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An investigation into mathematics-related pedagogical content knowledge of preschool educators based on institution type[1]

Yusuf Argın, *Sinop University,* Turkey, *yusufargn@gmail.com* ORCID: 0000 0003 2557 9808
Hacer Elif Dağlıoğlu, *Gazi University,* Turkey, *edaglioglu1@gmail.com* ORCID: 0000 0002 7420 815X

Abstract. This study aimed to investigate the level of mathematics-related pedagogical knowledge of educators working in preschool institutions. This descriptive study included 153 participants working as educators at preschool institutions affiliated to the Turkish Ministry of National Education or operated independently (private), or at kindergartens affiliated to the Turkish Ministry of Family, Labor and Social Services (MFLSS). The educators' knowledge levels were examined using the "Pedagogical Content Knowledge in Early Childhood Mathematics Education" scale, which was developed by Smith (1998) and adapted to the Turkish context by Aksu and Kul (2017). The scale consists of 15 items with 6 dimensions focused on numbers, patterns, sorting, shapes, spatial perception, and comparison. SPSS version 23 statistical software was used to analyze the data. The results of the study suggested that the pedagogical levels of the educators were low. Educators working at kindergartens operated by the MFLSS had significantly lower levels of pedagogical knowledge than educators working at other institutions, and the education level of those working at state preschools were higher than those working at other kindergartens.

Keywords: Preschool education, educator, mathematics-related pedagogical content knowledge, education level

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INTRODUCTION

Preschool represents the fastest period of development for children, a time in which they actively acquire many basic concepts and skills. The emergence of preschool education impacted on the academic success of children's lives in later years, signifying the importance of this developmental period in terms of knowledge and skills gained in becoming a functional member of society (Charlesworth & Lind, 2007; Clements, 2004; Clements & Sarama, 2011). This situation brought mathematics education, which is a powerful tool in understanding and exploring the world, onto the agenda for the period commonly known as "preschooling." Research in the field has shown that children gain the concepts and skills necessary to learn mathematics in their early years, and start school with the knowledge and mental skills that are essential to mathematics learning (Charlesworth & Lind, 2007; Clements & Sarama, 2004, 2011).

The mathematical knowledge that children gain during their preschooling can be surprisingly complex and extensive. Children spend most of their time playing free games that form the basis of their mathematical knowledge, with children establishing relationships, matching, grouping, patterning, sorting, counting, and using spatial relationships as well as, length and weight measurements in this process. In a way, the preschool years can be termed as "magical years," where the foundations of many mathematical concepts and skills important to educational processes and daily life are formed. In these years, the basis of mathematical knowledge, skills and concepts required in the understanding of mathematics and other sciences is established, but when the academic development and subsequent careers of individuals are taken into account, in general, it is the academic development and careers that are considered to be of the most importance (Choi & Chang, 2011). Children's stance not developing a fear of mathematics, but acquiring a love for mathematics, an enthusiasm for mathematics, and developing a positive

[1] The results of this article are taken from Yusuf Argın's master thesis titled "Examination Of Pedagogigal Content Knowledge Levels of Pre-School Educators in Regard to Mathematics Education in Terms of Various Variables" published in 2019.

attitude towards mathematics is seen as directly proportional to the mathematical experiences that teachers offer during early childhood education and to the future success of these children (Clements, 1984; Clements & Sarama, 2011; Metin, 1994; Zhang, 2015).

The National Council of Teachers of Mathematics (NCTM), which is one of the foremost authorities on mathematics education worldwide, put forward standards applicable for preschool through to secondary education, and has been seen as a common point of reference for researchers and teachers working in this area. The standards define what children should know and what they should do (Sperry-Smith, 2006). The NCTM formed the standards under two headings, arguing that mathematical skills and processes should be learned not through rote memorization, but through interacting with materials, peers, adults and the environment (National Council of Teachers of Mathematics [NCTM], 2000, 2009).

First are the content standards, which consist of five areas that children need to learn; (1) counting and processing, (2) algebra, (3) geometry, (4) measurement, and (5) data analysis and probability. The aim of these standards is for children to learn to recognize, show, understand relationships and counting systems, and to understand the meaning of transactions and inter-transactional relationships within the field of numbers and transactions. In algebra, the aim is to enable children to understand patterns, relationships and functions, and to show inter-quantity relationships (e.g., comparing, sorting, matching, classifying) and inter-mathematical relationships. In geometry, the aim is to analyze the characteristics of two- or three-dimensional shapes, and to have mathematical discussions about cross-shapes. The assessment content standard is intended to help children first understand how to assess using nonstandard assessment units such as hands, feet and pens, and then understand why standardized assessment units are required in order to make accurate and uniform assessments using standard assessment units such as rulers and watches. