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Investigation of Pedagogical Content Knowledge of In-service and Pre-Service Pre-school Teachers in Pre-school Mathematics*

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Abstract

The effect of academic skills acquired in the early period on future school success is indisputable. In this regard, it is important that pre-service teachers who are trained to be future teachers have appropriate content knowledge. The purpose of the current study is to examine the pedagogical content knowledge of in-service and pre-service pre-school teachers in - sub-dimensions of pre-school mathematics such as number, pattern, order, shape, spatial perception and comparison. In the current study, which was conducted using an explanatory mixed design, 439 pre-service and 73 in-service pre-school teachers took part in the quantitative section and 9 pre-service and 22 in-service pre-school teachers in the qualitative section. The Pedagogical Content Knowledge Scale in Preschool Mathematics and a semi-structured interview form were used to collect data. The results of the study revealed that the pedagogical content knowledge of the pre-service and in-service teachers is at a medium level. It was also observed that the pedagogical content knowledge of the in-service pre-school teachers varied significantly depending on the years of teaching experience and that the pedagogical content knowledge of the pre-service preschool teachers varied significantly depending on gender, grade level, academic achievement, having taken the Mathematics Education course and belief in the necessity of mathematics education in the pre-school period. It was also found that both the in-service and pre-service teachers consider mathematics education necessary in the pre-school period due to its importance to get ready for primary school education, the acquisition of basic mathematics skills and the existence of mathematics in life. Additionallyy, both groups mostly preferred activities based on numbers, counting, operations, patterns, matching and concrete life experiences.

Keywords: Pre-school Period, Mathematics Education, Pedagogical Content Knowledge, Teacher, Pre-service Teacher

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INTRODUCTION

Mathematics has been an indispensable part of life since the beginning of human history (Nasibov and Kaçar, 2005). Sometimes it has remained abstract as a result of intellectual activities, and sometimes it has employed symbols and numbers to be more concrete. Mathematics is in the words we express unconsciously in our daily life, in the sentences we use almost every day (Karakuş and Akman, 2016). According to Griffin (2004), mathematics consists of real quantities, numbers, written numbers and formal symbols in space and time. At the same time, mathematics is a support mechanism beyond numbers and symbols that makes life easier and helps to think logically and rationally (Yenilmez, 2011; Yıldız, 2005).

The science of mathematics, which enables us to acquire the knowledge and skills necessary in all areas of our lives, includes many concepts such as short-long, large-small, less-more, far-close as well as numbers, graphics and some calculations acquired in schools from an early age. Such an intense existence of mathematics in life makes its teaching compulsory. The beginning of mathematics education in the pre-school period is very important for the development of further mathematics skills. The preschool period, which covers the first six years of life, is a critical period in which effective learning takes place, which is full of new knowledge and experiences and which is not possible to live again. The fact that the knowledge and skills acquired in this period will be reflected in the following periods, increases the importance of mathematics education in pre-school period.

Conceptual Framework

Mathematics Education in Pre-school Period

In the preschool period, children's minds are completely open and their minds are ready for new information. Academic skills acquired in the early years have a positive effect in later years (Jordan, Kaplan, Ramineni and Locuniak, 2009; NCTM, 2000; Polat, 2007; Uyanık and Kandır, 2010). Acquisition of early mathematics skills as one of the academic skills, can be decisive for future school success and mathematics achievement. Children who receive pre-school education are exposed to mathematics skills at early ages. It has been determined that these children are more successful in primary school first grade mathematics than children who have not received pre-school education (Dağlı, 2007). Moreover, it has been observed that these children's conceptual acquisitions, knowledge of concepts of quantity and reasoning skills are at a better level (Erkan and Kırca, 2010; Karakuş, 2015). Moreover, these acquisitions ensure that children's readiness for primary school and school maturity are higher (Yazıcı, 2002). It has also been revealed that mathematics skills gained in early years of life are effective not only in the first gradeand second grade (Guven and Uyanık Balat, 2006), but also in the secondary school (Wolfgang, Stannard and Jones, 2003).

Sub-Dimensions of Pre-school Mathematics

The subject area of pre-school mathematics education is quite wide. Among the subjectsof mathematics education, there are different concepts and skills such as numbers, counting, operation, geometry, spatial perception, measurement, graphics, order, classification, comparison, matching and pattern. In the current study, six sub-dimensions including numbers, pattern, order, shape, spatial perception and comparison were addressed within the scope of preschool mathematics pedagogical content knowledge (Aksu and Kul, 2017; Smith, 2000).

The sub-dimension of *numbers* includes recognizing numbers, showing the wanted number, understanding the relationships between numbers and the number system (NCTM, 2000). Counting, on the other hand, is the coordination of tangible physical objects with numerical words. At first, children learn to count numbers in order. They, then, use this counting order when counting a group of objects (Baroody and Price, 1983). In the pre-school period, children can even count up to 100 in this way. However, this type of counting is mostly just a rhythmic counting and it is for sure that the real meaning of each number is not understood by the child because counting is a different activity than

counting letters in the alphabet or singing a song (Sarnecka and Carey, 2008). According to Piaget, in order for children to understand the concept of number, they should have the ability to sort and classify, understand a conservation about numbers and be able to make one-to-one matching (Aktaş-Arnas, 2013).

In addition, the sub-dimension of *pattern* refers to a combination of geometric shapes, symbols, situations or sounds (Souviney, 1994, as cited in Yıldırım, 2011), and a state of numerical or spatial order (Papic and Mulligan, 2005, as cited in Yıldırım, 2011). Pattern, as the concept, includes information about sorting, separating, and classifying objects by size, number and other similar properties. In a pattern, objects are classified according to one or more of their properties and then these properties are repeated in a certain "order". Pattern activities in the period from pre-school to the first grade of primary education consist of sorting, separating and classifying objects according to their number, size and different properties, then recognizing, maintaining, defining, analysing patterns that repeat or change and creating patterns (NCTM, 2000).

Another sub-dimension is *ordering* and it includes making a comparison among more than two objects or object groups and placing the compared objects in a certain order according to the given quality. Ordering is a complex math skill requiring much more than comparison (Charlesworth and Lind, 2013; Charlesworth and Radeloff, 1991, as cited in Uludağ, 2019). It also includes organizing events in a meaningful way. In this way, ordering the events in a story according to the order of occurrence allows the whole story to be understood (Aktaş-Arnas, 2013; Ministry of Education Republic of Singapore, 2013, as cited in Uludağ, 2019).

One of the other dimensions that come to mind in early childhood mathematics education is *geometric shapes*. A child learning to distinguish qualities can also distinguish shapes. However, the teaching of shapes should be with more concrete expressions and examples rather than explaining the concept of "triangle" because children learn better by associating shapes with objects they see in the natural environment (Güven, 2005).

Moreover, the sub-dimension of *spatial perception* is mostly related to the positions of objects in the space. It is quite complex in terms of the location of the objects and their relationship with otherobjects and events around them, also forms the basis of geometry by including the concepts of shapes and dimensions. Pre-school children are at a level to be able to learn concepts such as right-left, front-back, next to, up-down related to the sub-dimension of spatial perception. Supporting these concepts with different activities is important to improve children's acquisition of these concepts (Aktaş-Arnas, 2013).

The sub-dimension of comparison refers to the determination of whether two objects or groups of objects are the same or different according to their qualitative and quantitative properties (Aksu and Kul, 2017). The skill of comparison requires first paying attention to the properties of objects and then being able to grasp that this property is more or less than others or the difference of this property from others. Children make comparisons intuitively, without any measurement.(Clarke-Stewart and Friedman 1987, Resnick, 1989, as cited in Aktaş-Arnas, 2013).

In the pre-school period, it is primarily the duty of pre-school teachers to improve children's mathematics knowledge and competence as in all other areas of pre-school education. Children's liking and understanding mathematics, their success in problem solving and establishing relationships are related to the opportunities offered to them by their teachers during mathematics education. This is because, the teacher is the planner and organizer of the education process anda teacher with high pedagogical content knowledge who knows the developmental characteristics of children, can create daily education plans with a good command of mathematics content and give an effective mathematics education. Studies show that teachers with high pedagogical content knowledge can make explanations appropriate to students' cognitive levels, focus on their understanding and thinking, use methods and strategies that will respond to student interests and needs and present the content properly (Gudmundsdottir, 1990; Rovegno, 1992, as cited in Aksu and Kul, 2017). Therefore, it is important to

examine the pedagogical content knowledge of in-service and pre-service pre-school teachers in mathematics education.

In this context, the purpose of the current study is to examine the pedagogical content knowledge of pre-service and in-service pre-school teachers in preschool mathematics. To this end, answers to the following sub-problems will be sought:

1. What is the level of pedagogical content knowledge of pre-service and in-service pre-school teachers in the sub-dimensions of pre-school mathematics?

2. Does the pedagogical content knowledge of preschool teachers in pre-school mathematics vary significantly depending on different variables?

3. Does the pedagogical content knowledge of pre-service preschool teachers in pre-school mathematics vary significantly depending on different variables?

4. What are the opinions of pre-service and in-service pre-school teachers about preschool mathematics?

METHOD

Under this heading, the research model, population and sample, data collection tool and data analysis process are discussed.

Study Model

In the study, a mixed method research design was used in order to examine the pedagogical content knowledge of pre-service and in-service pre-school teachers in preschool mathematics. Mixed method is a way of collecting, analysing and mixing quantitative and qualitative data in a single study or in a series of studies to understand a research problem (Creswell and Plano Clark, 2015). In the current study, an explanatory design, one of the mixed research methods, was employed. The explanatory design involves collecting quantitative data first and then obtaining qualitative data to help explain and elaborate on the quantitative results (Creswell and Plano Clark, 2015). The explanatory design is frequently preferred by researchers because quantitative and qualitative research data are collected at separate times (Yıldırım and Şimşek, 2013).

Population and Sample

The population of the study consists of in-service and pre-service pre-school teachers. The sample of the study in the quantitative dimension consists of 73 teachers selected out of the 393 pre-school teachers working in official pre-school education institutions affiliated to Çanakkale Provincial Directorate of National Education in the 2018-2019 academic year and 439 pre-service pre-school teachers selected out of the 485 pre-service pre-school teachers attending the Pre-school Education Department in the Education Faculty of Çanakkale Onsekiz Mart University and the sample in the qualitative dimension consists of 9 in-service and 22 pre-service pre-school teachers. While determining the sample, the simple random sampling method was used as it allowed choosing each sample in the population at equal probability (Büyüköztürk, 2016a; Metin, 2015). While forming the study group in the qualitative dimension of the study, it was taken into account that the pre-service teachers had taken the "Mathematics Education in Preschool Period" course and had practical experience. Therefore, 3rd and 4th grade pre-service teachers participated in the interviews. The demographic information of the in-service teachers included in the sample in the quantitative dimension of the study is given in Table 1 and the demographic information of the pre-service teachers is given in Table 2. The demographic information of the in-service and preservice teachers participating in the interviews in the qualitative dimension of the study is given in Table 3 and Table 4.

Table 1. Demographic Information of the In-service Teachers Constituting the Sample

Variables		f	%
Length of Service	0-5	3	4.1
	6-10	15	20.5
	11-15	29	39.7
	16-20	9	12.3
	21 years or more	17	23.4
Education Level	Associate's degree	4	5.5
	Bachelor's degree	58	79.4
	Graduate degree	11	15.1
Level of Self-efficacy in Mathematics Education	(3) Level	15	20.5
	(4) High	33	45.3
	(5) Very high	25	34.2

As can be seen in Table 1, 39.7 % of the teachers have 11-15 years of teaching experience. When their education level is examined, it is seen that 79.5 % of teachers hold a bachelor's degree. When the mathematics education self-efficacy levels of the teachers are examined, it is seen that 45.2 % of them have a high level of self-efficacy in mathematics education.

Table 2. Demographic Information of the Pre-service Teachers Constituting the Sample

Variables		f	%
Gender	Female	364	82.9
	Male	75	17.1
Grade Level	1st grade	116	26.3
	2nd grade	110	25.1
	3rd grade	99	22.6
	4th grade	114	26.0
Grade Point Average	Very low (1.80-2.00)	7	1.6
	Low (2.01-2.50)	46	10.5
	Medium (2.51-3.00)	191	43.5
	High (3.01-3.50)	176	40.1
	Very high (3.51-4.00)	19	4.3
State of Having Taken the Mathematics Education Course	Yes	208	47.4
	No	231	52.6
Grade Point Taken from the Mathematics Education Course	Very low (40^-)	2	1.0
	Low (41-60)	4	1.9
	Medium (31-80)	45	21.8
	High (81-90)	72	35.0
	Very high (90^+)	83	40.3
Believing in the Necessity of Mathematics Education	Yes	363	82.7
	No	76	17.3

When Table 2 is examined, it is seen that 82.9 % of the pre-service teachers are female, 17.1 % are male, that the numbers of students from different grade levels are close to each other, that 43.5 % of them have grade points considered to be medium (2.51-3.00) and 40.1 % have grade points considered to be high (3.01-3.50)., 47.4 % of the pre-service teachers participated in the study took the Mathematics Education course while 52.6 % did not take the course. It is among the remarkable data of the study that the grade points of the pre-service teachers who took the Mathematics Education course are "high" (81-90) and "very high" (over 90). The percentage of the pre-service teachers who believe in the necessity of a mathematics education course was found to be 82.7 %.

Table 3. Demographic Information of the In-service Teachers Participating in the Interviews

Variables		f	%
Gender	Female	9	100.0
	Male	0	0
Length of Service	6-10	3	33.3
	11-15	5	55.5
	16-20	0	0
	21 years or more	1	11.2

When the demographic information of the in-service teachers participated in the qualitative section of the study is examined, it is seen that all the teachers participating in the interviews are female (Table 3). It is seen that 55.5% of the teachers have 11-15 years of teaching experience, 33.3% of them have 6-10 years of teaching experience and 11.2% of them have 21 years or more of teaching experience.

Table 4. Demographic Information of the Pre-service Teachers Participated in the Interviews

Variables		f	%
Gender	Female	19	86.4
	Male	3	13.6
Grade Level	3rd grade	14	63.6
	4th grade	8	36.4
Grade Point Average	Low (2.01-2.50)	2	9.0
	Medium (2.51-3.00)	11	50.0
	High (3.01-3.50)	9	41.0

Analysis of thedemographic information of the pre-service teachers participated in the qualitative section of the study is depicted in Table 4. It is seen that 86.4% of the pre-service teachers are female and 13.6% are male. 63.6% of the participants are 3rd grade and 36.4% are 4th grade students. When the grade point averages of the pre-service teachers are examined, it is seen that 50% of them have a medium grade point average, 41.0% of them have a high grade point average 9.0% have a low grade point average.

Data Collection Tools and Data Collection Process

In the quantitative section of the study, a "Personal Information Form" developed by the researcher, the "Pedagogical Content Knowledge in Preschool Mathematics (PCKPM)" Scale developed by Smith (2010) and adapted into Turkish by Aksu and Kul (2017) were used. In order to collect qualitative data a semi-structured interview form consisting of open-ended questions which was developed by the researcher was used. After obtaining the necessary permissions for quantitative data collection, pre-service teachers from every grade level were reached. For the data to be collected from in-serviceteachers, teachers working at kindergartens in independent pre-schools, in primary and middle schools were interviewed. The participation was on a voluntary basis. The in-service and pre-service teachers were informed about the study and asked to answer the questions impartially. The data were collected personally by the researcher and it took approximately 15-20 minutes for each group to answer the scale. On the other hand, qualitative data were collected with face-to-face interviews by using a semi-structured interview form. After the in-service and pre-service teachers approved the consent forms, the interviews were recorded. Each interview conducted by the researcher lasted approximately 15 minutes.

The "Pedagogical Content Knowledge in Preschool Mathematics (PCKPM)" Scale was developed by Smith (2010) and adapted into Turkish by Aksu and Kul (2017). The scale consists of 15 items and preschool mathematics is handled in six dimensions: "number", "pattern", "order", "shape", "spatial" and "comparison". The Cronbach Alpha value of the whole scale was found to be 0.71 by Aksu and Kul (2017). The reliability coefficients for the sub-dimensions were found to vary between

0.77 and 0.64. Each question in the scale has one correct answer. The highest score to be taken from the scale is 15, and the lowest score is 0. Scores in the range of 0.00-5.00 taken from the scale are considered "low", scores in the range of 5.01-10.00 are considered "medium" and scores in the range 10.01-15.00 are considered "high".

The semi-structured interview form, which was developed to elicit the views of the in-service and pre-service pre-school teachers on pre-school mathematics, was developed by the researchers considering the literature review and the sub-dimensions of mathematics. The form was reviewed by three different experts in the field of mathematics and pre-school education. In line with the feedbacks given by a field expert, the two question items were combined into a single item due to the fact that they presented similar statements. A pilot study was conducted with three in-service and three pre-service teachers. In line with the pilot applications and expert opinions, the interview questions were revised and the interview form was given its final form. In this form, questions about the necessity of preschool mathematics, the state of preschool mathematics in our country, the types of activities included in preschool mathematics education, the sub-dimensions of mathematics, the evaluation of the objectives and specifications of mathematics in the current preschool curriculum and their evaluation of preschool mathematics were asked.

Data Analysis

In the study, descriptive statistics were used to analyze the quantitative data. The quantitative findings obtained were analysed using the SPSS (Statistical Package for Social Sciences) 20.0 program package. In the determination of which statistical techniques to be used Kurtosis, skewness values and histograms regarding whether the distributions show a normal distribution were examined. The Kurtosis and skewness values of the Pedagogical Content Knowledge in Preschool Mathematics (PCKPM) Scale administered to the in-service and pre-service pre-school teachers are given in Table 5.

Table 5. The Kurtosis and Skewness Values of the Pedagogical Content Knowledge in Pre-school Mathematics (PCKPM) Scale Administered to the In-service and Pre-service Pre-school Teachers

	Sub-dimensions	N	Skewness	Kurtosis
In-service Teachers	Sub-dimension of number	73	.182	-1.064
	Sub-dimension of pattern	73	.572	-.627
	Sub-dimension of order	73	-1.672	2.006
	Sub-dimension of shape	73	-.415	-.713
	Sub-dimension of spatial	73	-.329	-.335
	Sub-dimension of comparison	73	-.845	-.269
	Whole scale	73	-.477	.188
Pre-service Teachers	Sub-dimension of number	439	.285	-.955
	Sub-dimension of pattern	439	.394	-.880
	Sub-dimension of order	439	-.521	-1.043
	Sub-dimension of shape	439	-414	-.992
	Sub-dimension of spatial	439	.233	-.522
	Sub-dimension of comparison	439	-.780	-.588
	Whole scale	439	.104	-.246

When Table 5 is examined, it is seen that the skewness value of the "Pedagogical Content Knowledge in Preschool Mathematics" Scale answered by the in-service pre-school teachers was found to be -.477 and the Kurtosis value was found to be .188 for the whole scale. When the sub-dimensions of the PCKPM Scale are examined, it is seen that the Kurtosis and skewness values obtained as a result of statistical calculations for the sub-dimensions of "number", "pattern", "order", "shape", "spatial" and "comparison" are between -1.5 and +1.5. The skewness value of the "Pedagogical Content Knowledge in Preschool Mathematics" Scale answered by the pre-service pre-school teachers was found to be .104 and the Kurtosis value was found to be -.246 for the whole scale.

When the sub-dimensions of the scale are examined, it is seen that the Kurtosis and skewness values found for the sub-dimensions of "number", "pattern", "order", "shape", "spatial" and "comparison" are between -1.5 and +1.5. By considering the results of the histogram analyses carried out in order to understand whether the distribution is parametric or not, it was decided to use parametric statistical techniques to answer the research questions. In this regard, it was decided to analyse the sub-questions of the study with two independent variables using the Independent Samples t-Test and the sub-problems with more than two independent variables using the One-Factor Analysis of Variance ANOVA (One Way ANOVA) test (Büyüköztürk, 2016b; Tabachnick and Fidell, 2013).

In the analysis of qualitative data, it was decided to use the content analysis method to provide a systematic, quantitative and objective perspective (Cartwright, 1953, as cited in Bilgin, 2006). The content analysis method is defined as the set of techniques that are used according to the issues requiring detailed examination between the message and interpretation, increasingly developing and efficient (Bilgin, 2006). In the analysis of the qualitative data in the study, the answers given to each question were examined separately, interview codes were created for each question and similar statements were coded under the same codes and themes that were created. The answers given by each teacher participated in the study were coded as T1, T2, T3, T4. In the coding of the pre-service teachers, the third grade pre-service teachers were coded as 3.1, 3.2, 3.3… and the fourth grade pre-service teachers were coded as 4.1, 4.2, 4.3, 4.4.

FINDINGS

The findings obtained in the analysis process are presented below in the light of research questions and research themes.

Findings Related to the First Sub-Question of the Study

The findings regarding the levels of pedagogical content knowledge of the in-service and pre-service pre-school teachers in pre-school mathematics are given in the tables below.

Table 6. Levels of Pedagogical Content Knowledge of the In-service and Pre-service Pre-school Teachers in Pre-school Mathematics

	Sub-dimensions	N	$\bar{X}$	Maximum value to be taken	Ss
In-service Teachers	Sub-dimension of number	73	1.27	3	1.00
	Sub-dimension of pattern	73	1.01	3	.95
	Sub-dimension of order	73	1.72	2	.50
	Sub-dimension of shape	73	1.30	2	.66
	Sub-dimension of spatial	73	1.57	3	.81
	Sub-dimension of comparison	73	1.49	2	.62
	Whole scale	73	8.38	15	2.45
Pre-service Teachers	Sub-dimension of number	439	1.20(0-3)	3	.98
	Sub-dimension of pattern	439	1.25(0-3)	3	.99
	Sub-dimension of order	439	1.28(0-2)	2	.74
	Sub-dimension of shape	439	1.25(0-2)	2	.71
	Sub-dimension of spatial	439	1.32(0-3)	3	.84
	Sub-dimension of comparison	439	1.42(0-2)	2	.69
	Whole scale	439	7.75(0-15)	15	2.50

When Table 6 is examined, it is seen that the pedagogical content knowledge of the in-service teachers who took part in the study regarding pre-school mathematics is 8.38 and that of the pre-service teachers is 7.75. When the sub-dimensions are examined, it is seen that the in-service teachers have the highest mean in the sub-dimension of *order* and the lowest mean in the sub-dimension of *pattern*. While the highest mean taken by the pre-service teachers is in the sub-dimension of *comparison*, and the lowest mean is in the sub-dimension of *number*.

Findings Related to the Second Sub-Question of the Study

The findings regarding the levels of pedagogical content knowledge of the pre-school teachers in preschool mathematics in terms of different variables are given in the tables below.

Table 7. Descriptive Statistics Showing the Scores Taken from the PCKPM Scale in relation to the Variable of teaching experience

	Teaching experience	N	$\bar{X}$	Ss
PCKPM Scale Scores	0-5	3	9.33	3.21
	6-10	15	8.66	2.02
	11-15	29	8.89	2.48
	16-20	9	8.00	2.39
	20 years or more	17	7.29	2.54
	Total	73	8.38	2.45

When Table 7 is examined, it is seen that in-service pre-school teachers who have 0-5 years of teaching experience have a score over the average out of 15 in the PCKPM scale ($\bar{X}$=9.33). The teachers with the lowest mean are those with 20 years or more of teaching experience. Based on this result, it can be said that the mathematics knowledge of the newly recruited teachers is higher. It was also revealed that the PCKPM levels of the teachers having the longest teaching experience ($\bar{X}$=7.29) are below the general average ($\bar{X}$=8.38).

Table 8. ANOVA Results Showing Whether the Scores Taken from the PCKPM Scale and its Sub-dimensions Vary Significantly Depending on the Variable of Teaching Experience

	Source of the Variance	Sum of Squares	Sd	Mean Squares	F	p	Significant Difference
Number	Between-Groups	1.888	4	.472	.454	.769	-
	Within-Groups	70.633	68	1.039			
	Total	72.521	72				
Pattern	Between-Groups	8.669	4	2.167	2.617	.043*	-
	Within-Groups	56.317	68	.828			
	Total	64.986	72				
Order	Between-Groups	.944	4	.236	.913	.462	-
	Within-Groups	17.577	68	.258			
	Total	18.521	72				
Shape	Between-Groups	.692	4	.173	.384	.820	-
	Within-Groups	30.677	68	.451			
	Total	31.370	72				
Spatial	Between-Groups	6.981	4	1.745	2.905	.028*	11-15 > 20
	Within-Groups	40.854	68	.601			
	Total	47.836	72				
Comparison	Between-Groups	.334	4	.084	.204	.936	-
	Within-Groups	27.912	68	.410			
	Total	28.247	72				
PCKPM Scale Total	Between-Groups	33.041	4	8.260	1.403	.242	-
	Within-Groups	400.219	68	5.886			
	Total	433.260	72				

*p< 0.05

When Table 8 is examined, it is seen that the pedagogical content knowledge of the in-service teachers in pre-school mathematics does not vary significantly depending on the variable of teaching experience (F(4.68)=1.403, p>.05). When the sub-dimensions of the scale are examined, it is seen that only the scores taken from the sub-dimension of *spatial* vary significantly depending on the variable of teaching experience (F(4.68)=2.905, p<.05). Although the *p* value in the sub-dimension of *pattern* was found to be smaller than .05, no significant difference was found as a result of the Scheffe test. According to the Scheffe test results, in the sub-dimension of *spatial*, there is a significant difference between the teachers who have been working as a teacher for 20 years or more ($\bar{X}$=1.11) and the teachers who have been working for 11-15 years ($\bar{X}$=1.89) in favour of the teachers with less experience.

Table 9. Descriptive Statistics Showing the Scores Taken from the PCKPM Scale in relation to the Variable of Education Level

	Education Level	N	$\bar{X}$	Ss
PCKPM Scale Scores	Associate's degree	4	8.50	.57
	Bachelor's degree	58	8.25	2.42
	Graduate degree	11	9.00	3.03
	Total	73	8.38	2.45

When Table 9 is examined, it is seen that the mean score of the teachers holding a graduate degree from the PCKPM Scale is quite high ($\bar{X}$=9.00), followed by the teachers holding an associate's degree ($\bar{X}$=8.50) and the teachers holding a bachelor's degree ($\bar{X}$=8.25).

Table 10. ANOVA Results Showing Whether the Scores Taken from the PCKPM Scale and its Sub-dimensions Vary Significantly Depending on the Variable of Education Level

	Source of the Variance	Sum of Squares	Sd	Mean Squares	F	p
Number	Between-Groups	.470	2	2.235	.229	.796
	Within-Groups	72.050	70	1.029		
	Total	72.521	72			
Pattern	Between-Groups	2.664	2	1.332	1.496	.231
	Within-Groups	62.322	70	.890		
	Total	64.986	72			
Order	Between-Groups	.448	2	.224	.867	.425
	Within-Groups	18.073	70	.258		
	Total	18.521	72			
Shape	Between-Groups	.320	2	.160	.360	.699
	Within-Groups	31.050	70	.444		
	Total	31.370	72			
Spatial	Between-Groups	.309	2	.154	.228	.797
	Within-Groups	47.527	70	.679		
	Total	47.836	72			
Comparison	Between-Groups	1.174	2	.587	1.518	.226
	Within-Groups	27.072	70	.387		
	Total	28.247	72			
PCKPM Scale Total	Between-Groups	5.140	2	2.570	.420	.659
	Within-Groups	428.121	70	6.116		
	Total	433.260	72			

When Table 10 is examined, it is seen that the pedagogical content knowledge of the teachers in pre-school mathematics does not vary significantly depending on the variable of educational conditions (F (2,70)=. 420, p> .05).

Table 11. Descriptive Statistics Showing the Scores Taken from the PCKPM Scale in relation to the Variable of Self-Efficacy in Teaching Mathematics in the Preschool Period

	Self-Efficacy Level	N	$\bar{X}$	Ss
PCKPM Scale Scores	Medium	15	8.53	2.06
	High	33	8.87	2.21
	Very high	25	7.64	2.84
	Total	73	8.38	2.45

Table 11shows that, the teachers who consider their self-efficacy as "very high" have lower scores on the PCKPM Scale than the teachers who consider their self-efficacy as "high" and "medium".

Table 12. ANOVA Results Showing Whether the Scores Taken from the PCKPM Scale and its Sub-dimensions Vary Significantly Depending on the Variable of Self-Efficacy in Teaching Mathematics in the Preschool Period

	Source of the Variance	Sum of Squares	Sd	Mean Squares	F	p
Number	Between-Groups	.882	2	.441	.431	.652
	Within-Groups	71.639	70	1.023		
	Total	72.521	72			
Pattern	Between-Groups	.443	2	.222	.240	.787
	Within-Groups	64.543	70	.922		
	Total	64.986	72			
Order	Between-Groups	.300	2	.150	.576	.565
	Within-Groups	18.221	70	.260		
	Total	18.521	72			
Shape	Between-Groups	2.354	2	1.177	2.840	.065
	Within-Groups	29.016	70	.415		
	Total	31.370	72			
Spatial	Between-Groups	2.735	2	1.368	2.122	.127
	Within-Groups	45.101	70	.644		
	Total	47.836	72			
Comparison	Between-Groups	1.013	2	.506	1.301	.279
	Within-Groups	27.234	70	.389		
	Total	28.247	72			
PCKPM Scale Total	Between-Groups	22.252	2	11.126	1.895	.158
	Within-Groups	411.008	70	5.872		
	Total	433.260	72			

In Table 12 it is seen that the scores obtained by the pre-school teachers from the PCKPM Scale and its sub-dimensions do not vary significantly depending on the variable of self-efficacy in teaching mathematics in the pre-school period ($F(2.70)=1.895$, $p>.05$).

