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# Enhancing Early Mathematical Skills Through Math Games

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**Abstract:** This study aims to examine the impact of math games on the development of preschoolers' mathematical skills. Fifty-four (54) children between 60-72 months of age participated in the research – 26 in the experimental group and 28 in the control group. A quasi-experimental model with a pre-test post-test control group design was employed in the study. Children in the experimental group designed their own math games with the guidance and support of their parents. Subsequently, they introduced these games to their classmates and played them together in their classrooms. Data for the research were collected through the Revised Early Numeracy Test and focus group interviews. The findings indicate that the intervention significantly improved the children's mathematical skills. The initial score difference in mathematical skills favoring the control group was closed after the intervention. In addition, a significant increase with a large effect size in the mathematical skill scores of the experimental group children was observed. Children in the experimental group expressed their enjoyment of the math games and willingness to participate again. The findings are discussed considering the role of math games in the development of early mathematical skills.

**Keywords:** Mathematical skills, preschool education, math games, early numeracy

# Matematik Oyunları Aracılığıyla Erken Matematik Becerilerinin Geliştirilmesi

**Öz:** Bu çalışma, okul öncesi çocukların matematik becerilerinin gelişimine matematik oyunlarının etkisini incelemeyi amaçlamaktadır. Araştırmaya, 60-72 ay aralığında 26'sı deney grubunda 28'i kontrol grubunda olmak üzere 54 çocuk katılmıştır. Çalışmada ön-test son-test kontrol gruplu yarı deneysel bir model kullanılmıştır. Deney grubundaki çocuklar, ebeveynlerinin rehberliği ve desteği ile kendi matematik oyunlarını tasarlamışlardır. Daha sonra bu oyunları sınıflarında arkadaşlarına tanıtmış ve birlikte bu oyunları oynamışlardır. Araştırmanın verileri, Güncellenmiş Erken Aritmetik Testi ve odak grup görüşmeleri aracılığıyla toplanmıştır. Bulgular, müdahalenin çocukların matematik becerilerini önemli ölçüde geliştirdiğini göstermektedir. Ön testte kontrol grubu lehine olan matematiksel beceri puanı farkı uygulama sonrasında kapanmıştır. Ayrıca, deney grubu çocuklarının matematiksel beceri puanlarında anlamlı ve yüksek etki düzeyinde bir artış tespit edilmiştir. Deney grubundaki çocuklar, matematik oyunlarını sevdiklerini ve tekrar katılmak istedikleri ifade etmişlerdir. Bulgular, erken matematik becerilerinin gelişiminde matematik oyunlarının rolü dikkate alınarak tartışılmıştır.

**Anahtar Kelimeler:** Matematik becerileri, okul öncesi eğitim, matematik oyunları, erken aritmetik becerileri

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## Introduction

Mathematics education is a crucial component of early childhood education because the mathematical foundation developed during this period significantly impacts children's later performance and attitudes toward mathematics (Clements & Sarama, 2014; Watts et al., 2014). Research indicates that deficiencies in basic number proficiency led to lower mathematics achievement in subsequent year – hindering children from reaching grade-appropriate mathematical performance (Jordan et al., 2007; Olkun et al., 2015). In Türkiye, students' poor mathematics performance – as evident from national and international assessments – underscores the urgency of building strong mathematical skills at an early age (TEDMEM, 2023).

Early childhood mathematical skills encompass a range of skills, namely: classification, matching, comparing, sorting, counting, recognizing numbers, basic addition and subtraction, patterns, and spatial skills (Charlesworth & Lind, 2015). In addition to these, preschool programs across Türkiye also include activities for measuring, recognizing geometric shapes and preparing graphics (Ministry of National Education [MoNE], 2013). Despite the potential to develop these skills through various learning activities, assessments currently tend to focus on numbers and operations, as they serve as a basis for other learning domains (Jordan et al., 2009; Clements & Sarama, 2007a).

Assessing early mathematical skills is crucial for helping educators identify a child's strengths and weaknesses, determine their needs, and implement appropriate intervention programs (Dalga et al., 2020). Various factors – including socioeconomic status – impact children's mathematical development, with those at higher socioeconomic levels enjoying such privileges as access to preschool education and parental support (Clements & Sarama, 2014; Jordan & Levine, 2009). Hence, preschool programs are specifically tailored to address the needs of children from lower socioeconomic backgrounds. Programs like "Building Blocks," "Big Math for Little Kids," and "Pre-K Mathematics Program" are designed to enhance the early mathematical skills of children from lower socioeconomic backgrounds. They emphasize that mathematics activities should be experience-based, use concrete materials, be integrated with routine classroom activities, be based on repetition, support family participation, be connected to daily life, and be fun (Clements & Sarama, 2007b; Greenes et al., 2004; Starkey et al., 2004). Similar elements are included in the goals of the national preschool programs for mathematics activities (MoNE, 2013).

Games are highly inclusive in fostering the development of early mathematical skills. For this reason, experts regard them as essential components of preschool programs, contributing to their widespread popularity among teachers (Karakuş et al., 2022). The utilization of games facilitates increases participation and motivation among children in mathematical activities, improves problem-solving skills, reduces math anxiety, and enhances self-confidence (Parks, 2014). Games that foster the exchange of ideas and peer learning contribute to the development of children's communication and collaboration skills (Vogel, 2016). Furthermore, games offer a more profound comprehension of mathematics by delivering a hands-on and personalized mathematical experience (Vos et al., 2011). Engaging in math games allow children to refine their mathematics communication and skills through discussions about concepts integral to the game, such as numbers, number sizes, spatial relationships, and part-whole concepts (Hendershot et al., 2016). One study involving primary school children in the Netherlands revealed that one group played a pre-existing game, while another group designed a similar game. The findings indicated that designing and playing games represent a more effective approach to enhancing motivation and strategy utilization in mathematics compared to merely playing the game (Vos et al., 2011). This underscores the significance of granting children autonomy in the process of teaching mathematics through games and activities.

In early childhood, playing games can manifest in various forms, namely unstructured, structured, and semi-structured play (MoNE, 2013). Unstructured play – commonly known as free play – empowers the child to initiate and engage in the game according to their preferences. During free play, adults (whether parents or teachers) assume the role of observers, refraining from direct intervention in the child's activities. Conversely, games orchestrated by adults by establishing the rules towards specific objectives are structured play. A third approach involves adults participating in children's free play without direct intervention. In such games, adults become integral parts of the play under the children's rules, supporting the children's learning by enhancing the game according to their designated roles (Synodi, 2010). They are also referred to as semi-structured play in which adult involvement enriches the experience for the child.

Preschool programs encompass various approaches to playing games, with the dominance of a particular play style varying from culture to culture (Reikeras, 2020). For instance, the United States has embraced the learning-by-play approach. This approach integrates the concept of semi-structured play, which is inclusive of free play but is more teacher-led. In contrast, Scandinavian countries predominantly favor child-led free play. Türkiye's preschool education curriculum emphasizes structured, semi-structured, and unstructured play. It is recommended to incorporate them because they cater diverse developmental needs of children, fostering creativity, problem-solving skills, and social interaction, thereby laying a strong foundation for their holistic growth and development (MoNE, 2013).

Diverse approaches to playing games provide a conducive environment for fostering mathematical development, specifically enhancing arithmetic skills (Vogt et al., 2020; Zosh et al., 2017). During free play, young children engage in mathematical exploration, such as building towers with blocks (Zosh et al., 2017). Activities may include grouping blocks based on size and color, exploring spatial relationships by considering block positions relative to each other, and enhancing reasoning skills by making inferences about block interactions, including potential tower collapses (Clements & Sarama, 2008). However, to grasp the terms associated with mathematical concepts discovered during play, children require adult guidance (Cankaya, 2022; Stipek & Johnson, 2021) – which is particularly valuable during semi-structured or structured play.

Research demonstrates just how significant a role parents play as effective guides in introducing their children to mathematical concepts during the early years (Skwarchuk, 2009; Zippert et al., 2020). Creating mathematical stimuli in the home through games and daily activities – alongside displaying a positive attitude towards mathematics – increases a child's chance of developing a robust mathematical foundation and a positive attitude towards math (Niklas & Schneider, 2014; Skwarchuk et al., 2014). Consequently, preschool programs incorporate activities for family participation to reinforce school-based activities (Clements & Sarama, 2007b; Greenes et al., 2004; MoNE, 2013; Starkey et al., 2004). Moreover, teachers can organize events for parents or guide them on how to discuss mathematics during playtime and they can assign math-related tasks for home, involving collaborative work with their children (Ramani & Eason, 2015).

In light of all these considerations, we posit that math games co-designed by preschoolers and their parents may contribute significantly to the enhancement of children's mathematical skills. Investigating this area addresses a significant gap in the current scientific literature and will yield valuable insights for future research initiatives. Therefore, our study aims to investigate the influence of math games on the enhancement of mathematical skills among preschoolers. In pursuit of this goal, the following research questions were sought:

1) Is there a statistically significant difference between the pre-test scores of mathematical skills in the experimental group, who participated in math games, and the control group, who did not?
2) Is there a statistically significant difference between the post-test scores of mathematical skills in the experimental and the control groups?
3) Is there a statistically significant difference between the pre-test and post-test scores of the mathematical skills of the control group?
4) Is there a statistically significant difference between the pre-test and post-test scores of the mathematical skills of the experimental group?
5) How do the children participating in the math games view mathematics?

## Method

### Research Design

We utilized a quasi-experimental approach with a pre-test post-test control group design to investigate the impact of math games on the development of mathematical skills in preschoolers (Çepni, 2014). Four classes randomly selected from a public kindergarten in Ankara, comprising children aged between 60 and 72 months, were allocated randomly into two experimental and two control groups.

When random assignment is not possible in experimental studies, measures should be taken to enhance internal validity (Fraenkel et al., 2012). In this study, we used a control group to monitor maturation and the potential effects of the measurement tool. Both the control and experimental groups were comprised of children from similar socioeconomic backgrounds within the same preschool. The 7-week duration between the pre-test and post-test helped us minimize potential pre-test effects. To mitigate possible teacher effects, we used two classes for both groups. We also conducted focus group interviews with 11 randomly selected children from the experimental group to gather their opinions about mathematics.

### Participants

Fifty-four (54) children (60-72 months old) who attended public preschool education institution in Ankara, Türkiye between 2023–2024 academic year participated in the study. None of the children had special needs. We examined the distribution of children in the experimental and control groups based on gender, previous preschool education, and parental education level. The experimental group consisted of 12 boys and 14 girls, while the control group had 15 boys and 13 girls. Table 1 shows the distribution of children based on how long they have been in preschool education for, and the education levels of their parents.

 

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**Table 1.**

*Distribution of Children Based on Length of Time in Preschool Education and Parental Education Level*

| | Preschool education duration | | | Mother's education level | | Father's education level | |
|---|---|---|---|---|---|---|---|
| | Experimental | Control | | Experimental | Control | Experimental | Control |
| 3 years | 6 | 2 | Postgraduate | 4 | 3 | 5 | 5 |
| 2 years | 3 | 4 | Master's | 14 | 14 | 14 | 12 |
| 1 year | 12 | 13 | High school | 6 | 9 | 5 | 9 |
| None | 5 | 9 | Middle school | 1 | 2 | 2 | 2 |
| | | | Primary school | 1 | 0 | 0 | 0 |

## Data Collection Tools

We have collected the data through the *Revised Early Numeracy Test* and focus group interviews. The test was administered to each child in both groups, once before and once after the implementation. Two sets of focus group interviews were conducted with 11 children randomly selected from the experimental group.

### *Early Numeracy Test-Revised*

The Early Numeracy Test was developed by Van Rijt et al., (1999), and aims to measure the developmental level of mathematical skills in children ages 4-7. Van Rijt and Van Luit revised the test a decade later in 2009, subsequently re-publishing it as the Early Numeracy Test-Revised. The test was adapted to Turkish by Kaçıra and Dağlıoğlu (2019) and proven to be a valid and reliable instrument.

The test consists of nine dimensions, each briefly explained below:

- Comparison: Observing and comparing the relationship between two objects or groups of objects in terms of qualitative and quantitative aspects.
- Classification: Separating objects based on features such as color, texture, quantity, shape, and smell.
- One-to-one correspondence: Matching each object in one group with each object in another group.
- Ordering: Arranging and ordering more than two objects based on certain features.
- Using numerals: Counting forward and backward using cardinal and ordinal numbers, and indicating the number and position of objects in the process.
- Synchronous and shortened counting (structural counting): Counting rapidly and consistently, as seen in the total number of dots on a die.
- Resultative counting: Noticing and counting structured and unstructured quantities with hidden numbers.
- Applying knowledge of numbers: Using number knowledge in simple problems, such as size, order, and total quantity.

- Estimation: Making deductions based on certain information.

The test comprises of 45 items, with 5 items per dimension. It is individually administered, and takes approximately 20-30 minutes per child. Responses are scored as correct (1) or incorrect (0). The total score provides information about the child's early math proficiency level according to their age (Kaçıra & Dağlıoğlu, 2019).

### *Focus Group Interviews*

Focus group interviews were conducted before and after the intervention. The first focus group was asked two questions:

- What do you think mathematics is? What is its purpose?
- Do you think math is fun? Why/Why not?

The second focus group was held after the intervention, and asked the two aforementioned questions plus two additional ones:

- Did you enjoy the math games? Which one did you like the most?"
- Would you like to do these games again? Why/Why not?

## Data Collection Process

The study spanned nine weeks, including one week of preparation, informing participants' parents, pre-test application, and the first focus group interview; seven weeks of implementing math games in the experimental group; one week of post-test application, and the second focus group interview. At the beginning of the study, we conducted a one-hour meeting with the experimental group's parents. We told them about the purpose of the study and the measurement tools to be used, and then asked them what their expectations were.

We administered the pre-test of Early Numeracy Test-Revised to each child in both groups over the span of a week. Subsequently, we implemented two mathematical activities to only the experimental groups on a weekly basis. After completing the intervention, a post-test of Early Numeracy Test-Revised was re-administered to all the children in both groups. For handling the remembering effect, we carried out forms A and B of the pre and post-tests.

Before and after the intervention, we randomly selected 11 children (7 boys and 4 girls) from the experimental group, and subjected them to both sets of focus group interviews, each one lasting approximately 15 minutes. The interviews took place in their classroom; we taped their responses on an audio recorder.

