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THE RELATIONSHIP BETWEEN PRESCHOOL TEACHERS PEDAGOGICAL CONTENT KNOWLEDGE IN MATHEMATICS, CHILDRENS' MATH ABILITY AND LIKING

Abstract: This study attempts to identify preschool teachers' pedagogical content knowledge levels in mathematics and to examine its effect on preschool children's mathematics ability and their liking of mathematics. The study utilised the relational survey model, one of the general survey models. The working group was composed of 600 children aged 54-66 months old and a total of 150 teachers. The study employed three data collection tools: with the 'Preschool Teachers' Pedagogical Content Knowledge Scale regarding Mathematics' and the 'Mathematics Liking Scale for Children' developed by the researchers; 'Early Mathematics Ability Test' to determine children's mathematics ability. The data were analysed using IBM's SPSS 22 statistical package. The correlation analysis results suggested that there were no significant relationships between teachers' pedagogical content knowledge in mathematics, children's mathematics ability, and their liking of mathematics, while a positive and significant relationship was found between children's mathematics ability and their liking of mathematics.

Keywords*:* Mathematics Education Pedagogical Content Knowledge in Mathematics**,** Liking of Mathematics**,** Mathematics Ability.

Introduction

Mathematics is the heritage of humanity, from past to present. Mathematics has been a part of people's lives since the first human and has since become a significant source of all the sciences and is known as the common language of science, engineering, and technology (Berlinghoff & Gouvea, 2019).

Mathematical competency is defined as one of the important competencies in information societies in order to ensure individual success, active citizenship, social environment, involvement in the process, and employment (Anthony & Walshow, 2009). In this regard, mathematics education has gained in importance for many countries since maths skills are deemed critical for children's long-term success (Jang, 2013). For children to possess advanced mathematics skills is of significant importance in terms of countries being ready and able to react to potential problems and to come up with viable solutions (Clements & Sarama, 2011).

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Since infancy, children have unknowingly made use of the materials and environmental opportunities available within their socioeconomic and cultural context as they explore the world. As children discover the rich mathematics sources around them, they begin to learn mathematical processes and the basics of mathematics (Anthony & Walshow, 2009), and then progress to gain and apply mathematical concepts through their experiences (Fisher, 2004). Thus, children's mathematical skills develop over time. Considering that children's mathematical skills relate directly to the quality of their early childhood education (Hsieh & McCollum, 2018), mathematics-based activities in preschool mathematics education and the relevant curricula are paramount in revealing children's abilities in this area (Clements & Sarama, 2014; Erdoğan, 2006). Academic studies have revealed that children who are unable to acquire basic maths skills during the preschool period may experience difficulties in mathematics throughout their subsequent learning years (Clements & Sarama, 2010; Toll et al., 2011), which places on the importance of the learning experiences provided during preschool (Shamir & Baruch, 2012).

The organisation of activities that children will be interested in, through the support of adults during the preschool period, may direct their interest and attention towards mathematics-based activities (Fisher, 2004). The participation of children with activities that align with their interests and wishes affects them emotionally, and thereby increases their attention span for that activity (Dunst & Raab, 2013). Considering the notable differences in the interest and motivation of children who have just commenced their preschool education, they can be turned into activities that can increase their desire for learning by creating various different learning experiences (Thompson, 2002). Recent studies have revealed that activities prepared by taking into account the interests of children in order to provide them with high levels of motivation can positively impact on their success (Berhenge, 2013; Mokrova, 2012), and training given in the field creates increased learning permanence (Fisher, 2004).

Various factors such as teachers' knowledge, skill, attitude, and experience, along with children's interests and abilities in educational settings, can affect the mathematics development of children (Benz, 2016; Clements & Sarama, 2014; Lee, 2017; Litkowski et al., 2020). Teachers play an important role in fostering children's mathematics development to an optimal level. Mathematics-based activities enable children to make discoveries, acquire scientific process skills, and to understand measurement skills through the use of numbers (Wortham, 2006). Thus, for teachers to plan maths activities in accordance with different contents and objectives is significantly important in terms of children's mathematics development.

The fundamentals of children's understanding of mathematics in the future are laid with high quality, interesting and applicable basic mathematics education that will be encountered at an early age (National Council of Teachers of Mathematics [NCTM], 2013). NCTM (2000) indicated that both mathematics curricula and teaching practices should be constructed on a pedagogically sound basis by taking into account both the maths content areas and the children's developmental characteristics. Thus, teachers' knowledge levels and skills about math education are deemed critical for the preparation of appropriate curricula for children, both in terms of supporting children's mathematics development and in their developing a positive attitude towards mathematics (Copley, 2010; Hsieh & McCollum, 2018).

In preschool education, teachers play an active role in both the structure of the educational environment and the selection of educational materials. They are also responsible for making a classroom environment appear sufficiently intriguing, and within which children will want to learn Teachers who are experienced in mathematics education can help children to develop positive attitudes towards mathematics by using research-oriented materials and in actively valuing the children's own ideas; moreover, they can create environments where each child can develop new ideas, as well as construct their own knowledge and ideas through their own learning (Clements & Sarama, 2014; Copley, 2010).

In line with organising the right learning environment, one of the most important factors in supporting children's development and achievement in the educational process is the teacher's own teaching ability and the quality of their instruction (Ergen, 2018; Zhang, 2015). Teaching ability and the quality of teachers are factors that can directly affect children's academic achievement (Guerriero, 2014). These factors signify that teachers have the right level of qualified knowledge, skills, and also experience regarding mathematics to ensure that children understand foundational mathematics (Zhang, 2015). In this regard, teachers should first set a goal related to mathematics, choose a path to be followed in accordance with the children's developmental characteristics, and then prepare appropriate activities that will help them to develop their mathematical thinking levels (Clements & Sarama, 2010). Studies have revealed that mathematics activities not carried out appropriately are not considered advantageous for preschool children (Gasteiger & Benz, 2018).

A high level of pedagogical content knowledge is an important criterion for teachers to be effective in the application of mathematics education (Jang, 2013). Pedagogical content knowledge is knowing what age group will be taught and how it can be integrated with knowledge. Pedagogical content knowledge in education was first introduced by Shulman (1986) and means a teacher creating an effective and efficient learning and teaching environment for the children they are to teach. McCray (2008) defined the intersection point of the questions of *'Who will teach?'*, *'What to teach?'* and *'How to teach?'* as pedagogical content knowledge in mathematics education.

The combination of pedagogical content knowledge, content knowledge, and the teaching ability of a teacher are the keys to children's success in learning (Jang, 2013; Zhang, 2015). Teachers who have wide-ranging knowledge of content related to lessons or activities, who can develop problem-solving strategies and apply them within the classroom environment by diversifying their learning experiences, who have high decision-making skills and who are sensitive and respectful to the children and their opinions in the classroom environment may be said to have wider pedagogical content knowledge (Guerriero, 2014). Although teacher's knowledge is an accepted prerequisite for being a good teacher, having high levels of knowledge alone does not necessarily equate to being a good teacher, which requires much more than just knowledge. The teacher's pedagogical content knowledge, skill, attitude, and motivation etc. can affect learning and teaching in different dimensions (Guerriero, 2014; Zhang, 2015).

Studies have shown that teachers with better content knowledge or higher pedagogical content knowledge can positively affect children's achievements; and that high-level pedagogical content knowledge is more effective in education than high-levels of content knowledge as pedagogical content knowledge directly affects the quality of the education they provide (Hill et al., 2005).

Today, there is a need for teachers to have a good level of mathematics knowledge and skills, high levels of mathematics pedagogical content knowledge, and to encourage mathematics-based learning in order to raise children with advanced mathematics skills (Gasteiger & Benz, 2018).

Having analysed the relevant literature, it can be seen that studies conducted on preschool teachers' mathematics knowledge are quite limited (Aksu & Kul, 2017; Argın & Dağlıoğlu 2020; Fırat & Dinçer, 2018; McCray, 2008; Parpucu & Erdoğan, 2017; Tirosh et al., 2011). In addition, no studies have specifically focused on the interests of preschool children in mathematics or their liking of mathematics. Since the importance of communication between teachers and the students becomes more evident in a child-centered approach that is based on the interests and needs of the child in preschool education, the teacher's pedagogical approach and the child's liking of the activities can positively affect their success.

Based on this finding, the current study attempts to examine the relationship between the children's level of liking mathematics, their teacher's pedagogical content knowledge, and the children's mathematical ability. In focusing on this aim, answers to the following questions were sought.

1. What is the level of preschool teachers' pedagogical content knowledge in mathematics?
2. Does teachers' pedagogical content knowledge in mathematics vary significantly by the type of school from which they graduated, their occupational experience, the type of institution at which they work, or the age group of children with which they work?
3. What is the children's mathematics ability level?
4. What is the children's level of liking mathematics?
5. Is there a statistically significant relationship between teachers' pedagogical content knowledge in mathematics, children's mathematics ability, and children's level of liking mathematics?

Methodology

The study utilised a relational survey model, one of the general survey models, as it aims to portray the relationship between preschool teachers' pedagogical content knowledge in mathematics and children's mathematics ability, as well as their liking of mathematics. Relational survey model is one of the general survey models used to determine the presence or degree of co-exchange between two or more variables (Fraenkel & Wallen, 2009).

Working Group

The study was conducted with preschool children and their teachers. The working group consisted of 150 teachers working with 54-66-month-old children attending formal independent kindergartens and kindergartens within primary and secondary schools affiliated to the Turkish National Ministry of National Education (MoNE) in the of Kahramanmaraş province, Turkey, during the 2017-2018 academic year. In addition, a total of 600 children attending these same kindergartens were included in the current study, where they were considered by their teachers to be making 'normal academic progress'.

Data Collection Tools

The study employed three data collection tools: 'Preschool Teachers' Pedagogical Content Knowledge Scale regarding Mathematics' (PTPCKSM); 'Early Mathematics Ability Test' (TEMA-3); and, 'Mathematics Liking Scale for Children' (MLSC).

Preschool teachers' pedagogical content knowledge scale regarding mathematics

The PTPCKSM scale was developed by Dağlı et al. (2019) with the aim of identifying teachers' awareness regarding mathematical content and processes in the language used by children. The tool includes five case studies based on the dialogues involving different maths content and processes designed through the instrument of expression used by children during the game.

The case studies included in the PTPCKSM involve mathematical contents based upon the NCTM (2000) standards such as '*counting, geometry, spatial perception, part-whole relationship, matching, classification/grouping, comparison, sorting, measuring, processing, patterns and graphics*' ; moreover, '*communication, connections, reasoning and proof, problem solving and representation/symbolization*' were included as the mathematical processes. Each case study consists of seven sentences (items). A mark-up form was created for each case study and teachers were asked to mark the maths content and processes they identified in accordance with this form.

For the validity of the scale, the scope and construct validity were examined, and both Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA) were performed. Seven experts' views were taken in order to determine the scope validity for the 'PTPCKSM', and all of the items were found to be suitable for usage in the scale. As a result of the evaluations regarding the 'PTPCKSM', the scope validity index was calculated as '+1', meaning that all items in the scale were deemed to be valid and that the scale provides scope validity as a whole (Büyüköztürk, 2010; Yurdugül, 2005). The internal consistency coefficient (Cronbach Alpha) of the scale was determined as .96.

The Exploratory Factor Analysis results confirmed the two-factor structure of the scale, and that these two factors covered 78.41% of the total variance of the scale. In addition, 73.11% was explained by the 1st factor and 5.30% by the 2nd factor. In terms of both the eigenvalue and the explained variance, the 1st factor was determined to be 14 times more dominant than the 2nd factor, and therefore the scale was evaluated as a single 1-factor scale. Upon analysing the factor loads of each relevant item, no item was found to have a factor load value below .30. Confirmatory Factor Analysis was conducted using the MPlus 7.4 program in order to test the construct validity of the scale in the main implementation. When the goodness of fit indices of the model were examined, the CFI and TLI values were noted to be both greater than .90, and the RMSEA and SRMR values were both less than .08, and therefore the model was deemed to be at an acceptable level. The results of the statistical calculations revealed the scale to be a valid and reliable measurement tool.

Test of early mathematics ability (TEMA-3)

The TEMA was developed by Ginsburg and Baroody in 1983 in order to evaluate the mathematical knowledge of children aged 3 years up to 8 years, 11 months. It was revised in 1990 and republished as 'TEMA-2', and was then updated in 1993 as 'TEMA-3' (Ginsburg & Baroody, 2003). TEMA-2's validity, reliability tests and adaptation studies were conducted by Güven (1997), while TEMA-3's was conducted by Erdoğan (2006). The test consists of 72 questions that measure informal mathematics fields such as more or less, counting, informal calculation, processing, and formal mathematics fields such as numbers, associations between numbers, computation and decimal concepts. The TEMA-3 consists of two similar parallel forms ('Form A' and 'Form B') that were designed to measure children's mathematical skills (Ginsburg & Baroody, 2003).

Pictures, mathematical symbols, and countable small objects are used as materials in both Form A and Form B of TEMA-3. The test is administered to children individually. The starting question corresponds to the child's age, with the test starting from the 1st item for children aged 36-48 months old, the 7th item for 48-60-month-old children, the 15th item for those aged 60-72 months old, the 22nd item for 72-84-month-old children, the 32nd item for 84-96-month-old children, and from the 43rd item for 96-107-month-old children. The questions previous to the respective start-point are accepted as being all correct. The test is terminated when there are five consecutive questions that the child is unable to attempt. Each item is marked as true or false, and the number of correct answers indicates the raw score. Raw scores are then converted into maths quotients. According to the age of the child, their maths score is then determined according to the quotients chart by taking into account the raw score obtained from the test. An increase in the maths score of a child reveals an increase in the child's mathematics ability (Ginsburg & Baroody, 2003).

The validity and reliability studies of TEMA-3 and its adaptation to the Turkish context were conducted by Erdoğan (2006). Experts' views were sought during this process and the items, statements, and pictures confirmed by the experts were included in Form A and Form B of the scale's Turkish version. After ensuring the scope validity of the scale, test-retest implementation was performed and the reliability of the scale examined. The analysis results revealed that the test-retest correlation between the groups was calculated as .90 from Form A to Form A, and .88 from Form A to Form B. As for Form B, the correlation was calculated as .90 from Form B to Form B and

.90 from Form B to Form A ($p < .01$). These results showed a high degree of correlation between the measurements, proving that the parallel forms of the scale could be used interchangeably. In her study, Erdoğan (2006) also calculated the internal consistency coefficient to analyse the reliability of the test. Accordingly, the internal consistency coefficient of TEMA-3 was found to be .92 for Form A and .93 for Form B, and that the internal consistency was therefore identified as being high.

Prior to the application of the scale, the lead researcher sought and obtained permission to apply the scale, and commenced 'TEMA-3 Application Training' with the children. The TEMA-3 was administered to a total of 600 children on an individual basis by the researcher, and the children's responses were then individually coded and scored.

Afterwards, another expert who had received the TEMA-3 training then separately re-coded the TEMA-3 scores again for 260 of the participant children. Then, the two sets of codings were compared in terms of their similarity and consistency based on the formula proposed by Miles and Huberman (1994) 'Reliability = Agreement/(Agreement + Disagreement)' and the consistency was ensured between the scores determined by both the researchers and another expert who had received the TEMA-3 training. Thus, the consistency between the coders was calculated as .97, which means that the coding was deemed to be reliable and that the consistency between the scores was high.

Mathematics liking scale for children

The MLSC was developed by the researchers in order to understand the participant children's ideas about mathematics, and also to gather information about their motivation towards mathematics (Dağlı & Dağlıoğlu, 2018). During the preparation process of the scale, Turkey's Preschool Education Curriculum (MoNE, 2013) as well as preschool curricula from various other countries were used as a guide with an eclectic view taken based on different approaches and models.

It was seen that the activities should be child-centred and that the children's views should be taken into consideration during the evaluation and planning stages. In addition, the researchers aimed to develop a measurement tool to record the children's views for due consideration, and to provide the teachers with data regarding the children's thoughts according to the processes highlighted in the Turkish Preschool Education Curriculum (MoNE, 2013). Six basic sets of mathematics contents were determined based on the Turkish Preschool Education Curriculum (MoNE, 2013) and the NCTM (2000) standards, and each identified content set then formed the sub-dimensions of the scale. Different materials were prepared in accordance with these content sets, and one female and one male child then used these materials in order to test them, and this process was recorded as short video clips. These videos were then used to provide concrete experiences to children while collecting data regarding the content.

The tool consisted of three parts. First, a 'Child-Family-Class Information Form' gathered demographic information such as the child's gender, age, and their period of preschool education up until that point. Second, a 'Child Registration Form' consisted of semi-structured open-ended questions related to the children's ideas about mathematics, which included images of the videos used in the scale, and the status of the children in recognising the materials used in the videos or their previous usage then examined.

The third part formed the core base of the MLSC, and contained videos not exceeding 2 minutes in which one female and one male child spent time using materials in accordance with the six determined basic mathematical content sets, where the children expressed their opinions, and the level of the children's liking of the maths activities was determined accordingly. The tool included numbers and counting with a number line, the contents of creating free composition with geometric shapes, the puzzle-piece-whole relationship, grouping with coloured shapes in boxes of the same colour, matching cards with different numbers of objects and numbers, and measuring with an equal scale. Since preschool children are not deemed able to read or write in general, their facial expressions were noted in order to determine the children's liking of mathematics. The MLSC was prepared as a 3-point, Likert-type scale consisting of 7 items in total.

All of the items presented to the experts for their views were found to be suitable for use in the scale. The content validity index was determined as '+1' following the experts' evaluation. Overall, all of the scale items were accepted, and the scale deemed to provide scope validity as a whole (Yurdugül, 2005).

The content-validity ensured scale was then administered to 100 children aged 54-66 months old, 50 of whom were female and 50 male. The test-retest method was then applied in order to calculate the reliability of the MLSC, and the internal consistency coefficient (Cronbach Alpha) was then calculated. Accordingly, the Test-Retest Correlation Reliability Coefficient was identified as .88, whilst the internal consistency coefficient (Cronbach Alpha) was determined as .75.

The study also utilised the Kaiser-Meyer-Olkin test and Bartlett Sphericity test for the Exploratory Factor Analysis of the scale, and CFI, TLI, RMSEA, and SRMR values were also calculated for the purposes of Confirmatory Factor Analysis. The Exploratory Factor Analysis was applied to both the first and second application. The Kaiser-Meyer-Olkin result was found to be .85 for the first application and .84 for the second, whilst the Bartlett Sphericity result was found to be statistically significant for both applications ($p < .01$). The Exploratory Factor Analysis results suggested that the scale had a single factor structure. In the first application, 53.4% of the total variance of the scale was explained in the first application, while 48.8% variance was explained in the second application. Overall, no items were found with a factor load value below .30.

Confirmatory Factor Analysis was also performed with the data obtained from the 600 participant children in order to test the construct validity of the scale. Considering the goodness of fit indices, the model was found to be at an acceptable level ($\chi^2(7.600) = 9.76$; CFI = .99; TLI = .99; RMSEA = .03; SRMR = .02). The analyses revealed that the scale was found to be a valid and reliable measurement tool for the purposes of evaluating 54-66-month-old children.

Data Collection Process

The study was conducted with 54-66-month-old children, and their teachers, attending official independent kindergartens and kindergartens within primary/secondary schools affiliated to the Turkish Ministry of National Education in the districts of Kahramanmaraş, during the 2017-2018 academic year.

The teachers were informed about the PTPCKSM scale by the lead researcher and the necessary evaluations were performed together.

In the part of the study that was conducted with the children, the teachers were briefed in advance by the researchers, with summary explanations provided for both the MLSC and TEMA-3. The teachers then identified four children considered to be of 'normal development' in their respective classes and forwarded the necessary information provided by the researchers to each of the children's families.

The researchers then spent a short amount of time with the children during the game process, and then interviewed the four children individually in accordance with the guidelines of the scale. During the child interviews, both the TEMA-3 and MLSC were administered. A quiet and calm environment was prepared in advance for the interviews in order that the children would not be distracted, and were therefore able to watch the videos in an appropriate location set aside by the institution. The TEMA-3 and MLSC were administered to each child with up to a 1-day interval between, based according to their developmental characteristics and attention span. Children who did not want to participate in the study were not forced to continue, and their interviews were terminated at that point.

Data Analysis

This study tested whether or not children's mathematics ability, their liking of mathematics, and teachers' pedagogical knowledge in mathematics showed normal distribution. The analysis results showed that each dependent variable was confirmed as being normally distributed, and thus parametric tests were applied.

Descriptive statistics method was used to calculate children's mathematics ability, their liking of mathematics and teachers' pedagogical knowledge in mathematics. One-way analysis of variance (ANOVA) was used to identify whether teachers' pedagogical content knowledge levels related to mathematics differed by the type of school from which they graduated, their length of occupational experience, and the type of institution at which they worked.

Since age and gender variables each consist of two categories, independent sample *t*-test was used to determine whether children's mathematics ability, their liking of mathematics and teachers' pedagogical content knowledge in mathematics varied by the children's age or gender. Pearson Correlation Analysis was used to identify the relationship between children's mathematical ability, their liking of mathematics, and their teachers pedagogical content knowledge levels.

Findings

The findings of the research, which was conducted with the aim of examining the preschool teachers' pedagogical content knowledge, children' mathematical ability, and their liking of mathematics, are presented in this section using a set of 8 tables.

Table 1. *Medium, lowest, and highest score distribution of teachers' pedagogical content knowledge levels in mathematics*

	N	$\bar{X}$	*SD*	Lowest score	Highest score
PTPCKSM	150	12.04	6.98	2.46	28.22

Table 1 shows that the average level of the teachers' pedagogical content knowledge was 12.04. Additionally, the teachers' highest score was 28.22, while their lowest score was 2.46.

Table 2. *Response distribution of teachers' mathematics content and process skills*

Mathematics Content	%
Counting	62.6
Graphic	56.0
Geometry	54.4
Matching	53.8
Pattern	47.0
Comparison	46.6
Measuring	45.5

Mathematics Content	%
Ranking	41.8
Classification/ grouping	29.8
Process	27.3
Part-whole	27.2
Spatial perception	25.9
No mathematical expression and or skill	0.00
Mathematics Processes	
Communication	58.9
Problem solving	48.1
Reasoning and proof	47.6
Association	46.8
Representation / visualization	45.9

Table 2 shows the distribution of responses regarding the teachers' mathematics content and process skills. Accordingly, the teachers mostly responded to 'counting' 'graphic' and 'geometry'; in addition, they mostly responded to 'communication' and 'problem solving' in terms of process skills.

Table 3. *Distribution of teachers' pedagogical content knowledge levels in mathematics by graduation school type*

	School type	*n*	*X̄*	*SD*	*f*	*P*	Post-Hoc (Tukey)
Pedagogical Content Knowledge Levels in Mathematics	Vocational College (Child Development)	32	7.70	4.62	14.97	.000	1-2 1-3 2-3 3-4 3-5
	Undergraduate (Preschool Education Teaching)	396	11.36	6.05			
	Undergraduate (Child Development / Education Teaching)	136	15.60	8.91			
	Postgraduate	24	10.50	5.23			
	Other	12	9.03	3.14			

According to Table 3, a statistically significant difference was identified as a result of the ANOVA tests conducted to analyse whether teachers' levels of pedagogical content knowledge in mathematics significantly differed by the type of school from which they graduated ($p < .05$). The Post-hoc Tukey test result showed that the average score of teachers who graduated from a 'preschool education undergraduate programme' was higher than that of teachers graduating from a 'vocational college child development programme' In addition, the average score of teachers who graduated from a 'child development/education teaching undergraduate programme' was determined to be higher than those graduating from 'other' departments.

Table 4. *Distribution of teachers' pedagogical content knowledge levels in mathematics by occupational experience*

	Occupational experience	*N*	*X̄*	*SD*	*F*	*p*
Pedagogical Content Knowledge Levels In Mathematics	Less than 1 year	4	13.98	9.09	2.10	.069
	1-5 years	23	10.76	7.09		
	6-10 years	64	13.45	7.56		
	11-15 years	37	12.41	6.38		

	16-20 years	13	9.00	5.36
	21 years or more	9	7.43	2.44

As can be seen from Table 4, there was no statistically significant difference found between the teachers' pedagogical content knowledge levels in terms of their occupational experience ($p = .069$), meaning that the teachers' pedagogical content knowledge levels did not significantly vary by how many years of occupational experience they had completed at the time the study was conducted; in general, as their occupational experience increased, their pedagogical content knowledge levels in mathematics decreased.

Table 5. *Distribution of teachers' pedagogical content knowledge levels in mathematics by children's age group*

	Children's age group	*n*	$\bar{X}$	*SD*	*t*	*df*	*p*
Pedagogical Content Knowledge Levels in Mathematics	54-60 months old	38	12.73	7.18	-2.00	148	.023
	61-66 months old	112	11.57	6.82			

As a result of the independent samples *t*-test, that was conducted in order to determine whether the teachers' levels of mathematics pedagogical content knowledge differed based on the children's age group with which they worked, a statistically significant difference was noted between the pedagogical content knowledge levels in mathematics of those teachers working with the 54-60-months-old group, and those working with the 61-66-months-old group ($p < .05$). This situation was found to be in favour of those teachers working with the 54-60-months-old group.

Table 6. *Medium, lowest, and highest score distribution of children's mathematics ability level*

	N	$\bar{X}$	*SD*	Lowest score	Highest score
Children's mathematics ability level	600	108.56	5.98	80	128

As can be seen from Table 6, the average mathematical ability level of all the participant children (aged 54-66 months old) was determined as 108.56.

Table 7. *Medium, lowest, and highest score distribution of children's mathematics liking level*

	N	$\bar{X}$	SS	Lowest Score	Highest Score
Children's mathematics liking level	600	17.49	3.19	7	21

As can be seen in Table 7, the average mathematics liking level of all the participant children (aged 54-66 months old) was determined as 17.49, and the mean level was found to be at the 'upper level'.

Table 8. *Relation between teachers' pedagogical content knowledge and children's mathematics ability and mathematics liking level*

	PTPCKSM	TEMA-3	MLSC
PTPCKSM	1.00*	.01	.06
TEMA-3		1.00*	.08*
MLSC			1.00*

*$p < .05$

As a result of the Pearson Correlation Analysis shown in Table 8, no statistically significant relationship was identified between the teachers' pedagogical content knowledge and children' mathematics ability ($r = .01$, $p = .898$), and their liking level of mathematics ($r = .06$, $p = .125$). However, the relationship between the children's mathematical ability and their liking level of mathematics was found to be statistically significant and positive ($r = .08$, $p < .05$).

Discussion and Conclusion

The current study was conducted in order to determine preschool teachers' pedagogical content knowledge in mathematics, children's mathematics ability, and their level of liking mathematics, and also to identify the predicting variables.

The study first analysed the preschool teachers' pedagogical content knowledge levels in mathematics and as a result, their pedagogical content knowledge average was found low level (Table 1). Upon analysing the relevant literature on early childhood educators' pedagogical content knowledge regarding mathematics, the published studies concluded that early childhood educators were found to have a low level of pedagogical content knowledge in mathematics (Argın, 2019; Ma, 2010; Zhang, 2015). In Hong (2013) analysed preschool preservice teachers' and teachers' knowledge of children's mathematics development and their beliefs about mathematics education, and both groups were found to be lacking in their understanding of how to help children through the teaching of mathematics. McCray and Chen (2012) noted that educators had a medium level of pedagogical content knowledge in mathematics. In other words, they stated that they had a pedagogical knowledge level regarding mathematics that could help children to understand and comprehend the situations around them related to mathematics. Overall, similar results were obtained to those of the current study's findings.