Findings Related to the Third Sub-Question of the Study

The findings regarding the levels of pedagogical content knowledge of the pre-service pre-school teachers in pre-school mathematics in terms of different variables are given in the tables below.

Table 13. T-test Results Showing Whether the Scores Taken from the PCKPM Scale and its Sub-Dimensions Vary Significantly Depending on the Variable of Gender

	Gender	N	$\bar{X}$	Ss	sd	t	*p*
Number	Female	364	1.20	.99	437	-.058	.954
	Male	75	1.21	.97			
Pattern	Female	364	1.27	.99	437	1.245	.214
	Male	75	1.12	.98			
Order	Female	364	1.33	.71	437	3.00	.003*
	Male	75	1.05	.83			
Shape	Female	364	1.29	.70	437	2.62	.009*
	Male	75	1.05	.75			
Spatial	Female	364	1.31	.83	437	-.434	.664
	Male	75	1.36	.93			
Comparison	Female	364	1.47	.68	437	3.45	.001*
	Male	75	1.17	.68			
Scale Total	Female	364	7.90	2.43	437	2.93	.004*
	Male	75	6.98	2.66			

*p< 0.05

Table 13 presents that there is a significant difference between the pedagogical content knowledge of the male and female pre-service teachers in favour of the female pre-service teachers (t(437)=2.93, p<.05). The mean scores taken from the sub-dimensions of "order" (t(437)=3.00, p<.05.), "shape" (t(437)=2.62, p<.05.) and "comparison" (t(437)=3.45, p<.05.) were found to vary significantly depending on gender.

Table 14. Descriptive Statistics Showing the Scores Taken by the Pre-service Pre-school Teachers from the PCKPM Scale in relation to the Variable of Grade Level

	Grade Level	N	$\bar{X}$	Ss
PCKPM Scale Scores	1st grade	116	7.23	2.37
	2nd grade	110	7.46	2.30
	3rd grade	99	8.43	2.68
	4th grade	114	7.96	2.50
	Total	439	7.75	2.50

As can be seen in Table 14, the first grade pre-service teachers have the lowest mean score from PCKPM Scale ($\bar{X}$=7.23) while the third grade pre-service teachers have the highest mean score ($\bar{X}$=8.43).

Table 15. ANOVA Results Showing Whether the Scores Taken by the Pre-service Preschool Teachers from the PCKPM Scale and its Sub-Dimensions Vary Significantly Depending on the Variable of Grade Level

	Source of the Variance	Sum of Squares	Sd	Mean Squares	F	p	Significant Difference
Number	Between-Groups	16.095	3	5.365	5.664	.001*	3>2
	Within-Groups	412.042	435	.947			4>2
	Total	428.137	438				
Pattern	Between-Groups	5.508	3	1.836	1.853	.137	-
	Within-Groups	430.930	435	.991			
	Total	436.437	438				
Order	Between-Groups	7.489	3	2.496	4.595	.004*	3>1
	Within-Groups	236.347	435	.543			
	Total	243.836	438				
Shape	Between-Groups	1.747	3	.582	1.128	.338	-
	Within-Groups	224.690	435	.517			
	Total	226.437	438				

Spatial	Between-Groups	3.979	3	1.326	1.851	.137	-
	Within-Groups	311.734	435	.717			
	Total	315.713	438				
Comparison	Between-Groups	4.481	3	1.494	3.176	.024*	-
	Within-Groups	204.558	435	.470			
	Total	209.039	438				
PCKPM Scale Total	Between-Groups	91.683	3	30.561	5.024	.002*	3>1
	Within-Groups	2446.253	435	6.083			3>2
	Total	2737.936	438				

*p< 0.05

When Table 15 is checked, it is obvious that the pedagogical content knowledge of the pre-service teachers varies significantly depending on the variable of *grade level* (F(3.435)=5.024, p<.05). According to the results of the Scheffe test, which was conducted to determine between which groups the difference was significant, it was determined that the third grade ($\bar{X}$=8.43) pre-service teachers have a higher mean than the first grade ($\bar{X}$=7.23) and second grade ($\bar{X}$=7.46) pre-service teachers. When the mean scores taken from the sub-dimensions were examined, it was found that in the sub-dimension of *number*, the third grade pre-service teachers ($\bar{X}$=8.43) and fourth grade pre-service teachers ($\bar{X}$=7.96) have higher mean scores than the second grade pre-service teachers ($\bar{X}$=7.46); in the sub-dimension of order, the third grade pre-service teachers were found to have a higher mean score ($\bar{X}$=8.43) than the first grade pre-service teachers ($\bar{X}$=7.23). Although the p value in the sub-dimension of comparison was smaller than .05, no significant difference was found as a result of the Scheffe test.

Table 16. Descriptive Statistics Showing the Scores Taken by the Pre-service Preschool Teachers from the PCKPM Scale in relation to the Grade Point Average

	Grade Point Average	N	$\bar{X}$	Ss
PCKPM Scale Scores	Very low (1.80-2.00)	7	5.57(0-15)	2.43
	Low (2.01-2.50)	46	6.91(0-15)	2.21
	Medium (2.51-3.00)	191	7.74(0-15)	2.52
	High (3.01-3.50)	176	7.98(0-15)	2.50
	Very high (3.51-4.00)	19	8.47(0-15)	2.16
	Total	439	7.75(0-15)	2.50

When Table 16 is examined, it is seen that the scores of the pre-service teachers in the PCKPM Scale increase depending on their grade point average.

Table 17. ANOVA Results Showing Whether the Scores Taken by the Pre-service Preschool Teachers from the PCKPM Scale and its Sub-Dimensions Vary Significantly Depending on the Variable of Grade Point Average

	Source of the Variance	Sum of Squares	Sd	Mean Squares	F	p	Significant Difference
Number	Between-Groups	3.071	4	.768	.784	.536	-
	Within-Groups	425.065	434	.979			
	Total	428.137	438				
Pattern	Between-Groups	3.612	4	.903	.905	.461	-
	Within-Groups	432.826	434	.997			
	Total	436.437	438				
Order	Between-Groups	9.699	4	2.425	4.494	.001*	4>2
	Within-Groups	234.137	434	.539			
	Total	243.836	438				
Shape	Between-Groups	3.873	4	.968	1.888	.111	-
	Within-Groups	222.564	434	.513			
	Total	226.437	438				

Spatial	Between-Groups	4.443	4	1.111	1.549	.187	-
	Within-Groups	311.270	434	.717			
	Total	315.713	438				
Comparison	Between-Groups	10.916	4	2.729	5.978	.000*	3>1, 3>2,
	Within-Groups	198.123	434	.457			4>1, 4>2,
	Total	209.039	438				5>1
PCKPM	Between-Groups	85.426	4	21.357	3.494	.008*	-
Scale	Within-Groups	2652.510	434	6.112			
Total	Total	2737.936	438				

*p< 0.05

The examination of table 17 presents that the pedagogical content knowledge of the pre-service teachers varies significantly depending on their grade point average (F(4.434)=3.494, p<.05). However, as a result of the Scheffe test, which was carried out to determine between which groups a significant difference occurs, no result was found in favour of any group. When the mean scores taken from the sub-dimensions were examined, it was found that the pedagogical content knowledge of the pre-service teachers varied significantly in the sub-dimensions of *order* (F(4.434)=4.494, p<.05) and *comparison* (F(4.434)=5.978, p<.05). According to the results of the Scheffe test, which was conducted to examine the significant difference, it is seen that pre-service teachers with a "high" grade point average ($\bar{X}$=7.98) in the sub-dimension of *order* have a higher mean score than the pre-service teachers with a "low" grade point average ($\bar{X}$=6.91). In the sub-dimension of *comparison*, the significant difference between the pre-service teachers having a medium and very low grade point average, between the pre-service teachers having a medium and low grade point average, between the pre-service teachers having a high and very low grade point, between the teachers having a high and low grade point average and between the teachers having a very high and very low grade point average was found to be in favour of the pre-service teachers having lower grade point averages.

Table 18. T-test Results Showing Whether the Scores Taken by the Pre-service Teachers from the PCKPM Scale and its Sub-Dimensions Vary Significantly Depending on the Variable of Having Taken the Mathematics Education Course

	Having Taken the Course	**N**	**$\bar{X}$**	**Ss**	**sd**	**t**	***p***
Number	Yes	208	1.38	1.01	437	3.615	.000*
	No	231	1.04	.93			
Pattern	Yes	208	1.35	1.00	437	2.103	.036*
	No	231	1.15	.98			
Order	Yes	208	1.42	.71	437	3.677	.000*
	No	231	1.16	.75			
Shape	Yes	208	1.25	.74	437	.117	.907
	No	231	1.24	.69			
Spatial	Yes	208	1.25	.81	437	-1.557	.120
	No	231	1.38	.87			
Comparison	Yes	208	1.56	.64	437	4.281	.000*
	No	231	1.29	.70			
Scale Total	Yes	208	8.25	2.57	437	4.031	.000*
	No	231	7.30	2.34			

*p< 0.05

When Table 18 is examined, it is seen that the pedagogical content knowledge of the pre-service teachers varies significantly depending on the state of having taken the mathematics education course (t(437)=4.031, p<.05). The pedagogical content knowledge ($\bar{X}$=8.25) of the pre-service teachers who took a mathematics education course was found to be higher than that of the pre-service teachers who did not take the course ($\bar{X}$=7.30). When the mean scores taken from the sub-dimensions were examined, it was found that the mean scores taken from the sub-dimensions of *number* (t(437)=3.615, p<.05), pattern (t(437)=2.103, p<.05), *order* (t(437)=3.677, p<.05) and *comparison* (t(437)=4.281, p<.05) varied significantly depending on the state of having taken the mathematics

education course. This significant difference was found to be in favour of the pre-service teachers having taken the mathematics education course.