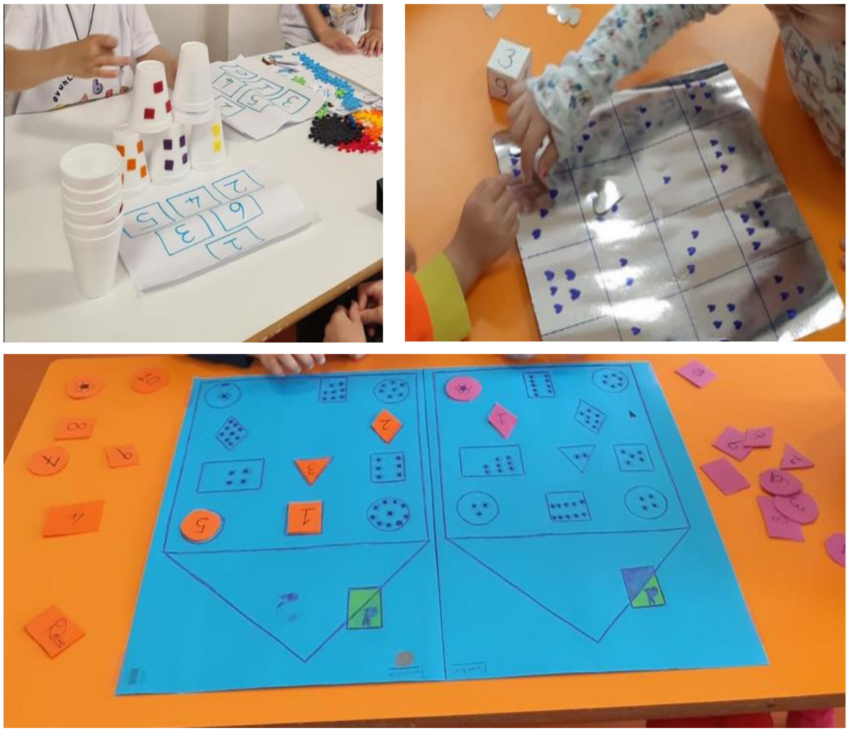
## Experimental Process

In the study, each child from experimental group and one of their parents collaborated to develop a game-based mathematical activity. We did not have any restrictions or directions to parents as to what they could create. A week was allotted for each child, and the child(ren) of the week (two per week) presented and played their games with their classmates. The teachers played no role in the process beyond providing minor guidance. Approximately 1.5 hours per week, consisting of two class hours, was allocated to present and play the games (See Figure 1).

**Figure 1**

*Sample Photographs of the Math Games*



The children had to leave their games at school. Additionally, one hour per week was set aside to allow children to re-play all of them in their classroom (See Figure 2).

**Figure 2**

*Classroom Activity Photograph*

Once the experimental phase was over, we organized a show-and-tell at the school. Those children who developed games introduced them to both their parents and classmates (See Figure 3).

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**Figure 3**

*Math Games, Show-and-Tell Photos*


## Data Analysis

We analyzed our data on the impact of games on the mathematical skills of preschoolers on SPSS (Statistical Package for the Social Sciences). Beforehand, we carried out a normality analysis. We chose non-parametric tests due for three reasons: the number of participants was less than 30, the data was not distributed normally in the control group, and there were some extreme kurtosis values. Accordingly, we executed the Mann-Whitney U (for questions 1 and 2) and the Wilcoxon Signed Ranks tests (for questions 3 and 4). Considering a significance level of 0.05, we interpreted and tabulated the quantitative sub-problems so that we could analyzes them better. In cases where a significant difference was found, we calculated the effect size (r) by dividing the z value by the square root of the total number of participants (Fritz et al., 2012). When evaluating the effect size values, we considered those suggested by Cohen (1988), where 0.10 is small, 0.30 is medium, and 0.50 is large. For the qualitative data (question 5), we examined the content of the transcribed texts of two 15-minute focus group interviews, and then interpreted the results accordingly.

## Result

We examined the presence of inter-group differences in the pre-test and post-test scores of the children's mathematical skills (i.e. questions 1 and 2) using the Mann-Whitney U test (Table 2). Accordingly, we discovered a significant difference between the pre-test scores of the experimental and the control groups ($U = 169.50$, $p < .05$). Considering the mean scores and rank averages, we observed that the control group scored higher than those in the experimental group.

 

**Table 2**

*Inter-Group Comparison of Pre-Test and Post-Test Scores: U-Test Results*

| Measurement | Group | n | $\bar{X}$ | Rank average | Rank sum | U | p |
|---|---|---|---|---|---|---|---|
| Pre-test | Experimental | 26 | 25.46 | 20.02 | 520.50 | 169.50 | .00* |
| | Control | 28 | 32.96 | 35.45 | 964.50 | | |
| Post-test | Experimental | 26 | 36.69 | 30.69 | 798.00 | 281.00 | .15 |
| | Control | 28 | 32.82 | 24.54 | 687.00 | | |

**p<.05*

The post-test scores of both groups showed no significant difference (U = 281.00, p >.05). However, considering rank averages, the experimental group scored higher than the control group. Notably, despite lower pre-test scores, the experimental group scored higher on the post-test overall.

We employed the Wilcoxon signed-rank test (Table 3) to investigate intra-group differences in the children's mathematical skills between everyone's pre-test and post-test scores (Research Questions 3 and 4). Our result indicates no significant difference between pre-test and post-test scores of the control group (z = -.179, p >.05). In contrast, we found a significant difference in the experimental group (z = -4.46, p <.05), in favor of the post-test. Consequently, it appears that the math games played by the experimental group improved the children's mathematical skills significantly.

**Table 3**

*Intra-Group Comparison of Pre-Test and Post-Test Scores: Wilcoxon Signed-Rank Test Results*

| Group | Post-test pre-test | n | Rank average | Rank sum | Z | p |
|---|---|---|---|---|---|---|
| Control | Negative rank | 7 | 5.00 | 35.00 | -.179* | .86 |
| | Positive rank | 4 | 7.75 | 31.00 | | |
| | Equal | 17 | - | - | | |
| Experimental | Negative rank | 0 | .00 | .00 | -4.46** | .00 |
| | Positive rank | 26 | 13.50 | 351.00 | | |
| | Equal | 0 | - | - | | |

** Based on positive ranks*
*** Based on negative ranks*

Table 4 shows the Wilcoxon signed-rank test results for the experimental group's Early Numeracy Test-Revised scores and sub-dimensions. The analysis results indicate a dramatic improvement across all nine sub-dimensions of the experimental group's mathematical skills between their pre-test and post-test scores. This suggests that the experimental group's math games enhanced all their skills, as measured by the Early Numeracy Test-Revised.

**Table 4**

*Experimental Group Pre-Test to Post-Test Sores: Wilcoxon Signed-Rank Test*

| Subskills | Measurement | n | $\bar{X}$ | sd | Z | r | p |
|---|---|---|---|---|---|---|---|
| Comparison | Pre-test | 26 | 4.65 | 0.63 | -2.46* | 0.48 | .014 |
| | Post-test | 26 | 5.00 | 0.00 | | | |
| Classification | Pre-test | 26 | 2.81 | 1.50 | -3.97* | 0.78 | .00 |
| | Post-test | 26 | 4.46 | 0.76 | | | |
| One-to-one correspondence | Pre-test | 26 | 3.19 | 1.41 | -3.62* | 0.71 | .00 |
| | Post-test | 26 | 3.92 | 1.06 | | | |
| Ordering | Pre-test | 26 | 3.08 | 1.29 | -4.06* | 0.80 | .00 |
| | Post-test | 26 | 4.23 | 0.82 | | | |
| Using numerals | Pre-test | 26 | 2.85 | 1.29 | -3.95* | 0.77 | .00 |
| | Post-test | 26 | 3.88 | 0.95 | | | |
| Synchronous and shortened counting | Pre-test | 26 | 3.12 | 1.73 | -4.46* | 0.87 | .00 |
| | Post-test | 26 | 5.00 | 1.68 | | | |
| Resultative counting | Pre-test | 26 | 1.77 | 1.34 | -4.42* | 0.87 | .00 |
| | Post-test | 26 | 3.81 | 0.80 | | | |
| Applying knowledge of numbers | Pre-test | 26 | 1.88 | 1.48 | -4.09* | 0.80 | .00 |
| | Post-test | 26 | 3.35 | 1.23 | | | |
| Estimation | Pre-test | 26 | 2.12 | 1.34 | -3.85* | 0.76 | .00 |
| | Post-test | 26 | 3.58 | 0.95 | | | |
| Total | Pre-test | 26 | 25.46 | 8.09 | -3.85* | 0.76 | .00 |
| | Post-test | 26 | 36.69 | 5.63 | | | |

The effect sizes calculated using Cohen's d formula indicate that the magnitude of the effect is above 0.50 for all skills except the comparison skill, where the r value is 0.48 – which still is substantial, despite it being slightly lower. That lower effect value in the comparison skill may be attributed to the high pre-test scores of the children for this skill. The entirely experimental group answered all comparison questions correctly after they played the math games. Accordingly, the increase in skill scores and the decrease in standard deviation for all the sub-dimensions suggests that math games are effective at helping children improve their mathematical skills.

## Qualitative Findings

Focus group interviews were conducted with 11 children randomly selected from the experimental group before and after they played the math games. During both pre- and post-interviews, we asked them "What is math? What is its purpose?" In the first interview, three children did no answer this question. The other eight children did, and their answers were similar. They associated math with numbers, learning, and addition: *"I think math is about learning, that is knowing numbers. It is useful for learning"* (Child 1), *"Math is about learning numbers, and is useful for knowing how to add"* (Child 2).

In the last focus group interview, all the children associated mathematics with numbers and operations: *"Math is about knowing numbers. Numbers appear everywhere"* (Child 1); *"Math is useful for doing operations with numbers"* (Child 4). Some children also related mathematics to daily life and provided examples from their own lives: *"Math is useful whenever we make a cake* *with mom"* (Child 2). *"For example, we went to the store with mom. We bought 3 loaves of bread and 2 bars of chocolate. When we added them together, we got 5. We used math"* (Child 6). Two children expressed that mathematics develops the brain and is useful for thinking: *"Math is for lessons. It develops our brain. For example, we use math when we look for the number of our apartment"* (Child 5), *"Math is about numbers and shapes. It helps us think"* (Child 2). Two children did not answer this question at all.

The second question we asked was "Do you think math is fun?" In the first focus group interview, four children gave no answer, while the remaining seven children said it was fun. However, when we asked why it is fun, none of them gave us a proper answer: *"Because it is a lot of fun"* (Child 7). *"We make a rabbit from 1, so it's fun"* (Child 9). *"Because learning numbers is very fun"* (Child 1). As for the last focus group interview, nine out of eleven children answered the question positively, and two children said nothing. We obtained similar responses to the question asking them why it is fun. Additionally, two children emphasized playing games: *"It is fun. We have fun playing with math"* (Child 1). *"Yes. Because I love playing with math"* (Child 3).

In the last focus group interview, we asked two more questions. According to the responses, all eleven children liked math games and expressed a desire to do them again. Although they mentioned specific activities that they liked the most, such as "addition machine, love wall, hopscotch mat, number apron, say and tell shape, what time is it?" they also said that they liked all of them.

## Discussion

We investigated the impact of incorporating math games on the development of preschoolers' overall mathematical skills. Our findings reveal a significant enhancement in children's mathematical skills through participation in these activities. The control group initially had higher pre-test scores, however the inter-group difference disappeared after the intervention. The study identified a substantial and significant improvement in both the experimental group's general mathematical skills and specific sub-skills between pre-test and post-test scores. This supports the efficacy of math games in improving preschoolers' mathematical skills.

Multiple studies have underscored the supportive role of math games in fostering mathematics learning (Hendershot et al., 2016; Parks, 2014; Salminen et al., 2015; Vos et al., 2011; Wilson et al., 2009). These studies have shown that games enhance how children perceive numbers (Wilson et al., 2009), makes mathematics easier for them (Salminen et al., 2015), and improve their overall problem-solving, mathematical communication, and skills (Hendershot et al., 2016; Parks, 2014; Ramani & Eason, 2015; Vos et al., 2011). Our study aligns with these findings, concluding that children's mathematical skills did improve. Notably, we observed substantial progress in their comparison, classification, one-to-one correspondence, ordering, using numerals, synchronous and shortened counting, resultative counting, applying number knowledge, and estimation skills – targeting the numbers and operations learning domain. Our results hold particular significance given the foundational role of this domain for other areas of mathematics and the potential long-term impact of deficiencies in basic number competence (Jordan et al., 2009; Clements & Sarama, 2007a; Olkun et al., 2015). Involving children in math games appears to be a potential predictor of success in their future education – in turn, emphasizing the need for longitudinal studies to explore this hypothesis.

Beyond supporting specific learning outcomes, incorporating games in mathematics education also cultivates children's motivation and positive attitudes toward math (Divjak & Tomie, 2011). Games inspire children to willingly engage with mathematics, foster positive attitudes, and strengthen self-efficacy perceptions by making the learning experience enjoyable and interactive (Clements & Sarama, 2009; Pan et al., 2022). Our focus group interviews with the experimental group further revealed that the children view mathematics as an enjoyable activity, not just concepts processes. Their enjoyment and a desire to participate again suggests that they have developed a positive attitude toward mathematics and learning through games. It is important to note that focus group interviews were not conducted in the control group, limiting direct comparisons.

The collaboration between children and parents to design the math games aligns with the Vos et al.'s (2011) finding. They too found allowing children to design their own games had a positive impact on their motivation and strategy usage. However, we involved parental support because it is unrealistic to expect preschoolers to design their own games. The improvement in the experimental group's mathematical skills underscores just how essential effective parental guidance can be (Cankaya, 2022; Stipek & Johnson, 2021; Skwarchuk, 2009; Zippert et al., 2020). Thus, we feel that parental involvement in math games is crucial for enhancing mathematical skills and fostering positive attitudes toward mathematics in early childhood. Not only does it establish a bridge between learning at home and school, it also guides parents on how to support their children's mathematical development. However, we should acknowledge that our findings are limited to data from the Early Numeracy Test-Revised and focus group interviews. The absence of data on a child's home environment and experiences with designing games restricts a definitive judgment regarding their activity and involvement in these aspects. We were able to mitigate uncertainty about the children's roles in the game design process by actively involving them in tasks such as introducing their game to their classmates and playing together. Therefore, more research is needed that features additional data regarding parental involvement in order to reinforce our findings.