Where an evaluation was made based on the correct responses of the teachers regarding mathematics content and process skills, the teachers were seen to mostly distinguish counting, graphic, and geometry contents, as well as communication and problem-solving process skills (see Table 2). Given that the teachers were likely prone to applying the concepts and skills that they were most familiar with in their practices, it is significant to mention that the teachers possessed limited content knowledge regarding mathematics education. In another study conducted on this subject, teachers were found to score above average in comparison, ranking, and shape perception in terms of their pedagogical content knowledge in mathematics, but obtained scores below average in number perception, pattern, and spatial perception (Argın & Dağlıoğlu 2020). Upon examining the maths concepts and skills that teachers use during their practice sessions in the classroom based on mathematical language, they were determined to frequently use expressions that include the concepts of counting/digit/number, time, shape, quantity, and location (Fırat & Dinçer, 2018; Piasta et al., 2013). For these results, it can be said that the teachers in these studies demonstrated limited knowledge regarding mathematics. In addition, Lee (2017) concluded that teachers possessed higher levels of pedagogical content knowledge about number sense, measurement, and classification, and that educators require greater knowledge for the application of practices in geometry skills. Although the teachers were determined to have satisfactory levels of pedagogical content knowledge with regards to different mathematical concepts and skills, especially in terms of maths contents, similar results emerged in studies based on their mathematics knowledge about concepts and skills in general being quite limited. In this regard, teachers' pedagogical content knowledge in mathematics being quite low may be considered as evidence of the similarity to the results of the current study.

The current study's findings suggested that the teachers' pedagogical content knowledge levels differed significantly based on the type of school from which they graduated, and that the average scores of teachers graduating from undergraduate Child Development and Education Teaching programmes were higher than for teachers graduating from other programmes (see Table 3). This may be due to teachers being trained according to different content matrices in different undergraduate programmes. In other words, the theoretical and practical weightings of courses in Preschool Teaching undergraduate programmes and those in Child Development/Education programmes may be quite different from each other.

When the curricula of Preschool Education and Child Development/Education Teaching undergraduate programmes published by the Turkish Board of Higher Education (Council of Higher Education [CoHE], 2018) were examined, the Child Development/Education Teaching programmes appear to be more advantageous, especially in terms of their practical course hours. This infers that teachers' pedagogical content knowledge in mathematics is positively affected according to their experience gained in more practical applications during their undergraduate education by working with children of different developmental characteristics. In this context, the 'Mathematics Education in Early Childhood' course in Turkey is stated as including 3-hours per week of theoretical lessons within the Preschool Teacher undergraduate programme, according to the Turkish Board of Higher Education (CoHE, 2018). The content of the Mathematics Education course in early childhood covers all content and process standards related to mathematics education, including the planning and theoretical application of mathematics activities, yet this course does not include any actual implementation. On the other hand, the Child Development/Education Teaching programmes include practical applications for maths activities in the 'Field Study' and 'Summer Internship' lessons, along with the 'Mathematics Education' lesson in the Child Development undergraduate programme, as well as many application courses for different groups of children (e.g., children in hospital, children with special needs) (Ankara University, 2019; Karabük University, 2019). This situation is thought to result in teachers who graduated from Child Development/Education Teaching programmes being more successful than those graduating from other undergraduate programmes in terms of their preparation of appropriate maths activities for children.

When teachers' pedagogical content knowledge level and their occupational (teaching) experience were analysed, no significant difference was identified; however, as their experience increased, the pedagogical content knowledge level in mathematics was generally found to have decreased (see Table 4). This relationship may be explained as teachers not having sufficiently worked to develop their professional knowledge and skills after commencement of their teaching career, or that they experienced professional burnout. Weisberg and Sagie (1999) stated that teaching can be a stressful job, and that increasing levels of professional stress in teachers can lead to burnout, and thereby negatively affecting the quality of their teaching. Likewise, Parpucu and Erdoğan (2017) concluded that preschool teachers used the mathematical language in classroom activities less in the first years of their teaching career, and then more in the 6-10-year period, but that it then decreased again in the subsequent years. These results are also considered to be in line with those of the current study.

When the teachers' pedagogical content knowledge levels were analysed in terms of the age group of the children that they taught, those working with 54-60-months-old children were found to have higher knowledge levels than those working with 61-66-months-old children (see Table 5). Upon examining the related literature in this area, it was seen that teachers are required to have knowledge about pedagogical strategies that can be applied in providing effective mathematics education for all children during their preschool period; moreover, that they should take into account the children's cognitive development characteristics, age-related developmental stage, individual differences, and their motivation and interests (NAEYC, 2009). In this regard, the current study's findings that teachers working with children aged 54-60 months old had higher pedagogical content knowledge levels than those working with children aged 61-66 months old may be due to the teachers working with the younger age group being more involved in basic maths-related activities, and thereby mostly having adopted a teacher-centred approach in the classroom. In a study conducted by Baki and Hacısalihoğlu Karadeniz (2013) on teachers' reflections of in-class mathematics applications in the Turkish preschool curriculum, the teachers were found to prefer the teacher-centred approach and other familiar methods. In addition, Pekince and Avcı (2016) conducted a study that evaluated how preschool teachers approached early childhood mathematics in their activity plans they implemented, and determined that different teachers applied numerous common activities and that the majority of the activities were teacher-centred. These results also parallel those of the current study.

