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The predictive power of planning and attention skills on mathematical ability in the preschool period*

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Highlights:

- The relationship between planning, attention skills, and mathematical abilities in preschool children
- There is a positive and significant relationship between planning skills and mathematical abilities during preschool.
- Despite a positive relationship between attention skills and mathematical abilities, attention skills are not a significant predictor.
- Together, planning and attention skills are significant predictors of mathematical abilities.

Abstract

This study examined the relationship between planning and attention skills and mathematical abilities in preschool children and then assessed the predictive power through regression analysis. In addition, the prediction power of children's planning and attention skills on mathematics ability was also investigated. The study, conducted using a relational survey model, consisted of 88 children aged between 60 and 72 months attending a preschool institution in Istanbul. The measurement tools used in the study were the "Cognitive Assessment System (CAS)" and the Test of Early Mathematics Ability (TEMA-3). The findings showed a moderate, positive, and significant relationship between early mathematical ability and planning skills ($r = .60$, $p < .01$). A lower yet still significant relationship was found between attention skills and early mathematical ability ($r = .40$, $p < .01$). According to multiple regression analysis results, planning and attention skills together accounted for 37% of the total variance in early mathematical ability ($R^2 = .37$, $p < .001$). Standardized regression coefficients indicated that planning skills ($\beta = .68$) were a significant predictor of early mathematical ability ($t = 5.23$, $p < .001$). However, attention skills ($\beta = -.11$) were not found to be a significant predictor ($t = -0.83$, $p > .05$). These results suggest that planning skills play a critical role in mathematical achievement during the preschool period. While a significant relationship was found between attention skills and mathematical ability, attention skills were not identified as a direct predictor of mathematical ability. This study highlights the importance of supporting planning skills in early childhood to enhance mathematical development.

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1. Introduction

Executive functions attract significant interest in developmental neuropsychology due to their importance in learning. Interrelated cognitive processes required for purposeful, goal-oriented behaviors are encompassed by the umbrella term " executive functions " (Barkley, 1997; Montgomery & Koeltzow, 2010; Rajendran & Mitchell, 2007). Executive functions help to monitor and control thoughts and actions that contribute to purposeful behavior (Meltzer, 2013) and include skills such as self- regulation, inhibitory control, planning, flexibility, error correction, perception, resistance to distraction, and working memory (Diamond, 2013; García et al., 2016; Welsh et al., 1991).

The early acquisition of executive function skills is one of the most critical tasks of childhood. Developing these skills early is essential for healthy growth in middle childhood and adolescence (Center on the Developing Child at Harvard University, 2014). Various studies indicate that children 's early executive function skills influence their academic performance cross-sectionally and longitudinally (Bull et al., 2011; Matthews et al., 2009). Research suggests that developing executive function skills as early as age three may be particularly crucial, as significant improvements in these skills are observed between the ages of three and five (Carlson & Moses, 2001; Kochanska et al., 2000). Furthermore, strong positive relationships have been established between executive function skills and math achievement during the preschool period (Allan et al., 2014; Blair et al., 2014; Purpura et al., 2017), and this relationship is bidirectional (Fuhs & McNeil, 2013). In particular, executive function skills developed in the early years of life guide later math and reading success (Fuhs et al., 2014; Razza et al., 2012). Research indicates that preschool children with lower executive function skills encounter more significant difficulties in academic areas such as reading and math, and this disparity widens over time (McClelland et al., 2006). Longitudinal studies show that academic learning enhances executive functions and contributes to academic success (Fuhs et al., 2014; Welsh et al., 2010). Since executive functions are critical for reasoning-intensive domains such as math and reading, these areas also require the effective use of executive function skills.

Additionally, studies highlight the significance of cultivating executive function skills beginning in preschool (Anderson, 2002; Diamond, 1990; Garon et al., 2008; Viterbori et al., 2015). Research has also concentrated on the effects of various components of executive functions (such as planning, attention, flexibility, and working memory) on learning (Brocki & Bohlin, 2004; Hanna-Pladdy, 2007; Miyake et al., 2000). Planning is a crucial element of executive functioning skills that play a role in the goal-setting process (Brocki & Bohlin, 2004; Hughes & Graham, 2002; Zelazo, Carter, Reznick, & Frye, 1997). Planning processes enable programming, organization, and verification of behaviors and are responsible for various actions, such as questioning, problem-solving, and self-monitoring (Naglieri & Gottling, 1997). Additionally, planning encompasses a range of skills, including working memory and error correction, which are vital for executive functions in problem-solving contexts (Marcovitch & Zelazo, 2009). Cognitive control, effective utilization of processes and knowledge, and self-regulating planning skills are essential to achieve a desired goal (Naglieri & Das, 1997, as cited in Naglieri & Rojahn, 2001). A child who excels in planning can assess different stimuli and effectively organize and analyze them (Naglieri & Kaufman, 2001). Researchers have noted that preschoolers begin to exhibit basic planning skills in familiar, uncomplicated tasks (Anderson et al., 2001; Welsh et al., 1991). Nearly any academic task, such as counting objects, necessitates planning to execute the various components correctly and appropriately. Students with underdeveloped planning skills may struggle to regulate their cognition (Locascio et al., 2010).

Researchers have shown intense interest in the effect of attention, an important component of executive functions, on learning. Attention is the ability to select and organize material perceived at the peripheral level; it is the strategy used by the organism to collect information from the surroundings (Motavallı, 2000). Attention involves focusing on the desired stimulus among the various stimuli in the environment, ignoring the undesired ones, and maintaining focus on goal-directed behaviors (Anderson, 2002). Flavell (1999) argues that as children age, they become better at controlling their attention and develop a greater interest in significant events and issues in their surroundings. Children with better attentional control learn more quickly than their less attentive peers (Clark, Pritchard, & Woodward, 2010; Geary, 2013). Researchers emphasize the importance of attention, as students with higher attentional skills also exhibit strong numerical mathematics skills (Cueli et al., 2020). Conversely, experts have noted that children experiencing attention processing difficulties during preschool are at higher risk of facing learning challenges in the future (Kroesbergen et al., 2003).

Experts have observed significant correlations between executive functions and academic achievements starting in preschool (Brocki & Bohlin, 2004; Bull, Espy, & Wiebe, 2008; Cueli et al., 2020; Duncan et al., 2007; Schmitt et al., 2017). For example, mathematical ability correlates with many aspects of executive functioning in typically developing individuals; moreover, executive functioning deficits are often found in individuals facing mathematical difficulties (Friso-van den Bos et al., 2013; Peng et al., 2018; Peng & Fuchs, 2016). Clements and Sarama (2019) showed that children with higher executive functioning skills, such as attention, working memory, and inhibitory control, achieve higher levels in mathematics. Evidence suggests that executive functioning skills play a significant role in solving complex mathematical problems as children mature (Swanson, 2006). For instance, research has indicated that attention skills are associated with mathematics performance, as they influence the ability to focus on stimuli (Cueli et al., 2020; Cowan et al., 2018; Steinmayr et al., 2010; Pappas et al., 2019; González Castro et al., 2014). Therefore, attention skills are crucial for children with mathematics difficulties (Bull & Scerif, 2001; Landerl & Kölle, 2009; Szucs et al., 2013). In preschool, focusing attention and ignoring distractions enhance learning in counting and associating numbers with specific symbols (Geary, 2013). Kroesbergen, Van Luit, and Naglieri (2003) found that students with learning disabilities in mathematics scored lower than their peers on all scales of the Cognitive Assessment System (CAS). Their cognitive deficits are particularly striking, especially in planning and sequential cognitive processing.

Regarding executive functions, several studies have focused on preschool children's planning and attention skills, considering variables such as age, gender, IQ, developmental disabilities, region of residence, and parents' education level (Bull et al., 2004; Carlson et al., 2004; Drake & Palmer, 2000; Freier et al., 2015; Naglieri et al., 2007; Ni et al., 2011; Sonuga-Barke et al., 2002). Some studies have shown strong correlations between preschool children' s executive functioning skills and their mathematics achievement and academic skills (Blair & Razza, 2007; Kroesbergen et al., 2009; Ribner et al., & The (Family Life Project Investigators, 2017) and demonstrate that executive functioning predicts academic skills in both preschool and later years (Allan et al., 2014; Blair & Razza, 2007; Blair, Knipe, & Gamson, 2008). On the other hand, it is well known that teachers face challenges in recognizing the diverse characteristics of their students and providing appropriate individualized education at every schooling level. This leads to many negative outcomes, such as poor academic performance and lack of motivation for many students. It is anticipated that this study will guide teachers in the areas of planning, attention skills, and mathematical ability, thereby contributing to the development of individualized approaches for students (Schmitt et al., 2017; Kaçan & Halmatov, 2017; Montoya et al., 2019). The primary purpose of this study is to analyze the relationship between preschool children's planning and attention skills and their mathematical abilities. The predictive power of children's planning and attention skills on their mathematical ability is also addressed. In our country, since we aim to improve learning, achievement, and behavioral outcomes for students, focusing on enhancing executive function skills in early years is a necessary and valuable goal. Therefore, investigating whether there is a relationship between executive functions and early math skills in preschool children is crucial for the early identification of children with these skills.

2. Method

2.1. Research Design

This study is based on a relational survey model, which aims to determine the presence and/or degree of change between two or more variables (Karasar, 2013). This study examined the relationship between planning and attention skills and the mathematical ability of 60-72-month-old children, and the predictive value of planning and attention skills on mathematical ability.

2.2. Study Group

In this study, the sample is formed through convenience sampling starting from the most easily accessible participants until the group reaches the desired size (Büyüköztürk et al., 2020) due to several reasons. The individual application of the three measurement tools applied to each child, the long duration of the application, and the intensity of the daily education program of the school/schools caused delays in the application. On the other hand, there was no expected level of response from the families regarding the permission requested by the parents to apply the measurement tools to the child individually. For these reasons, the convenience sampling method was preferred. To reach the study group, the preschools affiliated with a district municipality on the Anatolian side of Istanbul were visited, and the purpose of the study was explained to the institution director. First, communication was established with the institution administrators to provide information about the study. It was learned that 237 children were attending the relevant institution during the 2022-2023 academic year when the study was conducted. Subsequently, families were informed about the study, and consent forms were obtained from those who wished to participate. The study was carried out with children who volunteered to take part. In conclusion, the study sample consisted of 88 children, 44 girls and 44 boys, between the ages of 60-72 months ($\bar{x}$=64.86), attending preschool educational institutions in Istanbul.

2.3. Data Collection Tools

2.3.1 Cognitive Assessment System (CAS)

CAS is a test developed by Naglieri and Das (1997) for 5- 17-year-old children based on the PASS theory developed in line with Luria's (1973) research in neuropsychology to measure skills in four main cognitive processes (Planning, Attention-Arousal, Simultaneous, and Successive). CAS is organized as three separate yet interrelated score levels: individual subtests, PASS (Planning, Attention, Simultaneous, and Successive) composite scales, and a Full-Scale quotient. CAS has twelve subtests, each of which generates a scaled score. The instructions and materials for each subtest are divided into age-specific groups (5-7 years and 8-17 years). The validity, reliability, and norming study of CAS for 5-year-old children was conducted by Ergin (2003), and the analysis showed that the scale was both valid and reliable for 5-year-old children. The test-retest procedure showed that all subtests of the CAS, all scales in the Basic and Standard Batteries, and full-scale scores yielded statistically significant results. Reliability analyses showed that the internal Cronbach-Alpha coefficients of the CAS subtests and the Basic and Standard Batteries were .71 and above, and the scale was reliable. Pearson Product-Moment Correlation coefficients calculated for the scale's validity showed that the relationships between subscales were statistically significant at the $p<.01$ level.

The Planning Scale measures the student's ability to design and implement strategies to solve new problems. The subtests are Planned Codes, Planned Connections, and Matching Planned Numbers. Planned Codes require the individual to write specific codes. Planned Connections requires the person to connect a series of digits, numbers, and letters of increasing length and difficulty in a specific order as quickly as possible within a given time limit. In Planned Number Matching, each item presents the learner with an eight-row page. Each row has six numbers, and the learner is asked to find and underline two identical numbers on each row within a time limit (Best, et al., 2011; Ergin, 2003).

The attention Scale involves focusing attention on a specific activity. All CAS Attention subtests present children with activities having competing stimuli that require attention, requiring them to sustain focus throughout the performance of the activities. The Attention Scale subtests are Expressive Attention, Number Detection, and Receptive Attention. Expressive Attention is designed to measure selective and discriminative attention skills. Number Detection measures selective attention, asking to focus on a particular stimulus and resist distracting stimuli. Receptive Attention involves finding pairs of objects or letters that are apparently or lexically identical (Ergin, 2003; Naglieri & Otero, 2017; Naglieri et al., 2004).

The Simultaneous Cognitive Processing Scale measures how well one can combine separate stimuli into a conceptual whole. The Simultaneous Cognitive Processing Scale consists of the Matrices, Verbal-Spatial Relationships, and Shape Memory subtests. Matrices use spatially or logically related shapes and geometric layouts. Verbal-Spatial Relationship is a 6-item multiple-choice subtest in which each item consists of six drawings with a simple question at the bottom of each page. Shape memory asks the child to identify a recognizable geometric shape within a more complex design (Ergin, 2003; Naglieri & Otero, 2017).

The Sequential Cognitive Operations Scale was developed to test whether children understand the serial organization of events and, if yes, the extent of their understanding. The Sequential Cognitive Operations Scale comprises the Word Series, Sentence Repetition, and Visual Digit Span subtests. Word Series includes one-syllable, commonly used, and familiar words from everyday language. Sentence Repetition asks the child to repeat each sentence as it is presented. Visual Digit Span asks the child to recall a series of numbers in the order in which they are presented (Ergin, 2003; Naglieri & Otero, 2017; Naglieri et al., 2004).

Only the Planning and Attention subscales were used in this study because these domains are most relevant to the research objectives. These subscales specifically assess cognitive processes related to goal-directed behavior and attentional control, which are central to the study's focus.

2.3.2. Test of Early Mathematics Ability-3 (TEMA-3)

The Test of Early Mathematics Ability (TEMA) was developed by Ginsburg and Baroody (1983) to assess the mathematical abilities of children aged three to eight years and eleven months. In 1990, it was revised and published as TEMA-2. The validity and reliability study of TEMA-2 in Turkey was conducted by Güven (1997), and it was determined that the scale is valid and reliable. Later, the TEMA-2 test was revised again and developed as TEMA-3 in 1993. In TEMA-3, Forms A and B use materials such as pictures, mathematical symbols, and countable small objects. The validity and reliability study of TEMA-3 for children aged 60-72 months was conducted by Erdoğan and Baran (2006). In the test-retest reliability study, TEMA-3 Form A was administered to 100 children, and Form B was administered to 100 children, for 200 children. The correlation results (reliability coefficients) between the scores of the first and second administrations were as follows: Form A to Form A .90, Form A to Form B .88, Form B to Form B .90, and Form B to Form A .90. To test the reliability, the internal consistency coefficient was calculated, and the KR20 values for internal consistency were found to be .92 for Form A and .93 for Form B. To examine the criterion validity of TEMA-3, the mathematical ability levels of six-year-old children were taken as an external criterion. Based on teacher evaluations, TEMA-3 was administered to the top and lowest thirty children in terms of mathematical ability, and the Mann-Whitney U test results showed that the mathematical scores of the thirty children with the highest mathematical ability were significantly higher than those of the thirty children with the lowest ability, for both Form A and Form B. This finding demonstrates that TEMA-3 can differentiate between children with high and low mathematical abilities.

The test is administered individually to each child. It begins with a question corresponding to the child's chronological age, which is calculated beforehand. The test ends when the child fails five questions consecutively, and each response is marked as correct or incorrect. The number of correct answers is used to calculate the raw score, which is then converted into mathematical quotients. Based on the child's chronological age, the raw score helps determine the child's mathematical score from a score chart.

Practitioner training and permission for application were secured for the scale's use. In this study, Form A was utilized. The original scale demonstrated strong psychometric properties with high internal consistency. The reliability analysis recorded a KR-20 value of .92 for Form A, indicating high reliability and consistency (Erdoğan & Baran, 2006).

2.4. Data Collection

In this study, Pearson correlation analysis was conducted to determine the relationships between the variables. Multiple regression analysis investigated the predictive value of children's planning and attention skills on mathematical ability.

At the beginning of the study, the approval of the Maltepe University Ethics Committee was obtained on 30.05.2022, decision 2022/16-2 and number E-10267653-050.01.01.01-199963. Additionally, the necessary permissions were obtained within the "Collaboration Protocol in Education" framework, conducted between the municipality to which the preschools are affiliated and the institution where the researchers work. The researcher who administered the measurement tools completed the training and obtained the required certificates and permissions. After completing all required permissions before the study, the families were informed about the study in the preschool institutions; families interested in participating in this study first contacted the researcher by phone. The researcher gave preliminary information about the content of the study on the phone. At the end of this preliminary contact, "informed consent forms" were sent to the families who agreed to participate in the study through the administrators/teachers of the institutions. After the consent forms were signed, they were returned to the researcher. Then, the study was scheduled and conducted in the areas assigned at the institutions. Before starting the study, a short game was played with the children, and additionally, a 15-minute break was given between the administered measurement tools. Both measurement tools were applied as explained in the data collection tools section. The average duration of the administration was 90 minutes.

2.5. Data Analysis

Data was analysed by using SPSS 26.0. Before starting data analysis, potential errors were corrected by checking for missing data, outliers, and incorrectly entered values, as recommended by Pallant (2016). In the first stage, a box plot was used to check and remove outliers. In the second step, the normality of the data was tested. The skewness values were between -.226 and .436, and the kurtosis values were between -.225 and -.312. The values between +1.5 and -1.5 were accepted to show normal distribution (Tabachnick & Fidell, 2013). On the other hand, George & Mallery (2010) state that skewness and kurtosis values between -2 and +2 indicate normal distribution. Accordingly, the data distribution was normal, and Pearson correlation and multiple regression were used in the analysis. The number of participants in the study group meets the sample size requirement recommended in the literature for multiple regression models (Field, 2009; Green, 1991).

To begin with, after conducting Pearson Correlation Analysis, the assumption of a significant positive correlation between Early Mathematics Ability and the Planning ($r = .60$, $p < .01$) and Attention ($r = .40$, $p < .01$) subscales of CAS has been met. After revealing the interrelationships, multicollinearity between variables was checked before proceeding to multiple regression analysis. In this regard, VIF, CI, and tolerance levels were analyzed. As a result of these analyses, the VIF value was 2.29 for both variables, the tolerance was .44, and the CI value was below 30. So, it was decided that there was no multicollinearity between variables.

Another assumption that should be met for multiple regression analysis is that the error terms are normally distributed (normality), and their variance is constant (homoscedasticity). Figure 1 shows that the distribution of the error scores is normal and that the assumption of constant variance of the error terms (homoscedasticity) is met.

3. Findings

The relationship between early mathematical ability and the planning and attention subscales was examined using Pearson Correlation Analysis as presented in Table 1.

Table 1. Pearson Correlation Analysis for Tema–3 and planning and attention subscales of CAS

	Tema-3	Planning CAS	Attention CAS
Tema-3	-		
Planning	.601**	-	
Attention	.404**	.750**	-

As it is seen in Table 1, there are moderate and statistically positive and significant relationships between Early Mathematics Ability and the Planning sub-dimension (r=.60, p<0.01) and the Attention sub-dimension (r=.40, p < 0.01).

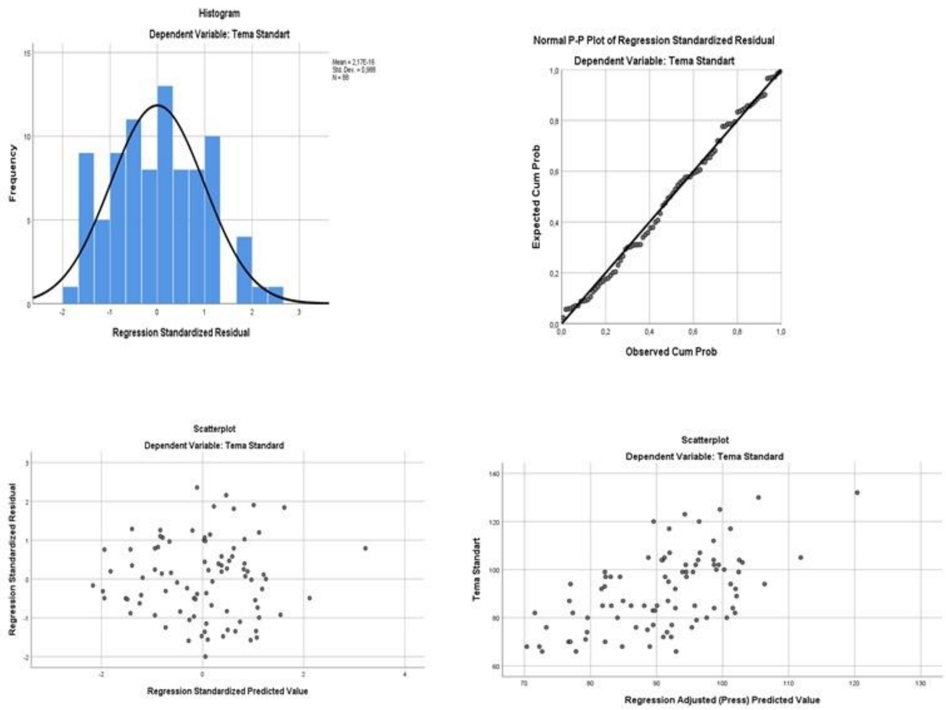

Figure 1. Distribution of error terms and homoscedasticity in multiple regression analysis

The results of the multiple regression analysis predicting early mathematics ability by the Planning and Attention sub-dimensions of CAS are shown in the table below.

Table 2. The results of the multiple regression analysis on the early mathematics skills total score and predictor variables

Variable	B	Standard Variation	*β*	*t*	*p*	Binary r	Partial R
Constant	32.34	12.39		*2.61*	*.01*		
Planning	.73	.14	.68	5.23	.00	.60	.49
Attention	-.15	.18	-.11	-.83	.41	.40	-.09
R=.61		R^2= .37					
$F_{(2, 85)}$= 24,611		p=.000					

As shown in Table 2, all predictor variables together explain 37% of the variance in the total score of early mathematics skills in a statistically significant manner (R = .61, R^2 = .37, F (2, 85) = 24.611, p<0.001). According to the standardized regression coefficients (β), the relative importance of the predictor variables on early mathematics skills is as follows: planning (.68) and attention (-.11). When examining the t-test results regarding the significance of the regression coefficients, it can be seen that planning ability (t = 5.23, p < 0.001) is a significant predictor. In contrast, attention ability (t = -0.83, p < 0.001) does not have a significant effect.

4. Discussion

This study examines the relationship between early mathematical skills in preschool children and the core components of executive function, namely planning and attention skills. The following results were obtained. It demonstrates that planning significantly predicts early mathematical skills and explains a moderate portion of the variance in early mathematical abilities. On the other hand, attention skills were not found to significantly contribute to predicting early mathematical ability. These findings highlight the importance of planning skills in early mathematical development and suggest that interventions to improve planning skills could positively impact preschool children's early mathematical abilities.

These results are consistent with previous studies in the literature that have identified the role of executive functions in the development of mathematical skills. Many studies report a direct relationship between developing executive functions across a wide age range and children's early mathematical skills (Blair & Razza, 2007; Bull et al., 2008; Clements et al., 2015; Harvey & Miller, 2017; Kroesbergen et al., 2007; Kroesbergen et al., 2009; Kroesbergen et al., 2003; Peng et al., 2018; Ribner et al., 2016). Best, Miller, and Naglieri (2011) have emphasized a similar relationship by pointing out that mathematics is a complex skill involving many executive function components. Studies in the literature show that planning skills are moderately related to academic achievement (Naglieri & Das, 1997; Naglieri et al., 2011; Naglieri et al., 2011; Best et al., 2011; Naglieri & Rojahn, 2004). Best, Miller, and Naglieri (2011) found a significant, moderate relationship between planning and mathematical skills in 5-year-old children. Specifically, planning may affect children's skills in solving mathematical problems, organizing tasks, and progressing step by step. The contribution of these types of executive functions to mathematical thinking processes lays the foundation for mathematical skills during the preschool period. Some experimental studies have shown that children with weak planning skills significantly benefit from cognitive strategy instruction that emphasizes planning in mathematical skills (Naglieri & Gotting, 1997; Naglieri & Johnson, 2000).

On the other hand, the limited role of attention skills on early mathematical skills in this study suggests that children's attention abilities are less determining in predicting mathematical achievement. However, there is research indicating a strong relationship between mathematical skills and attention skills (Altemeier et al., 2008; Blair et al., 2008; Brueggemann & Gable, 2018; Cueli et al., 2020; Walcott et al., 2010). According to researchers, executive function skills are the strongest predictors of mathematical problem-solving skills throughout development (Bull et al., 2008; Swanson, 2006; Van der Ven et al., 2012; Viterbori et al., 2015). Rabiner et al. (2000) reported that first-grade students' reading and mathematics skills and attention skills predicted their reading and mathematics success after the fifth grade. Duncan et al. (2007) also found that attention skills significantly predicted the mathematical skills of preschool children aged 60-72 months. In this sense, the inconsistency between our results and some previous studies may suggest implications for daily classroom activities. On the other hand, interventions focusing on executive functions may contribute to developing early mathematical skills, while stimulating early mathematical skills may support children's executive functions.

In a classroom environment, a child is expected to have the skills to sustain their attention by blocking out competing stimuli such as peer conversations, remembering information, following instructions, and switching their attention between tasks, for example, focusing on a task or the teacher (Morrison et al., 2010). The ability to perform such skills may enable children to participate in learning processes that are critical for academic success, and evidence suggests that children with high levels of executive function demonstrate better academic. (Van der Stel & Veenman, 2014). Rabiner et al. (2000) found that in the absence of activities aimed at developing attention skills in preschool, children may be at risk of academic failure when they start elementary school. According to this view, underdeveloped attention skills in elementary school may hinder the acquisition of basic academic skills and reduce the benefits children gain from formal education. However, experts argue that promoting mathematical skills can also enhance children's executive functions (Cueli et al., 2020). In line with this perspective, children who struggle with preparation-phase mathematical skills risk facing difficulties learning mathematics. Similarly, examining how preschool students with low executive functions progress in elementary school and how their mathematical skills develop is important.

In this study, while the effect of planning skills is significant, the lesser importance of attention suggests a need to re-evaluate educational policies and preschool programs. Specifically, focusing on planning skills in interventions to develop mathematical skills may help achieve more substantial and lasting mathematical success. However, attention skills should also be important for children's overall cognitive development. Given the potential interactions between attention, planning, and other executive functions, educational strategies that develop all these skills holistically should be created. Toplak, West, & Stanovich (2013) state that due to the complexity of the structure of executive functions, it is impossible to assess them with a single measurement tool.

In conclusion, the findings of this study suggest that interventions aimed at developing planning skills at an early age may contribute to mathematical achievement. However, a deeper examination of the role of attention and how these two skills work interactively is an important area for future research. This study has several limitations. First, using a convenience sampling method restricts the generalizability of the results. Future research conducted with larger and more socio-economically diverse samples could enhance the applicability of the findings to a broader population. Second, the measurement tools used in this study assess only specific components of executive functions. Given the multidimensional nature of executive functions, future studies are encouraged to incorporate different assessment methods (e.g., observations, performance-based measures, teacher or parent evaluations). Third, due to the study's design, causal relationships between variables cannot be established. Therefore, longitudinal studies could provide valuable insights into how the relationship between executive functions and mathematical skills evolves over time. Finally, it lasted approximately 90 minutes to conduct both measurement tools for participants.

Based on this study's findings and the existing literature, the following recommendations are considered to contribute to the literature. Future studies using mixed methods, supported by observation and interview data, can strengthen scientific research. Additionally, it is recommended that future studies include other components of executive function such as self-regulation, inhibitory control, flexibility, error correction, perception, resistance to distraction, and working memory. Performance-based executive function tasks should be used in studies with different groups, along with teacher or parent assessments. The relationship between planning, attention, and mathematical skills in preschool children from different socio-economic backgrounds can be examined. Considering that executive functions may be related to other psychological symptoms such as anxiety or emotional difficulties, a more detailed examination of the role of reaction time in the development of mathematical skills is suggested. Longitudinal studies can be conducted with different groups by rating these perspectives. Due to the time the study instruments are administered, different measurement tools may be used to assess children's mathematical skills and the execution of functional skills. Children who show low performance in preparatory mathematical skills and executive functions should be supported with educational interventions that improve their performance during the preschool period. Activities should be planned with a holistic approach. Teachers and teacher candidates may learn the importance of implementing a program that enhances planning and attention skills.

Statement of Researchers

Researchers' contribution rate statement:

YG: Conceptualization, investigation, resources, writing. DE: Conceptualization, data collection, methodology, writing – original draft preparation, writing – review & editing, data curation.

Conflict statement:

The authors declare that they have no conflict of interest.

Data Availability Statement:

The data supporting this study's findings are available on request from the corresponding author. However, the data are not publicly available due to privacy or ethical restrictions.

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Authors Biographies

Yıldız Güven graduated from Hacettepe University (1975), Child Development and Education Department; she got her master's degree in special education (Early Education of Mentally Handicapped) from the University of Illinois (1978). She worked at the Child Psychiatry Clinic at the University of Istanbul. She received his Ph.D. in Educational Sciences from Marmara University in

1997. In 2000, she became an associate professor in Preschool Education, and in 2008, she was promoted to professor. She retired from Primary Education Department from Marmara University in 2019.
Diğdem Enerem holds a bachelor's degree in Preschool Teaching, a double major bachelor's degree in Guidance and Psychological Counseling, and a master's degree in Developmental Psychology. She is currently working as a lecturer in the Department of Child Development at Maltepe University. Between 2019 and 2023, she worked with children, teachers, and families at the Street Children Application and Research Center using a peer-based therapeutic approach model through establishing attachment relationships. She continues to conduct workshop activities with children and families.

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