Table 19. Descriptive Statistics Showing the Scores Taken by the Pre-service Pre-school Teachers from the PCKPM Scale in relation to the Grade Point from the Mathematics Education Course

	Grade Point from the Mathematics Education Course	N	$\bar{X}$	Ss
PCKPM Scale Scores	Very low (1.80-2.00)	2	4.00	1.41
	Low (2.01-2.50)	4	6.00	1.63
	Medium (2.51-3.00)	45	7.68	2.80
	High (3.01-3.50)	72	8.30	2.53
	Very high (3.51-4.00)	83	8.63	2.49
	Total	206	8.21	2.61

When Table 19 is examined, it is seen that the grade points in the mathematics education course of the pre-service teachers and the PCKPM scale scores are parallel to each other. The PCKPM scale mean scores of the pre-service teachers who have a very low grade point in the mathematics education course are also quite low compared to the other pre-service teachers ($\bar{X}$=4.00). Similarly, the mean scores of the pre-service teachers with a very high grade point taken from the scale ($\bar{X}$=8.63) are higher than those of the other pre-service teachers.

Table 20. ANOVA Results Showing Whether the Scores Taken by the Pre-service Preschool Teachers from the PCKPM Scale and its Sub-Dimensions Vary Significantly Depending on the Variable of Having Taken the Mathematics Education Course

	Source of the Variance	Sum of Squares	Sd	Mean Squares	F	*p*	Significant Difference
Number	Between-Groups	5.807	4	1.452	1.423	.228	-
	Within-Groups	205.125	201	1.021			
	Total	210.932	205				
Pattern	Between-Groups	7.078	4	1.769	1.791	.132	-
	Within-Groups	198.616	201	.988			
	Total	205.694	205				
Order	Between-Groups	7.844	4	1.961	4.026	.004*	5>3
	Within-Groups	97.903	201	.487			
	Total	105.748	205				
Shape	Between-Groups	4.793	4	1.198	2.168	.074	-
	Within-Groups	111.071	201	.553			
	Total	115.864	205				
Spatial	Between-Groups	2.636	4	.659	.979	.420	-
	Within-Groups	135.228	201	.673			
	Total	137.864	205				
Comparison	Between-Groups	3.912	4	.978	2.319	.058	-
	Within-Groups	84.768	201	.422			
	Total	88.680	205				
PCKPM Scale Total	Between-Groups	83.091	4	20.773	3.163	.015*	-
	Within-Groups	1320.079	201	6.568			
	Total	1403.170	205				

*p< 0.05

As can be seen in Table 20, the mean scores taken from the PCKPM Scale vary significantly depending on the grade points in the mathematics education course (F(4.201)=3.163, p<.05). However, as a result of the Scheffe test, which was carried out to determine between which groups there was a significant difference, no result was found in favour of any group. When the mean scores taken from the sub-dimensions were examined, it was found that there was a significant difference in the sub-dimension of *order* (F(4.201)=4.026, p<.05). According to the Scheffe test findings, this

significant difference is in favour of the pre-service teachers with a medium grade point ($\bar{X}$=1.11) compared to the pre-service teachers with a very high grade point ($\bar{X}$=1.51).

Table 21. T-test Results Showing Whether the Scores Taken by the Pre-service Teachers from the PCKPM Scale and its Sub-Dimensions Vary Significantly Depending on the Variable of Believing in the Necessity of Mathematics Education in the Pre-school Period

	Believing in the Necessity	**N**	**$\bar{X}$**	**Ss**	**sd**	**t**	***p***
Number	Yes	363	1.27	.99	437	3.32	.001*
	No	76	.86	.89			
Pattern	Yes	363	1.27	1.00	437	1.01	.310
	No	76	1.14	.97			
Order	Yes	363	1.32	.74	437	2.17	.030*
	No	76	1.11	.74			
Shape	Yes	363	1.26	.72	437	1.06	.290
	No	76	1.17	.70			
Spatial	Yes	363	1.30	.83	437	-.97	.328
	No	76	1.40	.89			
Comparison	Yes	363	1.44	.68	437	1.65	.099
	No	76	1.30	.69			
Scale	Yes	363	7.90	2.51	437	2.85	.005*
Total	No	76	7.01	2.31			

*p< 0.05

As can be seen in Table 21, mean scores taken from the PCKPM scale by the pre-service pre-school teachers vary significantly depending on their state of believing in the necessity of mathematics education in the preschool period (t(437)=2.85, p<.05). Accordingly, the PCKPM scores of the pre-service teachers who believe in the necessity of mathematics education in the pre-school period ($\bar{X}$=7.90) are higher than those of the pre-service teachers who do not believe in the necessity of mathematics education ($\bar{X}$=7.01). When the mean scores taken from the sub-dimensions were examined, significant differences were found in the sub-dimensions of *number* (t(437)=3.32, p<.05) and *order* (t(437)=2.17, p<.05) in favour of the teachers believing in the necessity of mathematics education.

Findings related to the Fourth Sub-Question of the Study

The opinions of the in-service and pre-service pre-school teachers regarding pre-school mathematics are given in Tables 22, 23, 24, 25, 26 and 27 in the form of frequency and percentage.

Table 22. The Reasons Why the In-service and Pre-Service Pre-schoolTeachers Consider Mathematics Education Necessary in the Pre-school Period

	Codes	**f**	**%**
In-service Teachers	Preparation for primary education	3	33.44
	Because their minds are open/early education	2	22.22
	Acquisition of basic math skills	2	22.22
	Presence of it in all areas of life	1	11.11
	Acquisition of daily life skills	1	11.11
Pre-service Teachers	Acquisition of basic math skills	7	31.81
	Acquisition of daily life skills	5	22.72
	Providing support to cognitive development	4	18.18
	The importance of early education	2	9.00
	Preparation for literacy	1	4.54
	Teaching of abstract concepts	1	4.54
	Developing a positive attitude towards mathematics	1	4.54

As can be seen in Table 22, the answers of three teachers are related to the code of "preparation for primary education", the answers of two teachers are about the code of "children's minds are open" and the answers of two teachers are under the code of "acquisition of basic mathematics skills". Similarly, seven pre-service teachers consider mathematics education necessary for the "acquisition of basic mathematics skills", five pre-service teachers consider it necessary for the "acquisition of daily life skills" and four pre-service teachers consider it necessary for "supporting cognitive development". Some related explanations made by teachers and pre-service teachers are as follows:

"….It is very important because it is the beginning of education life and children's minds are open." (T7)

"Mathematics is in our life at any moment and it is one of the most important abilities necessary for cognitive development. Therefore, it should be included in early education….. I think it is necessary." (3.1)

Table 23. The Importance Given to Mathematics Education in the Pre-school Period in our Country according to the Opinions of the Preschool Teachers and Pre-service Teachers

	Codes	**f**	**%**
In-service Teachers	Due importance is given	6	66.66
	As teachers, we give importance	4	44.44
	Partially/insufficient	2	22.22
	It changes depending on the scope; the education system makes it necessary	1	11.11
	It is not taught by doing, by experiencing and through discovery	1	11.11
	Parents don't give enough importance	1	11.11
	Teachers' preference for being inactive/teacher incompetence	1	11.11
Pre-service Teachers	Inadequacy of implemented activities	4	18.18
	Mathematics' being abstract, not being able to concretize it	4	18.18
	Mathematics' being difficult and requiring effort	3	13.63
	Preference for art activities	2	9.09
	The comfort of its being given in primary school	1	4.54
	Not allocating enough time to subjects	1	4.54
	Preference for easy activities	1	4.54
	Presentation of too many concepts	1	4.54
	Inadequacy of teacher training	1	4.54
	Using too many games rather than teaching the subjects	1	4.54
	Lack of awareness	1	4.54
	Teaching by imitation	1	4.54

Table 23 shows that while six teachers stated that the required importance is given to mathematics education in the pre-school period in our country, all of the pre-service teachers stated that it is not given adequate importance. Some related explanations are as follows:

"I give importance. I try to include activities such as pattern, counting, matching activities." (T6)

"Mostly not given. Games are usually used rather than teaching the subjects because mathematics education is a more demanding than the teaching of other subjects, so most teachers do not give enough importance." (3.7)

Table 24. Activities that the Preschool Teachers and Pre-Service Teachers Include or Consider to Include in Preschool Mathematics Education

	Codes	f	%
In-service Teachers	Number-Counting	8	88.88
	Operations	5	55.55
	Pattern	4	44.44
	Matching	4	44.44
	Activities based on concrete life experiences	2	22.22
	Algorithm	2	22.22
	Attention/Perception activities	2	22.22
	Classification	1	11.11
	Table, graph	1	11.11
	Music-game-movement	1	11.11
Pre-service Teachers	Activities based on concrete life experiences	10	45.45
	Pattern	7	31.81
	Number-Counting	5	22.72
	Operations	4	18.18
	Matching	3	13.63
	Geometric shapes	3	13.63
	Length, weight measurements	1	4.54
	Part-whole, full-half	1	4.54
	Mind enhancing activities	1	4.54
	Music-game-movement	1	4.54

According to Table 24, the in-service and pre-service teachers mostly prefer activities based on number-counting, operations, patterns, matching and concrete experiences in preschool mathematics education. When the most preferred activities are examined, it is seen that 8 of the in-service teachers stated that they included or would include activities based on number-counting and 10 of the pre-service teachers stated that they included or would include activities based on concrete life experiences. Seven teachers stated that they preferred activities based on patterns and five pre-service teachers stated that they preferred activities based on number-counting. Some statements about the activities that teachers and pre-service teachers included are as follows:

"Activities requiring writing and recognizing numbers, performing simple addition and subtraction operations, pattern, matching, grouping, attention enhancing activities…." (T5)

"I would use activities that one could learn by doing and experiencing. Instead of printing numbers on paper, I would use activities through which they could understand by touching and feeling." (3.5)

Table 25. Codes that the In-service and Pre-Service Pre-school Teachers Have Difficulty or Think They will Have Difficulty in Implementing in Pre-School Mathematics

	Codes	f	%
Teacher	There is no theme that I have difficulty in	4	44.44
	Operations	2	22.22
	I have a hard time with developmentally retarded children	2	22.22
	Pattern	1	11.11
Pre-service Teacher	There is no theme that I have difficulty in	10	45.45
	Operations	4	18.18
	Abstract themes	3	13.63
	Spatial concepts	2	9.09
	Advanced mathematics	1	4.54
	Time	1	4.54
	Matching	1	4.54
	Volume	1	4.54

According to Table 25, nearly half of the in-service and pre-service teachers think that there is no code that they consider they will have difficulty in while teaching mathematics. The code of operations is one of the maincodes that the other in-service teachers and pre-service teachers have difficulty in or think they will have difficulty while teaching mathematics. In addition, two of the in-service teachers stated that they had difficulty in developmentally retarded children, and another teacher stated that he/she had difficulty in teaching patterns. On the other hand, three of the pre-service teachers stated that they would have difficulty in teaching abstract themes and two in teaching spatial concepts. Accordingly, some statements indicating the codes that teachers and pre-service teachers have difficulty or think they will have difficulty in teaching:

"We can have difficulties when starting the operations; we have to teach by using concrete things. However, we may have problems with some children even in operations performed on the basis of concrete objects." (T7)

"... it is difficult to teach abstract themes" (3.14)

Table 26. The Extent to which the In-serviceand Pre-Service Pre-school Teachers Find the Objectives and Specifications in the Current Pre-school Curriculum in the Field of Mathematics Sufficient

	Codes	**f**	**%**
Teacher	I find sufficient	8	88.89
	Can be improved	1	11.11
	It does not give enough opportunities to the teacher	1	11.11
	Activities should be increased	1	11.11
Pre-service	I find sufficient	12	54.55
Teacher	I don't find sufficient	9	40.91
	I have no idea, I don't have a grasp of the subjects	1	4.54
	Teachers should be consulted	2	9.09
	Training should be given to teachers	2	9.09
	Insufficient practice	2	9.09
	Concepts should be embodied	2	9.09
	Activities should be supported with materials	1	4.54
	Activities should be increased	1	4.54

As can be seen in Table 26, 8 of the in-service pre-school teachers and 12 of the pre-service teachers find the objectives and specifications in the field of mathematics in the Pre-school Curriculum prepared by the Ministry of National Education sufficient, 9 pre-service teachers do not find the objectives and specifications sufficient. Some of the explanations made by the teachers and pre-service teachers regarding the objectives and specifications in the field of mathematics in the preschool curriculum are as follows:

"Yes, they are sufficient. They have a wide scope." (3.9)

"The objectives and specifications in the current curriculum are not sufficient. They seem to be sufficient for mathematics education. The mathematics teaching carried out in the classroom needs to be improved so that we can evaluate the objectives and specifications accordingly." (4.8)

Table 27. Areas where the In-service and Pre-Service Pre-school Teachers Find Themselves Incompetent and their Attempts to Develop Themselves in these Areas

	Codes	f	%
Teacher	I don't think I have shortcomings	6	66.66
	I think I have shortcomings	2	22.22
	I am not good at individual learning	2	22.22
	I try to learn GEMS, STEM, coding etc. programs	1	11.11
	I'm looking for educational videos and activities	1	11.11
	I examine each child's paper and try to give feedback to the parents	1	11.11
Pre-service Teachers	I think I have shortcomings	15	68.18
	I don't think I have shortcomings	7	31.82
	I have lack of experience in practice	4	18.18
	I am not competent enough in subjects apart from number and counting	2	9.09
	I am not good enough in the implementation of the curriculum	1	4.54
	I am personally not competent enough in mathematics	1	4.54
	I am not competent enough in finding activities and making them concrete	1	4.54
	I am not competent enough in using techniques	1	4.54
	I can attend courses, workshops, seminars, conferences and certificate programs	2	9.09
	I consult the people around	1	4.54
	I get help from the internet	1	4.54
	I do research	1	4.54
	I participate in trainings	1	4.54
	I am planning to get help in the future	1	4.54

As can be seen in Table 27, 6 of the teachers and 7 of the pre-service teachers consider themselves competent in the field of preschool mathematics. Two of the in-service teachers evaluated themselves as inadequate in "individual learning". The pre-service teachers expressed themselves as inadequate especially in terms of practical experience in areas other than number and counting. They stated that they "followed different mathematics programs", "researched for videos and activities", and "communicated with parents" so that they could improve themselves in subjects in which they were not good enough. The pre-service teachers reported that they participated in courses, workshops, seminars, conferences and certificate programs. Accordingly, some expressions about the areas in which the teachers and pre-service teachers are not competent enough and their attempts made to improve themselves in these areas are given below:

"I try to learn GEMS and STEM, coding etc. programs. I am trying to improve myself." (T6)

"I don't find myself competent enough. I think that I can improve myself by attending courses and seminars that provide training I need." (4.7)

DISCUSSION, CONCLUSION AND IMPLICATIONS

In light of the results of the current study, which was carried out to examine the in-service and pre-service pre-school teachers' pedagogical content knowledge in mathematics education , it was determined that the pedagogical content knowledge of the in-service teachers and pre-service teachers in preschool mathematics was at a "medium" level. When the sub-dimensions of pre-school mathematics were examined, it was concluded that the highest mean score was taken from the sub-dimension of *order* by the teachers and the sub-dimension of *comparison* by the pre-service teachers. On the other hand, it was found that the lowest mean score was taken from the sub-dimension of *pattern* by the teachers and the sub-dimension of *number* by the pre-service teachers. In studies examining the pedagogical content knowledge of teachers in pre-school mathematics (Argın, 2019;

Avcı Güryet, 2021; Lee, 2017), it was determined that the content knowledge of the teachers was at a moderate level, similar to the current study. Different from this result, in various studies examining the pedagogical content knowledge of pre-school teachers, there are also results showing that teachers' pedagogical content knowledge about early mathematics is insufficient (Argın and Dağlıoğlu, 2020; Ginsburg and Ertle, 2008; Ginsburg and Golbeck, 2006; Zhang, 2015). Contrary to these findings, there are also studies concluding that teachers' pedagogical content knowledge in pre-school mathematics is high (Dal, 2015; Demirbaş, 2019). When studies conducted on pre-service teachers are examined, it is seen that there are results indicating that pre-service teachers' beliefs about mathematics, mathematics teaching and learning mathematics (Duru and Göl, 2016) and pedagogical content knowledge (Avcı and Kutluca, 2022) are high.

It was also concluded that there was no significant difference in the scores taken from the PCKPM Scale depending on the "educational level" and "the level of self-efficacy of the teachers in teaching mathematics in the pre-school period". On the contrary to this result, the results of the study conducted by Özdemir (2020)showed that there is a significant difference in the pedagogical content knowledge of pre-school teachers depending on their education level and the type of high school they graduated from. Similarly, in the study conducted by Argın (2019), it was concluded that the pedagogical content knowledge mean scores of the teachers holding a bachelor's or graduate degree are better than those of the teachers who were the graduates of a vocational high school or an associate's degree program.

When it was examined whether the mean scores taken from the PCKPM Scale by the teachers vary significantly depending on the variable of "teaching experience", it was seen that only in the sub-dimension of "spatial", the teachers with 11-15 years of teaching experience had a higher mean score than the teachers who had worked for more than 20 years. Parpucu and Erdoğan (2017) examined the relationship between the frequency of in-service pre-school teachers and pre-service teachers' using the mathematical language and their mathematical pedagogical content knowledge and they found that the teachers with 6-10 years of teaching experience used more mathematical expressions than the teachers who were novice and the teachers with 10 or more years of teaching experience. In the study conducted by Argın (2019), it was also reported that the teachers with 6-10 years of teaching experience had a higher pedagogical content knowledge mean score than the teachers with 0-5 years of teaching experience in the sub-dimension of pattern. In addition, in the same study, it was revealed that there was a significant age-related difference. Accordingly, in the sub-dimension of number, it was determined that the mean scores of the teachers aged between 23-30 and 31-40 years differed significantly compared to the mean score of the teachers aged between 18-22. In the sub-dimension of comparison, a significant decrease was observed in the mean scores of the teachers who were over 51 years old compared to younger teachers (Argın, 2019). This result is consistent with the result of the current study.

In the current study, it was found that the scores taken by the pre-service teachers from the PCKPM Scale varied significantly depending on the variables of "gender", "grade level", "grade point average", "having taken the mathematics education course", "grade point in the mathematics education course", "believing in the necessity of mathematics education in the preschool period". The significant difference found on the basis of gender was in favour of the female pre-service teachers. Different studies conducted on in-service teachers and pre-service teachers in the literature also support this result (Aksu, 2008; Duatepe Paksu, 2008; Duru and Göl, 2016). It was determined that the pedagogical content knowledge mean scores of the pre-service teachers studying at upper grade levels taken from the whole scale and from the sub-dimensions of number and order were higher than those of the pre-service teachers studying at lower grade levels. The mean scores taken from the PCKPM Scale by the pre-service teachers varied significantly depending on the variable of having taken the mathematics education course. As a result, it can be said that the Early Childhood Mathematics Education course that the pre-service teachers took during their undergraduate education contributed positively to the pre-school mathematics pedagogical content knowledge of the pre-service teachers. The mean scores taken from the whole scale and the sub-dimension of order were found to vary significantly depending on the grade point in the mathematics education course in favour of the pre-

service teachers whose grade points were "very high" and "high". Similarly, in the study by Duatepe and Paksu (2008), it was revealed that pre-service teachers found the mathematics course very useful.