Considering the mathematical ability level of the children in the current study who were aged 54-66 months old, they were found as above average (see Table 6). The relevant literature shows that various factors such as the child's home, the materials presented to children, the familial attitude etc. were all deemed to be effective in terms of high mathematical ability levels in children. Thus, the home environment and engagement in activities can positively affect children's ability and their levels of motivation (Ngussa & Gundula, 2019). Similarly, a number of studies revealed that the parents' education level, the income level of the family, different educational approaches, the materials and also the home learning environment were all found to positively affect children's mathematics ability (Erdoğan et al., 2017; Kandır & Koçak Tümer, 2013; Kleemans et al., 2012). The current study also suggested that the children's mathematics ability in this case was above average, indicating that the activities and materials presented to them in their home and school environment positively affected their level of interest, ability and love of mathematics.

Having examined the 54-66-months-old children's liking level of mathematics, the children were found to like mathematics at an overall high level (see Table 7). This may be due to the children not having encountered a negative maths life experience up until that point, and that they were therefore willing to accept activities without prejudice. The children had not frequently encountered activities or materials that addressed different areas of mathematics, nor had they watched videos about the use of new materials during the application of the scale; combined, these may be considered as being effective in developing positive views with regards to mathematics. Ojose and Sexton (2009) analysed the effect of manipulative materials on the achievement of first-grade students in mathematics. Accordingly, they found that the use of educational materials not only supported the cognitive process in mathematics learning, but also increased the interest of children in mathematics as well as their enjoyment of mathematics. Therefore, the results of Ojose and Sexton's (2009) study were found to be consistent with those of the current study. Other studies revealed that the content of mathematics aided with materials positively affected children's maths achievement and their attitudes towards maths; and materials that attracted children's attention also seemed to increase their levels of motivation (Aydoğdu et al., 2014).

The findings revealed no significant relationship between the teachers' pedagogical content knowledge and children's mathematics ability and the liking level of mathematics, yet there was a statistically significant and positive relationship found between children's mathematics ability and their liking level of mathematics (see Table 8). The findings showed that teachers had a low level of pedagogical content knowledge in mathematics; furthermore, the educational activities offered were insufficient to support the children's mathematical development. There is a consensus in the related literature on the idea that teachers have a critical role in building a solid mathematical foundation in children (Ball et al., 2008; Charalambous et al., 2019;). However, the current study's results showed that the teachers' pedagogical content knowledge in mathematics did not have an effect on children's mathematical abilities or their liking level of mathematics. In the study carried out by Güven et al. (2012), the teachers were determined to generally draw the children's attention to the process during the activities, but that they did not afford them the opportunity to express themselves, explain the meaning of the action they did, or explain the underlying reason behind their responses. The studies also signified that it is possible for children to enjoy activities within environments enriched with different materials and the correct applications, as well as opportunities for children to learn mathematics (Erdoğan et al., 2017; Marshall & Swan, 2005;). The inability of preschool teachers to adequately support children's mathematics development in classroom practices can be associated with the mathematics education they receive during their undergraduate education. All these may negatively affect their attitudes, beliefs and self-efficacies when they themselves later become teachers.

The current study found a statistically significant and positive relationship between the mathematics ability of children and their liking of mathematics; and that this may be explained by children being willing to repeat activities in which they were previously unsuccessful, and that their success increases their interest in the activity. When as child likes an activity, it increases their educational success and concentration on the activity; moreover, it is also a means to increasing their motivation towards mathematics (Hidi & Renninger, 2006). In other words, as children like mathematics, their abilities may be said to increase, and their maths abilities develop.

The current study's research results pointed out that preschool teachers' knowledge, skills and experiences regarding content and process skills related to mathematics education should be further developed. As children generally like mathematics and have high levels of mathematics ability, it is necessary for teachers to develop their professional knowledge, skills and experiences in order to conduct their mathematics development to the highest level. The active learning environments that teachers provide to children during early childhood and the methods that they apply in the classroom are of significant importance when it comes to the development of math concepts and skills that a child will use themselves in the subsequent years. However, it would be useful to include the family dimension in future studies considering the role of children in the development of their mathematics skills within the home environment and through family activities. In addition, studies based on a mixed-methods approach, in which the documents used by teachers to plan their daily flows and in-class observations are examined, will help to support preschool children's mathematics concept development. Increasing the competencies, knowledge and skills of preschool teachers, as well as providing additional applied training on mathematics content, process skills, and the use of the language of mathematics will help to contribute to the effectiveness of mathematics education. Organising in-service training, conferences or applied seminars on preschool mathematics education through collaborations with the MoNE and universities in Turkey would provide an opportunity for teachers' self-improvement in the area of mathematics education. Conducting workshops in which good examples related to both mathematics and other fields are examined could also be effective in the development of teachers' competence in media regulation, activity and field knowledge, and in the development of their pedagogical content knowledge in mathematics.

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