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Pre-school Teachers' Attitudes towards Mathematical Pedagogical Content Knowledge, Mathematics, and Mathematics Teaching*

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ABSTRACT

This study was carried out to examine the relationship between preschool teachers' mathematical pedagogical content knowledge (MPCK), their attitudes towards mathematics (ATM), and their attitudes towards mathematics teaching (ATMT). The research method was designed according to the relational survey model, one of the quantitative research methods. The study group consisted of 365 pre-school teachers working in pre-school educational institutions affiliated with the Ministry of National Education. The research data were obtained using the "General Information Form", "Knowledge Scale of Pedagogical Content in Preschool Mathematics" and "Scale of Attitudes for the Teaching of Mathematics". The obtained data were analyzed using the SPSS 22 package program. Firstly, as a result of the research, it was found that the ATM and ATMT levels of the teachers participating in the research were above average. In addition, findings showed that the levels of knowledge of mathematical pedagogical content were below average in some content areas (counting) and above average in some content areas (pattern, order, shape, spatial dimensions and comparison, and total score). Second, although the age of the teachers did not affect the levels of ATM and ATMT, on the contrary, it did affect the levels of MPCK. Third, the seniority variable was found to affect ATM and MPCK levels but did not affect ATM. Finally, low positive correlations were found between the levels of MPCK, ATM, and ATMT. These research findings were discussed in light of the relevant literature and suggestions were made.

Keywords:
Attitude towards mathematics, attitude towards teaching mathematics, mathematical pedagogical content knowledge, preschool teachers

1. Introduction

The foundation of mathematical development is laid in the pre-school period (NAEYC, 2010). It is crucial to present quality early mathematics to children while establishing this foundation because the quality of early mathematics education positively affects children's emotional attitudes, mathematics performance, and achievement (Zhang et al., 2020). In addition, early mathematics skills affect children's future academic achievement and mathematics learning (Dearing et al., 2009; Jordan et al., 2009). In this context, children's love of mathematics and ability to use it is directly related to developing positive attitudes towards mathematics and acquiring mathematical skills in early childhood (Boyd et al., 2008). The education provided in this period has critical importance since early childhood has a major impact on children's future lives. Some studies presented the shortcomings in children's mathematical skills development due to the low quality of the mathematics education offered in this critical period. For example, children who start primary school behind

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their peers in mathematics skills may fall further behind in time (Starkey & Klein, 2008) and have difficulties in learning mathematics (Dornheim, 2008).

In contrast to the negative effects of low-quality mathematics education, a study examining the development of mathematical performance and cognitive characteristics such as counting, visual attention, metacognition, and listening comprehension in children from preschool to second grade found that children who begin school with high-level mathematical skills progress more quickly in mathematics (Aunola et al., 2004).In this context, studies that explore the critical importance of the early period from the perspective of mathematics education and determine the variables that make a difference in supporting children become important.

Internationally, there are many outstanding resources related to what the content of early mathematics education should be. For example, the Principles and Standards for School Mathematics (NCTM 2000) in early mathematics education aims to provide children with skills such as describing, classifying, ordering, comparing, matching, graphing, symbolizing, communicating, and solving problems in the content of numbers and operations, algebra, geometry, measurement, statistics and probability (NCTM, 2000). In addition, the content of early mathematics in the document "Curriculum focal points for prekindergarten" published by NCTM (2007; 26-29); was determined as number and operations, geometry, data analysis, algebra, patterns, and detailed sub-objectives were listed. In another important document released in 2009, the National Research Council (NRC) committee established early mathematics's content as number core, relation core, and operation core (NRC, 2009). In addition to NRC (2009), Van de Walle et al. (2016) added content areas such as geometry, spatial thinking, measurement and data analysis to the content of early mathematics education. Finally, a resource in early mathematics education, early mathematics content is presented as number sense and counting, shape, spatial sense, measurement and graphing (Charlesworth, 2015). On the other hand, when the content of early mathematics education in Turkey is examined, estimation, matching, grouping, comparison, ordering and problem solving skills are emphasized. Content includes counting, operation (addition, subtraction), geometry (space skills and shape), measurement, pattern, and graphics (data analysis) (MoNE, 2013).

It is important to present the identified standards and support the development of relevant skills. However, concerning cognitive development, children in the early period are in the preoperational stage. Due to the period's specific limitations (such as transductive reasoning, inadequacy in conservation, limitation in symbolic thought, and inability to reverse the order of relationships between mental categories), Piaget asserts that children in the preoperational stage should be provided with experiences appropriate to the period's developmental characteristics (Piaget, 1952: cited in Berk & Meyers, 2016).Therefore, pre-school teachers should understand how to teach mathematical concepts and skills to children during this period. In this context, quality mathematics education requires teachers to know what to present, how to present it, and to whom to present it (Cerezci, 2020).

For this reason, pre-school teachers are expected to have a high level of mathematical pedagogical content knowledge (Gervasoni et al., 2012; MacDonald et al., 2012). In addition, it is recommended that teachers consider children's individual differences, thinking and understanding levels, use expressions and explanations appropriate for their development, employ different teaching methods and techniques and thus present the content to children in the most appropriate way (Rovegno, 1992; Smith & Neale, 1989). Teachers with sufficient knowledge and skills in early mathematics teaching have a very important role in improving children's mathematics skills with quality education (Chen & McCray, 2012; Zhang et al., 2020). It is important to investigate teachers' pedagogical content knowledge (Özdemir, 2020; Parpucu & Erdoğan, 2017) and attitudes toward mathematics (Dağlıoğlu et al., 2014; Kesicioğlu, 2014) to ensure that teachers can fulfill this critical role effectively. Although these variables were investigated separately before, they were not addressed together in previous studies. Since teachers' mathematical pedagogical content knowledge (Pelkowski et al., 2019; Trawick-Smith et al., 2016) and attitudes towards mathematics and mathematics teaching (Anders & Rossbach, 2015; McLeod, 1992; Relich & Way, 1992) were regarded as important variables in providing quality early mathematics experience, this study aimed to examine the relationships between these variables.

