-50 minutes per week. Visuals of the implementation process are given in Figure 3.

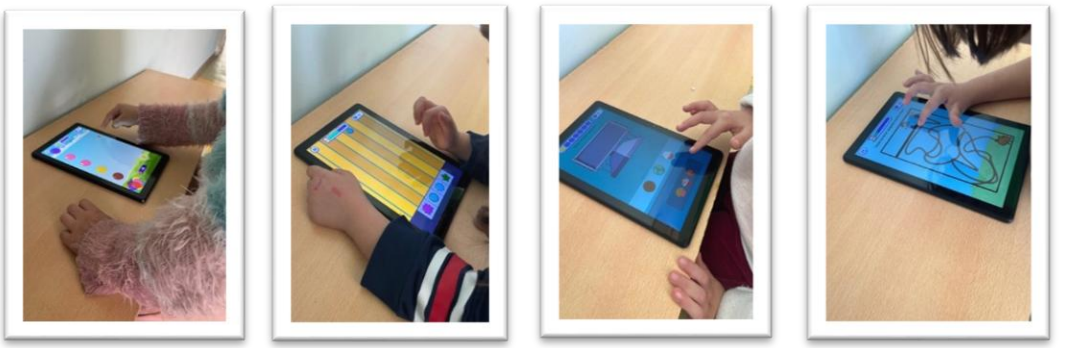


Figure 3. *Visuals on the implementation process*

Posttest Application

After the completion of the game application, the FTF-K was administered to the children in the study group as a posttest in the same environment and conditions as during the pretest application. The permanence of the training was evaluated by comparing the pretest scores of the children with the posttest scores.

Data Analysis

The data were analyzed using the SPSS 21 package program. In the comparisons of children's pretest and posttest scores, normality assumptions were first checked. Due to the sample size (n<30), the distribution of the data was tested with the Shapiro-Wilk normality test (Büyüköztürk et al., 2011). Table 3 shows the normality assumptions for the FTF-K pretest-posttest results.

Table 3. *Normality assumptions of data*

Scale	Measurement	Group	n	X̄	Skewness	Std. Error of Skewnesss	Kurtosis	Std. Error of Kurtosis	Shapiro Wilks
FTF-K	Pretest	Experiment	20	26.95	-1.073	.512	.124	.992	.004
		Control	20	29.65	-1.682	.512	4.323	.992	.013
	Posttest	Experiment	20	31.9	-363	.512	.029	.992	.664
		Control	20	28.7	-1.425	.512	3.292	.992	.029

Table 4 shows that the skewness and kurtosis values of the pretest and posttest scores for the control group did not remain within the normal distribution limits (+1.5, -1.5) and that the Shapiro-Wilks values for the experiment-control groups indicate the scores were not normally distributed ($p > .05$). Since the data did not exhibit a normal distribution, non-parametric tests were employed in the analysis of the tests. The Wilcoxon Signed-Rank Test was used to investigate the relationship between the pretest and posttest scores of the experiment and control groups, and the Mann-Whitney U Test was utilized to examine the relationship between the posttest scores of the experiment and control groups.

Ethical Procedures

The ethical committee report of the study was approved by Burdur Mehmet Akif Ersoy University board on November 1, 2023, with decision number GO 2023/522.

Results

The results of the Wilcoxon signed-rank test conducted to determine whether there was a significant difference between the pretest and posttest scores of the children in the experimental group are presented in Table 4.

Table 4. *Wilcoxon signed-ranks test results for the pretest-posttest scores of the children in the experimental group*

Posttest-Pretest	n	Mean Rank	Sum of Ranks	Z	p
Negative Rank	0	0	0	-3.728	.000
Positive Rank	18	9.50	171.00		
Ties	2	-	-		

Table 4 shows that there was a significant difference between the pre and posttest scores of the children in the experimental group (Z=-3.728, $p < .001$). The rank means and sums of the difference scores show that this difference was significant in favor of the post-test (posttest). This finding suggests that the digital educational game application may be effective in increasing children's attention skills.

The results of the Wilcoxon signed-rank test on whether there was a significant difference between the pretest and posttest scores of the children in the control group are presented in Table 5.

Table 5. *Wilcoxon signed-ranks test results for the pretest-posttest scores of the children in the control group*

Posttest-Pretest	n	Mean Rank	Sum of Ranks	Z	p
Negative Rank	11	10.68	117.50	-1.959	.051
Pozitive Rank	6	5.92	35.50		
Ties	3	-	-		

The analysis results in Table 5 show that there is no significant difference between the pretest and posttest scores of the children in the control group (Z =-1.959, $p > .05$).

The results of the Mann Whitney U test on whether there is a significant difference between the pretest and posttest scores of the children in the experimental and control groups are presented in Table 6.

Table 6. *Mann-Whitney U test results for the pretest and posttest scores of children in the experimental and control groups*

Groups	n	Pretest Mean Rank	Mean Rank	Sum of Ranks	u	Z	p
Experiment	20	17.00	23.43	468.50	141.500	-1.590	.057
Control	20	24.00	17.58	351.50			

Table 6 shows that the difference between the mean pretest scores of the children in the experimental and control groups was not significant (Z= -1.590 $p > .05$). When the rank averages of the children in the experimental group were analysed, it was observed that the posttest scores of the children in the experimental group were higher than those of the children in the control group, but when the rank averages of the children in the control group were taken into consideration, it was seen that there was a slight decrease in the posttest scores of some children in the control group compared to their pretest scores.

Discussion, Conclusion and Recommendations

This study examined the usability of digital educational games as an effective educational tool for developing preschool children's attention skills. The experiments and findings showed that digital educational game applications positively affected children's attention skills. These results addressed the shortcomings of previous studies and demonstrated that even short-term training can have significant effects on attention. A similar study by Liu et al. (2021) found that tablet applications with educational content improved children's creative thinking skills. Ramos and Melo's (2019) study also supported these findings by showing that digital game apps improved attention performance in Brazilian elementary school children. Another study conducted in different age groups found that 82 high school students' selective attention improved after 20 minutes of digital game practice per week for 6 weeks (Homer et al., 2018). Related studies and research findings emphasize that digital educational games can be used as an effective tool in attention development in preschool period. Digital educational games can be considered an effective and important tool in developing children's attention skills. The diversity of such educational methods and their availability from an early age can make a positive contribution to children's cognitive development.

Many studies examining the effects of digital games on cognitive performance generally present findings that these games increase children's cognitive performance (Boot et al., 2008; Eichenbaum et al., 2014; Feng et al., 2007; Homer et al., 2018; Lieberman et al., 2009; Miller & Robertson, 2010; Palaus et al., 2017). This study, which was based on the idea that digital educational games would support children's attentional skills, draws attention by limiting the duration of digital gaming and screen exposure. Previous research shows that increased digital game playing time can have a negative effect on children's attention test scores (Gözüm & Kandır, 2020; Lillard & Peterson, 2011). Mentalup application is an application that supports cognitive development areas with games for different age groups. The games in the category of "attention games" created for children aged 5-6 years were selected from the application. The applications were limited to 20-25 minutes with each child, taking care not to exceed the daily screen exposure time. In these aspects, it is thought that the digital game application has positive effects on children's attention development. Therefore, it is important to plan and limit digital games appropriately for children (Bers, 2010; Bozkurt, 2014; Hamilton et al., 2020, Johnson & Dinger, 2012). In addition, whether digital games are appropriate for children's developmental levels is also a topic of debate in the literature (Karaaslan, 2015; Kankaanranta et al., 2017; Monu & Ralph, 2016). The content in the MentalUp application selected for this study was determined to improve the attention skills of preschool children. Before being included in the education process, it should be ensured that digital applications are suitable for children's development and that the content supports learning and sustaining attention. Our research findings suggest that preschool children's attention skills can be improved and digital educational games can be integrated into education with appropriate durations and purposeful content.

No significant difference was found between the FTF-K prepost test scores of the children who were not included in the educational intervention but who continued the same curriculum and educational processes as the experimental group children. However, there are studies in the literature that show a significant difference between the pretest and posttest scores of children in the control group (Liu et al., 2021; Ramos & Melo, 2019). The researchers stated that this may be related to the test-retest factor. The fact that there was no significant difference between the pretest and posttest scores of the children in the control group in our study emphasizes once again that cognitive processes such as attention should be supported with effective practices, especially within the scope of the purposeful curriculum. Posner and Rothbart (2007) and Tang et al. (2010) stated that training programs for attention development can increase cognitive performance through the effectiveness of neural networks. The results of studies in which training programs for the development of attention, working memory, visual and verbal memory skills were implemented also advocate improvements in cognitive skills after intervention (Diamond & Lee, 2011; Jaeggi et al., 2008; Rueda et al., 2005; Thorell et al., 2009). These results indicate that curriculum interventions with rich stimuli offered to children in the early years make significant contributions to children's cognitive development.

As a result, it was determined that the children in the experimental group had higher posttest scores than the children in the control group. Both groups continued the preschool education curriculum during the training program. Differently, children in the experimental group participated in digital educational game training. It is thought that this result was realized due to the effect of the digital educational game application and based on this, the application had a positive effect on children's attention skills. Similarly, there are research results in the literature showing that children in the experimental group who received digital educational game intervention had longer fixation duration and higher posttest scores compared to children in the control group (Liu et al., 2021; Ramos & Melo, 2019; Xiong et al., 2022). These studies, whose results overlap with the results of our current study, show that producing special content and tools by utilizing children's brain network plasticity positively supports children's attention development.

The findings confirm the positive impact of digital educational games on children's attention skills. The benefits of these contents, which are purposefully integrated into the school curriculum in a fun and user-friendly way, have been proven with empirically validated results. However, it is important to underline that digital game applications should be presented to children in a qualified manner with behavior-targeted education.

Limitations and Recommendations

This study shows that digital educational game application supports preschool children's attention skills. It is worth noting that the results related to attention skills may be different depending on the test method used. For this reason, different results can be obtained by using other test methods in future studies. In addition, the study group of the research consisted of two classes of 5-6-year-old children who were studying in a kindergarten in a central city in Turkey. The study, which was conducted on 40 children selected from these classes, was limited to 16 applications in 4 weeks. Therefore, designing future studies with larger sample groups and different age groups may yield more generalizable results regarding the effects of digital educational applications.

Another limitation of the study is that the long-term effects of the intervention could not be analyzed since follow-up measurements were not made for the experimental and control groups. In future studies, long-term training and follow-up studies can be planned to determine the long-term effects of the interventions. In the study, the attention games in MentalUp, a digital educational game application, were applied; examining the effects of different digital educational game applications on children's attention development in different studies may be useful to see the potential of digital educational games. This study was designed and conducted in a quantitative design and only children were studied. Future studies may apply mixed design studies by adding data evaluating the observations of teachers and parents to test the effectiveness of digital educational game applications. In the study, the effect of digital game application on children's attention skills was examined. In future studies, the effects of digital game applications on children's cognitive skills such as executive functions, working memory, visual perception, and different developmental areas can be examined. The results of the research show that qualified and child-friendly digital game applications have a positive effect on children's attention development in the short term. By conducting educational studies to support children's developmental areas, digital game activities whose content and application features are suitable for children's age and developmental levels can be integrated into the curriculum by considering the application time.

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