Another limitation of this study is the lack of random assignment, as seen in true experimental studies. Existing groups were used in this study instead. This limitation was attempted to be addressed by attempting to close the gap through the random assignment of groups into experimental and control groups. However, as seen in pre-test results, the early arithmetic skills of children in the control group are statistically higher compared to those in the experimental group. The closure of this gap after the intervention was interpreted as the success of the intervention, concluding that designing math games with parental support and playing those games in the classroom increases children's early arithmetic skills. Nevertheless, there is a need for studies questioning the effectiveness of interventions under controlled conditions where random assignment is possible. Thus, the results obtained from this study can be verified or improved upon, contributing to the literature in the field.

## Conclusion

In conclusion, our study offers evidence that math games can be effective at helping preschoolers improve their mathematical skills. These activities not only deepen their understanding of mathematics but also contribute to fostering a positive relationship with mathematics. Incorporating more games into children's lives can expose them to mathematics an earlier age, and thus give them a robust foundation in mathematics. However, further research with broader samples, diverse measurement methods, and long-term follow-up studies is needed first. Likewise, comparative analyses of similar studies conducted on different student groups could also offer us and others a more comprehensive understanding of effective strategies for learning mathematics and the role of parental involvement.

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## Geniş Özet

### Problem Durumu

Bu araştırmanın amacı matematik oyunlarının okul öncesi dönem çocuklarının matematik becerilerinin gelişimi üzerine etkisini belirlemektir. Bu amaç doğrultusunda aşağıdaki sorulara cevap aranmıştır:

1. Matematik oyunlarına katılan deney grubu ile katılmayan kontrol grubunun matematik becerileri ön test puanları arasında istatistiksel olarak anlamlı bir farklılık var mıdır?

2. Matematik oyunlarına katılan deney grubu ile katılmayan kontrol grubunun matematik becerileri son test puanları arasında istatistiksel olarak anlamlı bir farklılık var mıdır?

3. Matematik oyunlarına katılmayan kontrol grubunun matematik becerileri ön test ve son test puanları arasında istatistiksel olarak anlamlı bir farklılık var mıdır?

4. Matematik oyunlarına katılan deney grubunun matematik becerileri ön test ve son test puanları arasında istatistiksel olarak anlamlı bir farklılık var mıdır?

5. Matematik oyunlarına katılan çocukların matematiğe ilişkin görüşleri nelerdir?

Araştırma kapsamında ebeveyn desteği ile kast edilen çocukların ebeveynleri ile birlikte kendi matematiksel oyunlarını tasarlamalarıdır.

### Yöntem

Bu çalışmada yarı-deneysel modellerden "ön test son test kontrol gruplu model" (Çepni, 2014) kullanılmıştır. Ankara ilinde Millî Eğitim Bakanlığı'na bağlı resmi bir okul öncesi eğitim kurumu anaokulu sınıflarından (60-72 ay) rastgele 4 sınıf seçilmiş ve 2 grup deney grubuna, 2 grup kontrol grubuna rastgele atanmıştır. Araştırmanın çalışma grubunu 2023–2024 eğitim-öğretim yılında Ankara ilinde Millî Eğitim Bakanlığı'na bağlı resmi bir okul öncesi eğitim kurumuna devam eden 60-72 ay arası 54 çocuk oluşturmaktadır. Deney grubunda 12 erkek, 14 kız, kontrol grubunda 15 erkek 13 kız çocuk bulunmaktadır.

Araştırmada verilerin toplanması; bir hafta hazırlık, bilgilendirme, ön test uygulaması ve ilk odak grup görüşmesi, 7 hafta deney grubu ile matematik oyunları uygulaması, bir hafta son test uygulaması ve odak grup görüşmesi olarak toplamda 9 hafta sürmüştür.

Matematik oyunları uygulaması kapsamında deney grubunda yer alan her çocuk velisi ile birlikte bir matematik etkinliği geliştirmiştir. Velilere geliştirecekleri oyunla ilgili bir sınırlama getirilmemiş veya bir yönlendirme yapılmamıştır. Her çocuk için bir hafta belirlenmiş ve haftanın çocukları (ikişer çocuk) geliştirdikleri etkinliği sınıfta arkadaşlarına anlatmış ve birlikte oynamışlardır. Bu süreçte öğretmenler herhangi bir müdahalede bulunmamış, sadece rehberlik etmiştir. Etkinliğin anlatılması ve oynanması için her hafta iki ders saatinden oluşan yaklaşık 1,5 saatlik bir zaman ayrılmıştır. Geliştirilen oyunlar sınıfta bırakılmış, eve geri gönderilmemiştir. İlk üç haftanın sonunda sınıfta biriken oyunlar için her hafta ayrıca 1 saatlik bir zaman ayrılmış ve çocukların oyunları yeniden oynamalarına fırsat tanınmıştır. Matematik oyunları süreci tamamlandığında okulda bir sergi düzenlenmiştir. Bu sergide, matematik oyunları geliştiren çocuklar oyunlarını hem velilere hem de okuldaki diğer çocuklara tanıtmıştır.