1.1. Mathematical Pedagogical Content Knowledge (MPCK), Attitudes towards Mathematics (ATM), and Attitudes towards Mathematics Teaching (ATMT)

Mathematical Pedagogical Content Knowledge (MPCK) consists of the intersections in mathematics teaching regarding who will teach what and how to teach it (McCray, 2008). Understanding mathematics is the basis of mathematics teaching. At this point, how mathematics will be taught to children, and which approaches and methods will be used become important (Zhang, 2015). For a quality mathematics education, teachers should have mathematical content knowledge, pedagogical knowledge regarding teaching methods, techniques, and strategies, and the ability to create learning environments that will support children's mathematical development, and to support children's inquiry and curiosity about mathematics (NCTM, 2000). NCTM standards in mathematics education include the content and process standards. Content standards are listed as number and operations, algebra, geometry, measurement, and data analysis, and probability and process standards are defined as problem-solving, reasoning and proof, communication, connections, and representation (NCTM, 2000). The primary purpose of mathematics education in the MoNE Preschool Education Program is to support children's mental development, create a positive attitude toward mathematics, establish meaningful connections between previous knowledge and new knowledge, make sense of mathematical concepts, and support the development of high-level thinking skills such as questioning and critical thinking. It can be said that the early math content presented in the Preschool Education Program in Turkey was affected by approaches such as Montessori, Reggio Emilia, Waldorf, and standards such as NRC, and NCTM. In addition, it can be argued that early mathematics education is based on theoretical foundations such as Piaget's cognitive development theory, Vygotsky's sociocultural development theory, van Hiele's theory of levels of geometric thinking (MoNE, 2013). Therefore, the content of early mathematics education in the measurement tool used in this study was examined with the measurement tool developed by Smith in 1998 and adapted into Turkish by Aksu & Kul (2017). It can be stated that the sub-dimensions in the content of the measurement tool are compatible with the "focal points" document published by NCTM (2007), but it has some deficiencies (e.g., operations, measurement, and graphics) compared to the MoNE Preschool Education Program. The pedagogical content in the measurement tool covers number, pattern, geometry (shape and spatial thinking), ordering, and comparison skills.

One of the most important goals of mathematics education is to provide a positive attitude towards mathematics (Reyes, 1984; 558). Attitude towards mathematics (ATM) is a more complex phenomenon characterized by people's emotions, beliefs, and behaviors related to mathematics (Zan & Di Martino, 2007; 158). The fact that developing positive attitudes towards mathematics is included among the objectives of mathematics teaching is crucial because positive attitudes affect students' mathematics learning positively (Neale, 1969; 631). Many studies in the literature report relationships between students' attitudes towards mathematics and their mathematics achievement (Chiesi & Primi, 2009; 312; Lubienski et al., 2012; 130; Marchis, 2011; 788).

Changing student attitudes is hard but not impossible. At this point, education has a significant impact. The importance of attitude towards mathematics teaching (MTA) emerges while examining teachers' ATM (Ernest, 1989). Relich & Way (1992), who developed a scale to investigate attitudes toward teaching mathematics, emphasizes the importance of teachers' attitudes towards teaching mathematics. For quality mathematics teaching, it is recommended that teachers stay away from all kinds of negative attitudes that may negatively affect the process (Sarı & Aksoy, 2016). Teachers' current attitudes towards mathematics were identified as an important variable predicting their sensitivity towards mathematical content and teaching (Anders & Rossbach, 2015). This study examined pre-school teachers' attitudes towards both mathematics and mathematics teaching.

1.2. Relationships between MPCK, ATM, and ATMT

MPCK in mathematics education was highly correlated with teacher efficacy, methods, and skills used by teachers, and students' attitudes and achievements towards mathematics (Empson & Junk, 2004; Hill et al., 2005; Oppermann et al., 2016). Also, a relationship was identified between teachers' ATM, beliefs, and MPCK (Thiel, 2010). Affective characteristics such as attitudes, beliefs, emotions, and values were found to be effective in quality mathematics education as well as teachers' MPCK (McLeod, 1992). Teachers' ATM determined their mathematics teaching achievement and student attitudes (Relich & Way, 1992). Similarly, pre-school teachers'

ATMs were found to be an important predictor of their sensitivity to mathematical content (Anders & Rossbach, 2015). In addition, teachers' MPCKs and their beliefs about mathematics education were also related (Demirbaş, 2019; Işıtan, 2020). In addition, pre-school teachers' ATMs were found to affect developmentally appropriate mathematics applications (Lee, 2005), while ATMs affected their choices regarding mathematical skill areas and the mathematical development of 6-year-old children (Çelik, 2017b). From another perspective, teachers' beliefs about mathematics affected their level of access to resources, which in turn influenced their mathematics teaching (Dawkins, 2020). Preschool teachers' high-level positive attitudes toward mathematics supported mathematics teaching in their classrooms, direct them to child-centered practices, increase their awareness of early mathematics education, and support their self-confidence in teaching (Lema, 2019). Finally, pre-school teachers' high-level positive ATMs created high-level positive MTAs (Benz, 2012).

Many variables have been identified that affect the quality of early mathematics education. Among these variables, there are variables such as family background, teaching (McCray & Chen, 2012), mathematical language, active participation of children, use of concrete materials (Aktaş Arnas, 2012; Clements & Sarama, 2009), curriculum, effective teaching, assessment, and technology support (NCTM, 2000). Besides these variables, as explained above, MPCK, ATM, and ATMT appear as variables that affect the quality of early mathematics education. Therefore, examining the relationships between MPCK, ATM, and ATMT in this research is significant in the context of the relevant literature.

1.3. Variables Affecting MPCK, ATM, and ATMT

MPCK, ATM, and ATMT levels of preschool teachers are influenced by variables such as age, seniority, experience, whether they received education in mathematics, the type of school from which they graduated, the type of institution in which they worked, the length of their experience, the number of children they worked with, and the frequency with which they included mathematics activities in their lessons.Teachers' pedagogical content knowledge levels were found to be in favor of teachers who are in a specific age range (Argın, 2019) and who received in-service training on mathematics teaching (Işıtan, 2020). In addition, in some groups, teachers' pedagogical content knowledge levels were in favor of teachers with 0-5 years seniority (Bilgen, 2019) and 6-10 years seniority (Argın, 2019), while MPCK levels increased as seniority increased (Lee, 2010; Lee, 2017). MPCK was found to be directly proportional to experience as well (Dewi et al., 2020).

The age variable affected teachers' ATMs and ATMTs but differed according to the group. In some groups, older teachers felt more open to mathematics and had a more positive attitude. In comparison, younger teachers were found to have a more reluctant and negative attitude towards mathematics (Thiel, 2010). On the contrary, in some groups, attitude levels decreased as their age increased (Çelik, 2017a) and in some groups, teachers' attitudes were at a lower level at a certain age range (Tokgöz, 2006). In parallel, seniority created different effects in different groups. In some groups, the attitudes of teachers with a seniority of 6-10 years were higher (Tokgöz, 2006). In some groups, as seniority increased, attitude levels decreased (Çelik, 2017a) while, on the contrary, attitudes increased with time and experience in some groups (Sumpter, 2020; Thiel, 2010). In addition, in-service training/courses/seminars regarding mathematics positively affected teachers' attitudes (Karataş et al., 2017; Markovits & Forgasz, 2017; Sumpter, 2020).
In summary, the research results in Turkey revealed that age and experience differ significantly from the results of the international research. While the MPCK, ATM, and ATMT levels of young teachers are high in Turkey, on the contrary, the MPCK, ATM, and ATMT levels of older and senior teachers are understood to be higher in the international context. Therefore, examining the reasons for this fundamental difference may be suggested.

1.4. Problems in Early Mathematics Education

Studies on early mathematics education revealed that some teachers who participated in the research did not have sufficient awareness of the spatial aspects of mathematics, they experienced limitations regarding the targeted application of mathematical content (Björklund & Barendregt, 2016), the majority of the teachers participating in the research could not define the concept of countdown embedded in a math game, and they made one-to-one matching and counting errors such as the cardinality principle (Li, 2021). In addition, a study found that nearly half of the teachers were unaware of the necessity of using the correct language, and some teachers lacked the knowledge regarding denomination, definitions, and properties of two- and three-dimensional shapes. However, they are included in the curriculum (Markovits & Patkin, 2020). Studies

conducted with teacher candidates reached similar conclusions as well. For example, it was observed that pre-school teacher candidates' field knowledge was insufficient in defining angular shapes and in providing examples from daily life (Korkmaz & Şahin, 2019). On the other hand, some pre-school teachers were found to use everyday objects rather than didactic applied materials; they progressed by reducing field knowledge to merely numbers, counting, and calculations, such as counting materials, knowledge of numbers, simultaneous recording of numbers, and matching numbers and objects; they rarely addressed domain-specific skills (Kroger et al., 2013); they did not recognize the spontaneous mathematical learning opportunities in the classroom (Costa et al., 2021; Figueiredo et al., 2018; Reimer, 2020). A study examining children's level of participation in mathematical activities determined that only 28 activities out of 171 activity plans were on the participation level, and 143 activities were not participatory (Pekince & Avcı, 2016).

Many studies in national and international literature reported that most pre-school teachers had low knowledge levels of mathematical pedagogical content (Björklund & Barendregt; 2016; Korkmaz & Şahin, 2019; Li, 2021; Torbeyns et al., 2020). In addition, it was found that teachers considered themselves inadequate for teaching mathematics (Lee, 2010; Lee & Ginsburg, 2007; Sheridan et al., 2011) and were afraid of making mistakes during mathematics activities (Wigfield & Eccles, 2002). However, negative perceptions of mathematics, and shortcomings in content and pedagogy were reported to be important variables limiting mathematics experiences (Knaus, 2017). In addition, pre-school teachers were found to associate early mathematics with numbers and counting general and experienced problems in presenting other content areas to children (Pekince & Avcı, 2016; Thiel, 2010). Based on the evaluation of all these research results together, it can be argued that the quality of early mathematics teaching is quite low (Cerezci, 2019).

Although teachers were aware of the significance of early mathematics education, they had an insecure attitude and beliefs of inadequacy in mathematics teaching (Noviyanti, 2019). The effects of teachers' attitudes and beliefs on teaching and mathematics achievement were clear in studies. It was concluded that teachers needed to change negative attitudes such as fear, anxiety, and concern that may negatively affect the quality of mathematics teaching process (Sarı & Aksoy, 2016). After all, teachers cannot be expected to teach children the knowledge, skills, and attitudes they do not possess (Kandemir, 2017). Based on the effects of all these cognitive and affective properties relevant to mathematics teaching, this study was planned to examine pre-school teachers' mathematical pedagogical content knowledge and their attitudes towards mathematics and mathematics teaching. The research aimed to contribute to the limited amount of literature in this field by identifying the relationship between pre-school teachers' mathematical pedagogical content knowledge and their attitudes towards mathematics and mathematics teaching, and by presenting the effect of different variables on this relationship. From this point of view, it can be argued that the findings and conclusions in this study are important to raise awareness in terms of supporting the development of positive attitudes towards mathematics and mathematics teaching and mathematical pedagogical content knowledge in teacher education.

2. Methodology

2.1.Research Model

This quantitative cross-sectional research was conducted with a relational survey model. As a research approach, the survey model describes situations in the past or present as they are. On the other hand, the relational survey model investigates the relationships between two or more variables (Fraenkel et al., 2012). Since the purpose of the present study was to determine the relationship between pre-school teachers' mathematical pedagogical content knowledge and their attitudes toward mathematics and mathematics education, the relational survey model was chosen from the research models, and the relational variables were identified as pre-school teachers' mathematical pedagogical content knowledge, attitudes toward mathematics, and mathematics education.

2.2. Research Sample

The study group was composed of 365 pre-school teachers employed at schools affiliated with the Directorate of National Education in Province Maraş. The convenience sampling method was used to determine the study group. Convenience sampling involves choosing a non-representative sample by selecting respondents as it is

convenient for the researcher (Scott & Usher, 2010). Table 1 presented below provides information on the study group's demographic characteristics.

Table 1. *Distribution of Demographic Variables*

Gender	*f*	*%*	*Valid %*	*Cumulative %*
Female	354	97,0	97,0	97,0
Male	11	3,0	3,0	100,0
Total	365	100,0	100,0	
Age	*f*	*%*	*Valid %*	*Cumulative %*
Between 20-25	80	21,9	21,9	21,9
Between 25-30	110	30,1	30,1	52,1
Between 30-35	89	24,4	24,4	76,4
Between 35-40	49	13,4	13,4	89,9
40 or older	37	10,1	10,1	100,0
Total	365	100,0	100,0	
Seniority	*f*	*%*	*Valid %*	*Cumulative %*
1-5 years	154	42,2	42,2	42,2
6-10 years	98	26,8	26,8	69,0
11-15 years	71	19,5	19,5	88,5
16 years or more	42	11,5	11,5	100,0
Total	365	100,0	100,0	

According to Table 1, 354 of the 365 preschool teachers participating in the research were females (%97,0) and 11 were males (%3,0); 80 were in the 20-25 age range (%21,9), 110 were in the 25-30 age range (%30,1), 89 were in the 30-35 age range (%24,4), 49 were in the 35-40 age range (%13,4) and 37 were 40 years or older (%10,1); 154 had 1-5 years seniority (%42,2), 98 had 6-10 years seniority (%26,8), 71 had 11-15 years seniority (%19,5) and 42 had 16 years or more seniority (%11,5).

2.3. Data Collection Tools and Procedure

The research data were obtained by using the "*General Information Form*", "*The Survey of Pedagogical Content Knowledge in Early Childhood Mathematics*" and "*Attitudes to Teaching Mathematics Questionnaire*". Below, you can find detailed information about the data collection tools used in this study.

General Information Form: The general information form designed by the researcher to collect data about the demographic characteristics of the participating teachers included questions about gender, age, and seniority.

The Survey of Pedagogical Content Knowledge in Early Childhood Mathematics: Developed by Smith in 1998, the scale consists of 6 sub-dimensions (number, pattern, ordering, shapes, spatial skills and comparison) and 15 items. Aksu & Kul (2017) carried out the Turkish adaptation of the scale. KR-20 reliability coefficient was calculated to determine the internal consistency reliability of the scale. The overall Cronbach alpha value of the adapted scale was 0.71. In this study, the scale's reliability was found to be KR-20=0,719. This value shows that the scale is reliable and that the items in this scale are in harmony. The questions in the measurement tool are scored as 0-1. High scores indicate a high level of content knowledge.

Attitudes to Teaching Mathematics Questionnaire: The measurement tool developed by Relich & Way (1992) was adapted into Turkish by Tabuk & Tabuk (2018). The 8-point Likert type scale consists of 2 sub-dimensions and 20 items. Cronbach's alpha coefficients were calculated as .82 and .85, respectively, for the internal consistency of attitudes towards mathematics teaching and attitudes towards mathematics dimensions. In this study, the internal consistency of the scale between the dimensions of attitude towards mathematics teaching and attitude towards mathematics was determined to be 0.91 and 0.90, respectively, and 0.95 for the entire scale. These values show that the scale is consistent and reliable within itself. Of the scale items, 11 measure attitudes towards teaching mathematics, and the remaining 9 measure attitudes towards mathematics (Tabuk & Tabuk, 2018).

2.4. Data Analysis

The obtained data were analyzed using the SPSS 22 statistical package program. The data analysis started by examining the parametric test conditions and Kolmogorov-Smirnov and Shapiro-Wilk tests were applied to test normality.

Tablo 2. *Kolmogorov-Smirnov and Shapiro-Wilk Test Results for Testing Normality*

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistics	sd	p	Statistics	sd	p
ATM	ATMT	,095	365	,000***	,939	365	,000***
	ATM	,108	365	,000***	,942	365	,000***
MPCK	Number	,196	365	,000***	,861	365	,000***
	Pattern	,186	365	,000***	,865	365	,000***
	Ordering	,347	365	,000***	,726	365	,000***
	Shape	,447	365	,000***	,588	365	,000***
	Spatial	,218	365	,000***	,827	365	,000***
	Comparison	,322	365	,000***	,771	365	,000***
	Total	,104	365	,000***	,979	365	,000***

****p*<,001, *Note: ATMT: Attitudes Towards Mathematics Teaching, ATM: Attitudes Towards Mathematics , MPCK: The Survey of Pedagogical Content Knowledge in Early Childhood Mathematics*.

In table 2, the analysis results showed that the data were not normally distributed (p<,05). Non-parametric tests were used for the analysis of the data that were found to be not normally distributed. While comparing the data, the Mann-Whitney U test was used for comparisons between two groups, and the Kruskal Wallis H test was used for comparisons between more than two groups. Spearman correlation analysis was performed to determine the existence and direction of the relationship between the variables.

2.5. Ethical

Permission for the study was obtained from Bolu Abant Izzet Baysal University, the Human Research Ethics Committee in Social Sciences, and the directorate of national education of a province located in the east of the Mediterranean in Turkey. The data were obtained from 365 pre-school education teachers employed at pre-schools in the 2020-2021 academic year. Because there was a worldwide pandemic at the time of the study and the opening and closing of schools was affected by the pandemic, research data were collected online to reach teachers as effectively as possible in terms of time, money, and health.Forms were delivered to teachers via Google Forms. The link address was forwarded to the relevant schools and teachers through the Provincial Directorate of National Education to obtain the data.

3. Findings

The findings regarding pre-school teachers' mathematical pedagogical content knowledge levels and their attitudes towards mathematics and mathematics teaching are presented below.

Table 3. *Preschool Teachers' MPCK Levels*

	N	$\bar{X}$	*Sd*	*Min.*	*Max.*
Number	365	1,49	1,10	,00	3,00
Pattern	365	1,63	1,07	,00	3,00
Ordering	365	1,47	,65	,00	2,00
Shape	365	1,69	,57	,00	2,00
Spatial	365	2,09	,79	,00	3,00
Comparison	365	1,10	,61	,00	2,00
Total	365	9,44	2,61	1,00	15,00

According to Table 3, the arithmetic mean values of pre-school teachers' pedagogical content knowledge levels in pre-school mathematics were 1.49 (below the average) in the number dimension; 1.63 (above the average) in the pattern dimension; 1.47 (above the average) in the ordering dimension; 1.69 (above the average) in the shape dimension; 2.09 (above the average) in the spatial dimension; and 1.10 (above the average) in the comparison dimension. Regarding total scores, 9.44 was the value (above the average).

Table 4. *The Effect of the Age Variable on MPCK Scores*

Sub-dimension	Age	N	Mdn	$\bar{X}$	MR	X^2	sd	p
Number	Between 20-25	80	2,00	1,61	195,19	8,123	4	,087
	Between 25-30	110	1,00	1,48	182,49			
	Between 30-35	89	2,00	1,62	195,76			
	Between 35-40	49	1,00	1,12	150,17			
	40 or older	37	1,00	1,35	170,93			
	Total	365						
Pattern	Between 20-25	80	2,00	1,99	216,71	22,048	4	,000***
	Between 25-30	110	2,00	1,73	192,12			
	Between 30-35	89	1,00	1,46	166,37			
	Between 35-40	49	1,00	1,16	136,86			
	40 or older	37	2,00	1,65	184,14			
	Total	365						
Ordering	Between 20-25	80	2,00	1,56	193,99	10,613	4	,031*
	Between 25-30	110	2,00	1,53	194,45			
	Between 30-35	89	2,00	1,47	184,43			
	Between 35-40	49	1,00	1,20	147,90			
	40 or older	37	1,00	1,35	168,24			
	Total	365						
Shape	Between 20-25	80	2,00	1,76	193,42	7,381	4	,117
	Between 25-30	110	2,00	1,71	184,44			
	Between 30-35	89	2,00	1,66	182,85			
	Between 35-40	49	2,00	1,49	155,73			
	40 or older	37	2,00	1,76	192,68			
	Total	365						
Spatial skill	Between 20-25	80	2,00	2,13	191,11	1,113	4	,892
	Between 25-30	110	2,00	2,07	180,14			
	Between 30-35	89	2,00	2,10	185,20			
	Between 35-40	49	2,00	2,00	173,92			
	40 or older	37	2,00	2,08	180,70			
	Total	365						
Comparison	Between 20-25	80	1,00	1,06	178,30	8,582	4	,072
	Between 25-30	110	1,00	1,21	200,01			
	Between 30-35	89	1,00	1,04	176,07			
	Between 35-40	49	1,00	1,12	187,53			
	40 or older	37	1,00	0,89	153,27			
	Total	365						
Total MPCK	Between 20-25	80	10,00	10,13	208,22	19,022	4	,001**
	Between 25-30	110	10,00	9,75	196,59			
	Between 30-35	89	9,00	9,36	178,71			
	Between 35-40	49	9,00	8,10	132,68			
	40 or older	37	9,00	9,08	165,04			
	Total	365						

**p<,05, **p<,01, *** p<,001, Note: Total MPCK: Total score obtained from the Survey of Pedagogical Content Knowledge in Early Childhood Mathematics*

The Kruskal Wallis H test, which was conducted to determine whether the MPCK scores differed based on the ages of the teachers, revealed that the mean rank of the groups did not differ significantly based on the number (X2=8,123, p>.05), shape (X2=7,381, p>.05), spatial (X2=1,113, p>.05), and comparison (X2=8,582, p>.05) sub-dimension scores.However, statistically significant differences were found between pattern (X^2=22,048, p<,05), ordering (X^2=10,613, p<,05) sub-dimensions and total score (X^2=19,022, p<,05). Mann Whitney U test was performed to determine the source of the difference and the results are presented below.

Examination of the differences revealed that the pattern dimension differences were in favor of the teachers in the 20-25 age range between the teachers in the 20-25 age range (MR =97,01) and the teachers in the 30-35 age

range (MR =74,20); in favor of the teachers in the 25-30 age range between the teachers in the 25-30 age range (MR =87,57) and the teachers in the 35-40 age range (MR =63,00); and in favor of the teachers in the 40 or older age range between the teachersThe ordering scores also differed significantly. Significant differences were found in favor of teachers in the 20-25 age range between those in the 20-25 age range and those in the 35–40 age range (MR =71.38 and 54.59, respectively); in favor of teachers in the 20-25 age range between those in the 20-25 age range and those in the 35-40 age range (MR =86.14 and 66.22, respectively; and in favor of teachers in the 30-35 age range between those in the 30-35 age range and those in the 35–40 age range (MR =59.17).

The total MPCK scores were found to differ significantly as well. These significant differences were in favor of teachers aged 20 to 25 years between teachers aged 20 to 25 years (MR =75.31) and teachers aged 35 to 40 years (MR =48.17); in favor of teachers aged 20 to 25 years between teachers aged 20 to 25 years (MR =63, 40) and teachers aged over 40 years (MR =49.49); in favor of teachers in the age range 20-25 between teachers in the age range 20-25 (MR =88.89) and teachers in the age range 35-40 (MR =60.05, and finally in favor of teachers in the age range 30-35 between teachers in the age range 30-35 (MR =75.19) and teachers in the age range 35-40 (MR =59.17).

Table 5. *The Effect of the Seniority Variable on MPCK Scores*

	Seniority	N	Mdn	$\bar{X}$	MR	X^2	Sd	p
	1-5 years	154	1,00	1,47	181,54	3,397	3	,334
	6-10 years	98	2,00	1,62	196,14			
Number	11-15 years	71	1,00	1,45	180,13			
	16 years or more	42	1,00	1,26	162,56			
	Total	365						
	1-5 years	154	2,00	1,90	207,73	17,932	3	,000***
	6-10 years	98	1,00	1,42	162,26			
Pattern	11-15 years	71	2,00	1,59	178,02			
	16 years or more	42	1,00	1,28	149,13			
	Total	365						
	1-5 years	154	2,00	1,56	196,67	6,224	3	,101
	6-10 years	98	2,00	1,42	175,71			
Ordering	11-15 years	71	1,00	1,32	166,56			
	16 years or more	42	2,00	1,42	177,69			
	Total	365						
	1-5 years	154	2,00	1,73	189,37	3,125	3	,373
	6-10 years	98	2,00	1,68	182,99			
Shape	11-15 years	71	2,00	1,66	179,89			
	16 years or more	42	2,00	1,54	164,92			
	Total	365						
	1-5 years	154	2,00	2,15	192,56	3,194	3	,363
	6-10 years	98	2,00	2,00	170,02			
Spatial skill	11-15 years	71	2,00	2,05	180,43			
	16 years or more	42	2,00	2,07	182,57			
	Total	365						
	1-5 years	154	1,00	1,15	191,06	6,951	3	,073
	6-10 years	98	1,00	1,04	175,14			
Comparison	11-15 years	71	1,00	1,15	193,28			
	16 years or more	42	1,00	0 ,90	154,38			
	Total	365						
	1-5 years	154	10,00	9,97	203,20	12,515	3	,006**
	6-10 years	98	9,00	9,18	172,10			
Total MPCK	11-15 years	71	10,00	9,24	176,58			
	16 years or more	42	9,00	8,50	145,21			
	Total	365						

***p<,01, *** p<,001, Note: Total MPCK: Total score obtained from the Survey of Pedagogical Content Knowledge in Early Childhood Mathematics*

According to Table 5, the result of the Kruskal Wallis H test performed to determine whether the pedagogical content knowledge scores of pre-school teachers in pre-school mathematics differed according to their seniority, there were no significant differences in the number (X^2=3,397, p>,05), ordering (X^2=6,224, p>,05), shape (X^2=3,125, p>,05), spatial (X^2=3,194, p>,05), and comparison (X^2=6,951, p>,05) sub-dimensions. Contrary

to this finding, the pattern sub-dimension (X^2=17,932, p<,05) and MPCK total scores (X^2=12,515, p<,05) differed significantly according to teachers' seniority. Mann Whitney U test was performed to determine the source of the difference. It was concluded that the pattern scores obtained by the teachers with 1-5 years seniority and 6-10 years seniority (U=5678,500, p<,05), the teachers with 1-5 years seniority and 11-15 years seniority (U=4548,000, p<,05) and the teachers with 1-5 years seniority and 16 years or more seniority (U=2212,000, p<,05) differed significantly.

Based on mean rank, these differences in pattern scores were in favor of teachers with 1-5 years seniority between the teachers with 1-5 years seniority (MR =138,63) and the teachers with 6-10 years seniority (MR =107,44); in favor of teachers with 1-5 years seniority between the teachers with 1-5 years seniority (MR =118,97) and the teachers with 11 -15 years seniority (MR =100,06) and finally in favor of the teachers with 1-5 years of seniority between the teachers with 1-5 years seniority (SO=105,14) and the teachers with 16 years or more seniority (MR =74,17).