When the results from the qualitative dimension of the study were examined, it was seen that all of the pre-school teachers consider mathematics education necessary because of a variety of reasons such as "preparation for primary education, the importance of early education as the minds of pre-school children are open, the acquisition of basic mathematics skills, the acquisition of daily life skills and the necessity of mathematics is in all areas of life". Similarly, all of the pre-service teachers interviewed consider mathematics education necessary in the pre-school period for reasons such as its necessity for "preparation for primary education, acquisition of basic mathematical skills and daily life skills and the importance of early education". In the quantitative dimension of the study, it was revealed that the pedagogical content knowledge mean scores of the pre-service teachers taken from the whole scale and the sub-dimensions of *number* and *order* varied significantly depending on the variable of belief in the necessity of mathematics education in the pre-school period in favour of the pre-service teachers believing in the necessity of mathematics education in the preschool period. In this sense, it was observed that the quantitative and qualitative results of the study concurred with each other. Similarly, in the study by Umay (2003) and İnan (2014), the pre-service teachers stated that mathematics exists in all areas of life. According to another result that emerged in the qualitative dimension of the study, it was stated that activities based on concrete experiences were preferred by both the teachers and pre-service teachers in preschool mathematics education. This result is parallel to the results of the study conducted by Tarım and Bulut (2006) on pre-service teachers.

The teachers' opinions on the importance given to mathematics in the preschool period in our country are that the due importance is given to mathematics. Few teachers on the other hand stated that mathematics education is partially given importance in the pre-school period in our country. The stated reasons for lack of importance attached to mathematics education include reasons related to the teaching method such as not teaching in such a way as to allow students to learn by doing and experiencing or through discovery and parental attitude such as their not much caring about their children's education. The pre-service teachers also stated that "teachers are not very active, activities are insufficient, mathematics is abstract as a subject area, it cannot be concretized, mathematics is challenging, difficult, artistic activities and easy activities are preferred, it will be given in primary school and the subjects are not emphasized much".

The participated preschool teachers stated that they mostly used activities based on number and counting, operations, pattern, matching and activities based on concrete experiences, algorithm and attention/perception in mathematics education. In the study by Lee (2017), it was concluded that the content knowledge about number, measurement and classification is higher than the subjects of shape and spatial perception. The pre-service teachers stated that they would mostly include activities based on concrete life experiences, similar to the teachers. After the activities based on concrete life experiences, the activities most preferred were based on pattern, number-counting, operations, matching, geometric shapes, length, weight measurements, piece-whole, full-half, mind-enhancing activities and music-game-movement activities. In the study by Avcı and Kutluca (2022), it was seen that the pre-service teachers adopted child-centred pedagogical beliefs.

When the mean scores obtained by the in-service teachers and pre-service teachers from the PCKPM Scale were examined in terms of sub-dimensions, it was seen that the teachers and pre-service teachers had the lowest mean scores from the sub-dimensions of number, pattern and shape. According to the results ofthe interviews, although the in-service and pre-service teachers gave importance to the mentioned sub-dimensions of mathematics, the scale scores showed the opposite. In addition, the sub-dimensions that the teachers and pre-service teachers had the highest mean scores in the quantitative dimension are the sub-dimensions of spatial and comparison. However, in the qualitative dimension, the most difficult subjects for the in-service teachers and pre-service teachers were found to be abstract themes and spatial issues after operations. In this sense, it is seen that the results obtained from the interviews in the qualitative dimension and the results obtained from the scale in the quantitative dimension do not concur.

While the in-service teachers mostly agree with the idea that the Preschool Curriculum is sufficient in the field of mathematics, about half of the pre-service teachers consider it sufficient. In the suggestions made regarding the areas deemed insufficient in the curriculum, there are suggestions regarding the need to consult teachers, train teachers, increase practice opportunities, concretize concepts, support activities with materials and increase the number of activities. To do so, teachers must first have this competence.

The in-service pre-school teachers considered themselves highly competent in pre-school education. In the variable of the level of competence, which was considered in the quantitative dimension of the study, the teachers generally evaluated themselves as "competent enough" and "very competent". Seen from this perspective, it can be said that the quantitative and qualitative data of the study concur with each other. According to the results of the studies conducted by Di Santo, Timmons and Lennis (2017), and Avcı and Kutluca (2022), it was concluded that early childhood educators who receive pre-service education believe that pre-school education has a high pedagogical importance in children's learning. In this respect, their results are in line with the results of the current study. However, in the current study, when the self-efficacy of the pre-school teachers in teaching mathematics was examined, it was determined that the scale scores of the teachers who expressed themselves as quite competent were lower than the other groups. Studies in the literature also support the results that teachers have high self-efficacy in mathematics education (Çelik, 2017; Gömleksiz and Serhatlıoğlu, 2013; Kesgin 2006). In the current study, contrary to the in-service teachers, the majority of the pre-service teachers stated that there is a theme in which they are not competent enough or have difficulty within the field of preschool mathematics education.

In the study, apart from the teachers and pre-service teachers who do not think that they have a deficiency in the field of pre-school mathematics education, there are pre-service teachers who stated that they feel inadequate in terms of "practice experience, subjects other than numbers and counting, the curriculum, finding activities and techniques" and there are teachers who stated that they are inadequate in terms of "individual learning". As a result of the study conducted by Özdemir (2020), it was concluded that the negative past experiences of preschool teachers in mathematics or their participation in mathematics studies do not affect their self-efficacy. This result does not concur with the result of the current study. In the current study, the pre-service teachers stated that they participated in training programs, consulted people around, sought help from the internet, conducted research and would receive support in the future" to improve themselves in the areas in which they feel not competent enough. When the opinions of the teachers were examined, it was seen that they tried to learn GEMS (Great Exploration in Math and Science), STEM (Science, Technology, Engineering and Mathematics) and coding programs, examined the educational videos and activities and gave feedback to the parents about the children's performances to improve themselves in the areas in which they feel not competent enough.

According to the results of the current study, it can be suggested to organize training and certificate programs to increase the pedagogical content knowledge of pre-school teachers and pre-service teachers in the field of mathematics. Based on the idea that mathematics remains abstract, it can be suggested to examine the resources related to activities based on concrete life experiences and to follow educational videos. Additionally, the result obtained from the current study highlights the importance of the Mathematics Education course in Preschool Education undergraduate programs and its relationship with other disciplines. Accordingly, it can be suggested to enrich the content of the Mathematics Education course and increase the practical courses in undergraduate programs. Moreover, the results emphasize the importance of learning based on concrete experiences in daily life in the teaching of mathematical concepts. In this direction, families can be offered activities where they can include many skills such as comparison, matching, classification in kitchen activities, daily housework, house arrangement and closet arrangement. For teachers, in-service training can be given to integrate mathematics education with different types of activities such as art, Turkish, games and drama. Finally, it can be suggested that academicians should make more use of practice while educating teachers and pay more attention to giving more place to mathematics activities in practice-oriented lessons.

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REFERENCES

Aksu, H. H. (2008). Öğretmen adaylarının matematik öğretimine yönelik öz-yeterlilik inançları, *Abant İzzet Baysal Üniversitesi Eğitim Fakültesi Dergisi*, *8*(2), 161-170. Retrieved from https://dergipark.org.tr/tr/pub/aibuefd/issue/1495/18091

Aksu, Z. ve Kul, U. (2017). Turkish adaptation of the survey of pedagogical content knowledge in early childhood mathematics education, *International Journal Of Eurasia Social Sciences, 8*(30), (1832-1848). Erişim adresi: https://openaccess.artvin.edu.tr/xmlui/handle/11494/4165

Aktaş-Arnas, Y. (2013). *Okul öncesi dönemde matematik eğitimi.* Ankara: Vize.

Argın, Y. (2019). *Okul öncesi eğitimcilerinin matematik eğitimine ilişkin pedagojik alan bilgi düzeylerinin çeşitli değişkenler açısından incelenmesi.* (Yayınlanmamış yüksek lisans tezi). Gazi Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Avcı Güryel, İ. (2021). *Okul öncesi öğretmenlerinin matematik eğitimine yönelik özyeterlikleri ile matematik pedagojik alan bilgileri arasındaki ilişkinin incelenmesi (Afyonkarahisar örneklemi)* (Yayınlanmamış yüksek lisans tezi). Afyon Kocatepe Üniversitesi, Sosyal Bilimler Enstitüsü, Afyon.

Avcı, A. ve Kutluca, A. Y. (2022). Okul öncesi öğretmen adaylarının pedagojik inançları ve pedagojik alan bilgilerinin öğretim uygulamaları üzerindeki etkisi. *TEBD, 20*(2), 394-428. https://doi.org/10.37217/tebd.1065083

Baroody, A. J., & Price, J. (1983). The development of the number-word sequence in the counting of three year olds. *Journal for Research in Mathematics Education, 14*(5), 361-368. Erişim adresi: https://www.jstor.org/stable/748681#metadata_info_tab_contents

Büyüköztürk, Ş. (2016a). *Bilimsel araştırma yöntemleri.* Ankara: Pegem Akademi.

Büyüköztürk, Ş. (2016b). *Sosyal bilimler için veri analizi el kitabı.* Ankara: Pegem Akademi.

Creswell, J. W. & Plano Clark, V. L. (2015). *Karma yöntem araştırmaları tasarımı ve yürütülmesi.* Ankara: Anı.

Çelik, M. (2017). Okul öncesi öğretmenlerinin erken matematik eğitimine ilişkin öz-yeterlikleri. *Uluslararası Türk Eğitim Bilimleri Dergisi, 5*(8), 240-247. Erişim adresi: https://dergipark.org.tr/tr/download/article-file/408869

Dağlı, A. (2007). *Okul öncesi eğitimi alan ve almayan ilköğretim birinci sınıf öğrencilerinin Türkçe ve matematik derslerindeki akademik başarılarının karşılaştırılması* (Yayınlanmamış yüksek lisans tezi). Selçuk Üniversitesi, Sosyal Bilimler Enstitüsü, Konya.