Bu araştırmada Güncellenmiş Erken Aritmetik Testi (GEAT) ve Yarı Yapılandırılmış Odak Grup Görüşme olmak üzere iki farklı veri toplama aracı kullanılmıştır. GEAT 4-7 yaş aralığındaki çocukların matematik becerilerinin gelişim seviyesini ölçmeyi amaçlamaktadır. Van Rijt vd., (1999) tarafından geliştirilen test Van Rijt ve Van Luit (2009) tarafından yapılan araştırma ile revize edilmiştir. Test Kaçıra ve Dağlıoğlu (2019) tarafından Türkçeye uyarlanmış; geçerli ve güvenilir bir test olduğu ispatlanmıştır. GEAT; karşılaştırma, sınıflama, birebir eşleme, sıralama, sayıları kullanma, eş zamanlı ve kısaltılmış sayma (yapısal sayma), sonuçsal sayma, sayı bilgisini uygulama, tahmin etme olmak üzere toplam 9 boyuttan oluşmaktadır. Testte her bir boyuta ait 5 madde olmak üzere toplam 45 madde bulunmaktadır. Test, kontrol grubu ve deney grubundaki her bir çocuğa uygulama öncesi (öntest) ve sonrasında (sontest) olmak üzere bireysel olarak uygulanmış ve her biri yaklaşık 20-30 dakika sürmüştür. Uygulama öncesinde ve sonrasında deney grubunda yer alan çocuklardan rastgele seçilen 6 çocukla odak grup görüşmeleri yapılmıştır. Nicel verilerin analizinde Mann-Whitney U Testi ve Wilcoxon İşaretli Sıralar Testi'nden; nitel verilerinin analizinde ise içerik analizi yönteminden yararlanılmıştır.

## Bulgular

Çalışmaya katılan çocukların matematik becerileri ön test puanlarında gruplar arası anlamlı farklılık bulunmuştur (U= 169,50 p<.05). Ön test sonuçlarında, kontrol grubundaki çocukların deney grubundaki çocuklardan daha yüksek puan aldıkları görülmüştür. Son test sonuçlarında ise anlamlı bir farklılık bulunmamıştır (U= 281,00 p>.05). Ancak, ön test sonuçlarına göre kontrol grubundan daha düşük puana sahip olan deney grubu, son testte kontrol grubundan daha yüksek puan almıştır.

Çalışmaya katılan çocukların matematik becerileri ön test puanları ile son test puanlarında grup içi fark olup olmadığı Wilcoxon işaretli sıralar testi ile test edilmiştir. Analiz sonuçları, kontrol grubundaki çocukların matematik becerileri ön test puanları ile son test puanları arasında anlamlı bir fark olmadığını göstermiştir (z=-.179, p>.05). Buna karşın, deney grubundaki çocukların matematik becerileri ön test puanları ile son test puanları arasında anlamlı bir farklılık tespit edilmiştir (z=-4,46, p<.05). Fark puanlarının sıra ortalaması ve toplamları dikkate alındığında, gözlenen bu farkın son test puanı lehinde olduğu görülmüştür.

## Sonuç ve Tartışma

Deney grubunda gerçekleştirilen uygulamaların çocukların matematik becerileri toplam puanını artırdığına yönelik bulgu, GEAT ile ölçülen matematik becerilerin alt boyutlarını da içeren ek analizler yapılmasını gerekli kılmıştır. Analiz sonuçları, dokuz alt boyutun tamamında araştırmaya katılan deney grubu çocuklarının matematik becerileri ön test ve son test puanları arasında son test lehine anlamlı ve büyük etki düzeyinde bir fark olduğunu göstermiştir. Bu sonuçlar, matematik oyunlarının okul öncesi çocuklarının matematik becerilerini geliştirmede etkili bir yöntem olduğunu desteklemektedir.

Deney grubu öğrencileriyle yapılan odak grup görüşmeleri, çocukların matematiği sadece kavram ve süreçlerle değil aynı zamanda eğlenceli bir aktivite olarak gördüklerini, matematik oyunlarını sevdiklerini ve tekrar katılmak istediklerini ortaya koymuştur. Bu ifadeler, çocukların matematik ve oyunla matematik öğrenimine yönelik olumlu tutum geliştirdiği şeklinde yorumlanabilir. Buna rağmen çalışma kapsamında kontrol grubunda odak grup görüşmesinin yapılmadığı göz önüne alınmalıdır.