It was found that the total MPCK scores of the teachers with 1-5 years seniority and 6-10 years seniority ((U=6242,500, p<,05) and the total MPCK scores of the teachers with 1-5 years seniority and over 16 years seniority (U=2207,000, p<,05) differed significantly. Based on mean rank, these differences were found to be in favor of the teachers with 1-5 years seniority between the teachers with 1-5 years seniority (MR =134,96) and the teachers with 6-10 years seniority (MR =113,20) and in favor of the teachers with 1-5 years seniority between the teachers with 1-5 years seniority (MR =105,17) and the teachers with 16 years or more seniority (MR = 74,05).

Table 6. *Teachers' ATMT and ATM Levels*

	N	Min.	Max.	$\bar{x}$	Sd
ATMT	365	1,27	8,00	5,90	1,60
ATM	365	1,00	8,00	5,69	1,65

Note: ATMT: Attitudes towards mathematics teaching, ATM: Attitudes towards mathematics

Table 6 shows that the arithmetic means value of the attitude levels of pre-school teachers towards teaching mathematics was 5,90 (above the average) and the arithmetic mean value of the attitudes toward mathematics was 5,69 (above the average).

Table 7. *The Effect of the Age Variable on ATMT and ATM Scores*

	Age	N	Mdn	$\bar{X}$	MR	X^2	sd	p
ATMT	Between 20-25	80	78,50	74,37	174,05	1,247	4	,870
	Between 25-30	110	79,50	77,05	189,91			
	Between 30-35	89	79,00	76,16	186,22			
	Between 35-40	49	78,00	75,14	179,49			
	40 or older	37	80,00	75,91	178,70			
	Total	365						
ATM	Between 20-25	80	62,50	59,86	177,56	3,571	4	,467
	Between 25-30	110	63,00	62,04	193,86			
	Between 30-35	89	66,00	60,47	188,01			
	Between 35-40	49	62,00	58,30	175,78			
	40 or older	37	57,00	57,24	159,99			
	Total	365						

Note: ATMT: Attitudes towards mathematics teaching, ATM: Attitudes towards mathematics

According to Table 7, the result of the Kruskal Wallis-H test performed to determine whether the ATMT scores of pre-school teachers differed according to their ages indicated no statistically significant difference between the mean rank of the groups (X^2=1,247; p>.05). Similar to this finding, there was no statistically significant difference between ATM scores and the age variable (X^2=3,571; p>.05).

Table 8. *The Effect of the Seniority Variable on ATMT and ATM Scores*

	Seniority	*N*	*Mdn*	$\bar{X}$	*MR*	X^2	*sd*	*p*
ATMT	1-5 years	154	78,00	75,34	178,64	5,510	3	,138
	6-10 years	98	83,00	78,71	199,01			
	11-15 years	71	73,00	71,21	163,37			
	16 years or more	42	80,00	79,11	194,85			
	Total	365						
ATM	1-5 years	154	62,00	60,34	179,73	11,318	3	,010*
	6-10 years	98	67,00	63,56	207,76			
	11-15 years	71	56,00	54,36	153,15			
	16 years or more	42	63,50	61,64	187,67			
	Total	365						

p<,05, Note: ATMT: Attitudes towards mathematics teaching, ATM: Attitudes towards mathematics

According to Table 8, there was no statistically significant difference between the mean ranks of the groups based on the Kruskal Wallis-H test, which was conducted to determine whether the pre-school teachers' ATMT scores differed according to seniority (X^2=5,510; p>.05). Contrary to this finding, it was determined that the pre-school teachers' ATM scores differed according to their seniority (X^2=11,318; p<.05). Mann Whitney U test was performed to determine the source of this significant difference. A significant difference was observed between the ATM scores of the pre-school teachers with 1-5 years seniority and 6-10 years seniority (U=6362,000, p<,05) and between the ATM scores of the pre-school teachers with 6-10 years seniority and 11-15 years seniority (U=2520,500, p<,05). Based on mean rank, this difference was found to be in favor of the teachers with 6-10 years seniority between the teachers with 1-5 years seniority (MR =118,81) and 6-10 years seniority (MR =138,58) and similarly in favor of the teachers with 6-10 years seniority between the teachers with 6-10 years seniority (MR =94,78) to 11-15 years seniority (MR =71,50).

Table 9. *Relationships between MPCK, ATMT, and ATM*

		1	2	3	4	5	6	7	8	9
ATMT (1)	r	1,00								
	p	.								
	N	365								
ATM (2)	r	,865**	1,00							
	p	,000	.							
	N	365	365							
Number (3)	r	,110*	,110*	1,00						
	p	,036	,036	.						
	N	365	365	365						
Pattern (4)	r	,166**	,161**	,127*	1,00					
	p	,001	,002	,015	.					
	N	365	365	365	365					
Ordering (5)	r	,110*	,143**	,164**	,232**	1,00				
	p	,036	,006	,002	,000	.				
	N	365	365	365	365	365				
Shape (6)	r	,054	,053	,044	,154**	,119*	1,00			
	p	,308	,315	,405	,003	,023	.			
	N	365	365	365	365	365	365			
Spatial skill (7)	r	,250**	,197**	,088	,284**	,193**	,143**	1,00		
	p	,000	,000	,095	,000	,000	,006	.		
	N	365	365	365	365	365	365	365		
Comparison (8)	r	,083	,051	-,028	,211**	,126*	,106*	,125*	1,00	
	p	,112	,334	,594	,000	,016	,042	,017	.	
	N	365	365	365	365	365	365	365	365	
Total MPCK (9)	r	,242**	,229**	,557**	,694**	,530**	,341**	,540**	,374**	1,00
	p	,000	,000	,000	,000	,000	,000	,000	,000	.
	N	365	365	365	365	365	365	365	365	365

*p<.05, **p<,01, Note: Total MPCK: Total score obtained from the Survey of Pedagogical Content Knowledge in Early Childhood Mathematics

Table 9 presents the results of the Spearman correlation analysis performed to determine the relationship between the MPCK, ATM, and ATMT scores of pre-school teachers. The findings are listed below:

- No significant correlation was found between ATMT and shape (r=,054; p>,05) and comparison scores (r=,083; p>,05).
- No significant correlation was found between ATM and MPCK shape sub-dimension (r=,053; p>,05) and comparison scores (r=,051; p>,05).
- ATM and number (r=,110; p<,05), pattern (r=,166; p<,05), ordering (r=,110; p<,05), spatial (r=,250; p<,05) and MPCK total scores were positively correlated with low levels of significance (r=,242; p<,05).
- Positive low-level significant correlations were found between ATM and number (r=,110; p<,05), pattern (r=,161 p<,05), ordering (r=,143, p<,05), spatial (r=,197, p<,05), and MPCK total score (r=,229, p<,05).
- A high level of positive correlation was found between ATMT and ATM (r=,865; p<,05).

4. Conclusion and Discussion

This investigation has yielded several results. First, the MPCK level of preschool teachers was found to be below average regarding the number dimension but, above-average regarding the pattern, ordering, shape, spatial, and comparison dimensions and regarding the overall MPCK level.The highest values were found for shape and spatial dimensions. In contrast to the results of this study, there are studies in the relevant literature that show that teachers have low MPCK (Bates et al., 2011; Dağlı, 2019; Pekince & Avcı, 2016). However, although MPCK was generally low in these studies, research findings were inconsistent across sub-dimensions. While some studies concluded that teachers had low levels in the dimensions of number, pattern, and space, high levels were found in the dimensions of order, shape, and comparison (Argın, 2019), and some of these studies concluded that teachers had higher levels in the dimensions of number and shape compared to other dimensions and tended to have low levels in the dimensions of space and comparison (Lee, 2010).As stated above, this study concluded that pre-school teachers' MPCK level was below average in the number dimension; but above average in pattern, ordering, shape, spatial and comparison dimensions, and total MPCK levels. There are differences between the results obtained in this study and the results in national and international studies. In addition, according to studies in the literature, teachers mostly associated mathematics with the number concept and gave priority to number and counting activities (Baki & Hacısalihoğlu Karadeniz, 2006; Tarım & Bulut, 2006; Thiel, 2010). Although it was anticipated that teachers would have greater pedagogical content knowledge regarding the number and counting dimension due to the fact that mathematics focuses more on content standards such as number and counting and that teachers have positive attitudes toward mathematics and mathematics education, the findings indicate the opposite. The lowest level of pedagogical content knowledge found in this study was in the number and counting sub-dimension. Therefore, further studies should be conducted in this regard. Based on the result of the findings related to the age variable, it was determined that although the ages of the teachers did not affect the number, shape, spatial, and comparison levels of MPCK, age had an effect on the pattern and ordering sub-dimensions and on the total MPCK level.

Although significant differences were observed in the form of different effects in different age ranges, examination of the age groups demonstrated that this significance was generally in favor of the teachers in the lower age range. Similarly, the total MPCK level of teachers in older age groups was lower than in other age groups. This result suggests that young teachers' knowledge and skills are up-to-date and that teachers who have been working for a long time cannot closely follow up-to-date studies in which they can improve their knowledge and skills. Research results in the relevant literature are mixed in this regard. For example, while studies conclude that the age variable did not affect MPCK (Demirbaş, 2019), many studies did not investigate the age variable (Anders & Rossbach, 2015; Dunekacke et al., 2015; Figueiredo et al., 2018; Li, 2021; Parpucu & Erdogan, 2017). In addition, MPCK may differ according to different age ranges (Argın, 2019). Considering the research results in the literature and the result reached in this research; no pattern emerged between teachers' age and MPCKs. Therefore, it is clear that further qualitative research is needed to examine these variables.

Examination of the obtained results regarding participating teachers' seniority demonstrated that the level of knowledge about the number, ordering, shape, spatial, and comparison dimensions was not affected by seniority. However, seniority was determined to be the variable affecting the pattern dimension and total MPCK level. The results show that teachers with 1-5 years seniority significantly differed from other groups. This result may be because new teachers' knowledge is more current and up-to-date than that of more senior teachers. The research results are compatible with the Turkish literature. The MPCK level of teachers with a low level of seniority can be expressed as higher than the MPCK level of teachers with a high level of seniority (Argın, 2019; Bilgen, 2019; Hacıibrahimoğlu & Akman, 2021). Contrary to Turkish literature, internationally the MPCK level was found to increase as the seniority increased (Dewi et al., 2020; Lee, 2010; Lee, 2017). Therefore, examining the reasons for this fundamental cultural difference may be suggested.

The research results in the literature are mixed in this regard. While there are studies in which the relationship between seniority and MPCK level could not be determined (Dağlı, 2019); some studies reported differences in the level of MPCK in favor or against teacher groups with certain seniority brackets (Argın, 2019; Bilgen, 2019; Hacıibrahimoğlu & Akman, 2021). In some groups, the MPCK level was found to increase as the seniority increased (Dewi et al., 2020; Lee, 2010; Lee, 2017). MPCK was also found to be directly proportional to experience (Dewi et al., 2020). Therefore, studies conducted in Turkey should examine why the MPCK levels of younger age groups and pre-school teachers with low levels of experience decrease and the possible variables that make up this difference. Here, it can be thought that the high MPCK levels of preschool teachers when they start working after their undergraduate education may be due to their fresh knowledge and skills and their ease of remembering. The reason for this situation is that MPCK levels do not develop due to the fact that they are not supported by in-service training, courses, or seminars over time, or the decrease in their individual efforts to support their professional development. In addition, it can be thought that the fact that in the pre-school period teachers gave greater importance to supporting areas such as the arts, language, and social skills other than the field of mathematics. Therefore, it can be suggested that new research should focus on the main international and domestic differences and the sources of these differences.

Based on the findings related to the attitudes, it was concluded that teachers' attitudes towards mathematics teaching and mathematics were above the average. Examination of the relevant literature demonstrated that many studies reached similar conclusions (Chen et al., 2014; Keleş et al., 2016; Markovits & Forgasz, 2017; Şeker & Alisinanoğlu, 2015). Previous studies were conducted with both pre-school teachers (Chen et al., 2014; Şeker & Alisinanoğlu, 2015) and pre-school teacher candidates (Keleş et al., 2016; Markovits & Forgasz, 2017). The attitudes of both pre-school teachers and pre-school teacher candidates towards mathematics and mathematics teaching are similar to the results obtained in this study. Therefore, it can be argued that teachers' attitudes towards mathematics and their attitudes towards mathematics teaching are generally at medium and high levels.

According to another finding obtained in the study, the age of pre-school teachers did not affect their attitudes towards mathematics and mathematics teaching. In other words, teachers' ATM and ATMT scores did not differ according to their age. When the relevant literature was examined, no studies were found that reached similar results with pre-school teachers. It is reported in the literature that teachers' attitudes towards mathematics improved as they grew older (Thiel, 2010); but some studies reported that teachers' attitudes decreased with age (Çelik, 2017a) or there were differences in favor of teachers in certain age ranges (Tokgöz, 2006). Although the age variable was proven to affect the attitudes towards mathematics and mathematics teaching in the literature, the fact that the effect of the age variable was not significant in this study may be due to different variables that were not investigated in this study.