Duatepe Paksu, A. (2008). Comparing teachers' beliefs about mathematics in terms of their branches and gender. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 35,* 87-97. Erişim adresi: https://www.researchgate.net/publication/279765917_Comparing_teachers'_beliefs_about_mathematics_in_terms_of_their_branches_and_gender_Ogretmenlerin_matematik_hakkindaki_inanclarinin_brans_ve_cinsiyet_bakimidan_karsilastirilmasi

Duru, A. ve Göl, R. (2016). Öğretmen adaylarının matematik, matematik öğretimi ve matematik öğrenmeye ilişkin inançları. *Adıyaman Üniversitesi Eğitim Bilimleri Dergisi, 6*(2), 255-282. Erişim adresi: http://dspace.adiyaman.edu.tr:8080/xmlui/handle/20.500.12414/254

Erkan, S. ve Kırca, A. (2010). Okul öncesi eğitimin ilköğretim birinci sınıf öğrencilerinin okula hazır bulunuşluklarına etkisinin incelenmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 38*(38), 94-106. Erişim adresi: https://search.trdizin.gov.tr/yayin/detay/104800/

Ginsburg, H. P. & Ertle, B. (2008). Knowing the mathematics in early childhood mathematics. *In Contemporary Perspectives on Mathematics in Early Childhood Education (O. N. Saracho ve B. Spodek.,* pp. 45–66). Charlotte, NC: Information Age Publishing.

Ginsburg, H. P. & Golbeck, S. L. (2006). Thoughts on the future of research on mathematics and science learning and education. *Early Childhood Research Quarterly, 19*(1), 190-200. https://doi.org/10.1016/j.ecresq.2004.01.013

Gömleksiz, M. N. ve Serhatlıoğlu, B. (2013). Okul öncesi öğretmenlerinin öz-yeterlik inançlarına ilişkin görüşleri. *Turkish Studies- International Periodical for the Languages, Literature and History of Turkish or Turkic, 8*(7), 201-221. DOI:http://dx.doi.org/10.7827/TurkishStudies.5336

Griffin, S. (2004). Building number sense with number worlds: A mathematics program for young children. *Early Childhood Research Quarterly, 19*(1), 173-180. https://doi.org/10.1016/j.ecresq.2004.01.012

Gudmundsdottir S. (1990). Values in Pedagogical Content Knowledge. *Journal of Teacher Education 41*(3), 44-52. DOİ:10.1177/002248719004100306

Güven, Y. (2005). *Erken çocuklukta matematiksel düşünme ve matematiği öğrenme.* İstanbul: Küçük Adımlar Eğitim.

Güven, Y. ve Uyanık Balat, G. (2006). *1. ve 2. sınıf öğrencilerinin matematik yeteneğinin okul öncesi eğitimi alıp almama ve kurumda veya ailesinin yanında kalma durumlarına göre karşılaştırılması. I. Uluslararası Okul Öncesi Eğitim Kongresi Bildiri Kitabı I. Cilt,* 384-397. İstanbul: Ya-Pa.

İnan, C. (2014). Okul öncesi öğretmen adaylarının matematik dersini ögretebilme konusunda hazır bulunuşluk düzeylerinin değerlendirilmesi (Diyarbakır il örnegi). *Turkish studies, 9*(8), 537-550. DOI:http://dx.doi.org/10.7827/TurkishStudies.7021

Jordan, N. C., Kaplan, D., Ramineni, C. & Locuniak, M. N. (2009). Early math matters: Kindergarten number competence and later mathematics outcomes. *Developmental Psychology, 45*(3), 850-867. DOI: 10.1037/a0014939

Karakuş, H. (2015). *Okul öncesi öğretmenlerinin matematiksel gelişimine ilişkin inanışları ile çocukların matematik kavram kazanımları arasındaki ilişkinin incelenmesi.*

(Yayımlanmamış yüksek lisans tezi). Hacettepe Üniversitesi, Eğitim Bilimleri Enstitüsü, Ankara.

Karakuş, H. ve Akman, B. (2016). Okul öncesi dönem çocuklarının matematik kavram kazanımlarının incelenmesi. *Pegem Atıf İndeksi, North America, 0, oct. 2016.* Available at: http://www.pegemindeks.net/index.php/Pati/article/view/9786053183563b2.029/9786053183563>. Date accessed: 11 Jul. 2019.

Kesgin, E. (2006). *Okulöncesi eğitim öğretmenlerinin özyeterlik düzeyleri ile problem çözme yaklaşımlarını kullanma düzeyleri arasındaki ilişkinin incelenmesi. (Denizli ili örneği).* Yayınlanmamış Yüksek Lisans Tezi. Pamukkale Üniversitesi, Denizli.

Lee, J. E. (2017). Preschool Teachers' Pedagogical Content Knowledge in Mathematics. *International Journal of Early Childhood, 49,* 229–243. Erişim adresi: https://link.springer.com/content/pdf/10.1007/s13158-017-0189-1.pdf?pdf=button

Metin, M. (2015). *Eğitimde bilimsel araştırma yöntemleri.* Ankara: Pegem Akademi.

Nasibov, F. ve Kaçar, A. (2005). Matematik ve matematik eğitimi hakkında. *Kastamonu Eğitim Dergisi, 13*(2), 339-346. Erişim adresi: https://search.trdizin.gov.tr/yayin/detay/117139/

NCTM (2000). *Principles and standards for school mathematics.* Reston, Va. NCTM.

Özdemir, B. (2020). *Okul öncesi öğretmenlerinin erken matematik eğitimine ilişkin pedagojik alan bilgileri ile özyeterlilikleri arasındaki ilişkinin incelenmesi* (Yayınlanmamış Yüksek Lisans Tezi). Sabahattin Zaim Üniversitesi, Lisansüstü Eğitim Enstitüsü, İstanbul.

Parpucu, N. ve Erdoğan, S. (2017). Okul öncesi öğretmenlerinin sınıf uygulamalarında matematik dilini kullanma sıklıkları ile pedagojik matematik içerik bilgileri arasındaki ilişki. *Erken Çocukluk Çalışmaları Dergisi, 1*(1), 19-32. DOI:10.24130/eccd-jecs.19672017118

Rovegno, I. (1992). Learning a new curricular approach: Mechanisms of knowledge acquisition in preservice teachers. *Teaching and Teacher Education, 8*(3), 253-264. https://doi.org/10.1016/0742-051X(92)90024-W

Sarnecka, B. W. & Carey, S. (2008). How counting represents number: What children must learn and when they learn it. *ELSEVIER, 108*(3), 662-674. Erişim adresi: https://www.sciencedirect.com/science/article/pii/S0010027708001145

Smith, K. H. (2000). *Early childhood teachers' pedagogical content knowledge in mathematics: A quantitative study.* Unpublished Doctoral Dissertation, Georgia State University, Georgia, Atlanta.

Tarım, K. ve Bulut, M. S. (2006). Okul öncesi öğretmenlerinin matematik ve matematik öğretimine ilişkin algı ve tutumları. Çukurova Üniversitesi, *Eğitim Fakültesi Dergisi, 32*(2), 152-164. Erişim adresi: https://search.trdizin.gov.tr/yayin/detay/96170/

Umay, A. (2003). Okul öncesi öğretmen adaylarının matematik öğretmeye ne kadar hazır olduklarına ilişkin bazı ipuçları. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi 25,* 194-203. Erişim adresi: https://search.trdizin.gov.tr/yayin/detay/3090/

Polat Unutkan, Ö. (2007). Okul öncesi dönem çocuklarının matematik becerileri açısından ilköğretime hazır bulunuşluğunun incelenmesi. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi, 32*(32), 243-254. Erişim adresi: https://www.researchgate.net/publication/330967429_Okul_oncesi_donem_cocuklarinin_matematik_becerileri_acisindan_ilkogretime_hazir_bulunuslugunun_incelenmesi

Uyanık, Ö. ve Kandır, A. (2010). Okul öncesi dönemde erken akademik beceriler. *Kuramsal Eğitimbilim Dergisi, 3*(2), 118-134. Erişim adresi: https://dergipark.org.tr/tr/download/article-file/304144

Wolfgang, C., Stannard, L., & Jones, I. (2003). Advanced constructional play with LEGOs among preschoolers as a predictor of later school achievement in mathematics. *Early Child Development and Care, 173*(5), 467-475. doi:https://doi.org/10.1080/0300443032000088212 [Taylor & Francis Online], [Google Scholar]

Yazıcı, Z. (2002). Okul öncesi eğitiminin okul olgunluğu üzerine etkisinin incelenmesi. *Milli Eğitim Dergisi, 155.* Erişim adresi: http://dhgm.meb.gov.tr/yayimlar/dergiler/milli_egitim_dergisi/155-156/yazici.htm

Yenilmez, K. (2011). Matematik öğretmeni adaylarının matematik tarihi dersine ilişkin düşünceleri. *Pamukkale Üniversitesi Eğitim Fakültesi Dergisi, 30,* 79-90. Retrieved from https://dergipark.org.tr/tr/pub/pauefd/issue/11113/132873

Yıldırım, B. (2011). Matematik ilkeleri ve standartları. B. Akman (Ed.), *Okul öncesi matematik eğitimi* (ss. 12-24). Ankara: Pegem Akademi.

Yıldırım, A. ve Şimşek, H. (2013). *Sosyal bilimlerde nitel araştırma yöntemleri* (9. baskı). Ankara: Seçkin.

Yıldız, G. (2005). *Erken çocuklukta matematiksel düşünme ve matematiği öğrenme*. İstanbul: Küçük Adımlar Eğitim.

Zhang, Y. (2015). *Pedagogical content knowledge in early mathematics: What teachers know and how ıt associates with teaching and learning.* Loyola University Chicago