It was concluded that teachers' ATMT did not change according to seniority, but seniority affected ATM. The ATM level of teachers with 6-10 years of seniority was higher than other seniority categories. Although studies in the relevant literature reported that pre-school teachers' seniority affected their attitudes towards mathematics and mathematics teaching, this significance varied in different samples. Some studies concluded that pre-school teachers' attitudes improved as their seniority increased (Sumpter, 2020). However, some studies reported decreases in teacher attitudes when teachers had higher seniority (Çelik, 2017a). Other studies reported differences in attitudes in seniority brackets compared to others (Tokgöz, 2006). In this study, the seniority of the teachers did not influence their attitudes toward mathematics, and the attitudes of teachers with 6 to 10 years of experience were higher than those of other teachers. This may be due to the characteristics

of the study group. As a result, it can be argued that the variable of seniority has different effects on different groups. Therefore it is difficult to make a common inference about the effect of pre-school teachers' seniority on their attitudes towards mathematics and mathematics teaching. Therefore, it is clear that studies on different and large samples are needed to determine the effect of seniority more understandably.

The result of the analysis performed to determine the relationships between pre-school teachers' MPCK, ATM, and ATMT levels, the main problem statement of this research, demonstrated low level and positive correlations between ATMT levels and the number, pattern, ordering, and spatial dimensions and total MPCK scores and between ATM level and the number, pattern, ordering and spatial dimensions and total MPCK scores. In other words, as teachers' number, pattern, ordering, spatial, and total MPCK levels increase, both ATMT and ATM levels increase. Many studies have similar findings in the relevant literature (Anders & Rossbach, 2015; Demirbaş, 2019; Işıtan, 2020; Lee, 2005). In addition, a high level of positive correlation was found between ATMT and ATM. Studies with similar results are available in the literature (Benz, 2012; Lema, 2019). In addition, studies report that different variables such as anxiety, self-efficacy perception, and belief are associated with variables such as attitude, achievement, and content knowledge (Aslan et al., 2013; Cook, 2017; Jenßen, 2022; Jenßen et al., 2020; White et al., 2005). In this context, it is important to examine the variables that affect attitudes together in future studies.

A study in the literature found that pre-school teachers placed special emphasis on early childhood mathematics education. However, it was presented that they did not feel ready to teach mathematics to the same extent that they considered it important to teach mathematics (Kaçan & Karayol, 2017). However, it is known that children's mathematics achievement increases as pre-school teachers' content knowledge and beliefs about mathematics increase (Gündoğan & Aslan, 2020), and teachers' pedagogical content knowledge levels affect their classroom practices (Dewi et al., (2020). The view that teachers should have the mathematical pedagogical content knowledge to provide quality mathematics education in the pre-school period is supported by studies in the literature (Dunekacke et al., 2016; Godoy et al., 2021). However, many research results reveal teacher shortcomings in mathematical pedagogical content knowledge (Björklund & Barendregt, 2016; Korkmaz & Şahin, 2019; Li, 2021; Torbeyns et al., 2020). In support of these findings, some studies revealed that teachers do not realize the mathematical learning opportunities that develop naturally in the classroom and that they are far from using these opportunities effectively due to their limited content knowledge (Costa et al., 2021; Figueiredo et al., 2018; Reimer, 2020).

Studies suggest that pre-school teachers' attitudes toward mathematics and their mathematical pedagogical content knowledge are effective on children's mathematical development. Based on the results of this study and previous research, it can be argued that when pre-school teachers have a high level of mathematical knowledge and confidence in their mathematical abilities, their attitudes toward mathematics improve and they are able to comprehend the significance of early mathematics education.Teachers who believe that they can effectively support children's mathematical skills and have high pedagogical content knowledge can plan more and better quality mathematics activities in their classrooms. They can make a point of using different teaching methods and techniques, taking into account children's developmental and individual characteristics (Chen & McCray, 2012; Gervasoni et al., 2012; MacDonald et al., 2012; NCTM, 2000; Rovegno, 1992; Smith & Neale, 1989). Thus, it will be possible to support the mathematical skills of children exposed to mathematics in daily life and through quality activities. In addition, teachers need the training to learn how to use spontaneous mathematics opportunities in classroom environments in fun ways and how to open spaces for children's mathematics learning to develop and support children's mathematical thinking skills.

5. Limitations and Recommendations

There are many limitations to this research. In the first place, the number of pre-school teachers who participate in the research and the way in which they were chosen can be expressed. In addition, the lack of observation of the research data can be explained as another limitation. Furthermore, there are deficiencies when evaluating the content and scope of the measurement tools used based on the content of initial mathematics education. Therefore, one of the limitations is not examining other content that is not included in the measurement tools. The fact that the gender distribution among teachers does not adequately represent both genders can be considered a limitation. In summary, this study is a one-way measurement. Another limitation is that the effects of teachers' MPCK, ATMT, and ATM on children's mathematical ability were not

examined.Several suggestions have been developed based on the research results. More studies should be conducted on different and larger samples to reach a higher amount of pre-school teachers to determine how pre-school teachers' mathematical pedagogical content knowledge, their attitudes towards mathematics and mathematics teaching are affected by different variables related to participant demographic characteristics such as seniority, age, gender, and the status of receiving mathematics education. In addition, longitudinal studies may be conducted in the future in addition to qualitative or mixed-method research that includes techniques such as observation and interview to reach multiple data on teachers' mathematical pedagogical content knowledge and attitudes towards mathematics and mathematics teaching.

This study found low-level positive relationships between pre-school teachers' mathematical pedagogical content knowledge, and their attitudes towards mathematics and mathematics teaching. For this reason, it is believed that pre-school teachers should have a high-level MPCK, ATMT, and ATM to provide quality mathematics education. It is suggested to support teachers and teacher candidates through teacher training programs and in-service and post-service training by providing training on mathematical content knowledge, pedagogical knowledge, and attitude (Cook, 2017; Markovits & Forgasz, 2017; Torbeyns et al., 2020). It is important to increase the applied courses of teacher candidates (Cook, 2017; Torbeyns et al., 2020) in the pre-school education undergraduate program in Turkey and to review the differences between the undergraduate program renewed in 2018 from the previously applied undergraduate program in terms of practice and course hours. In addition, measures such as increasing the credits and hours of the mathematics education course in undergraduate education and reorganizing the conditions used in undergraduate admissions of teacher candidates (equal weight score type) are considered vital for early mathematics education.

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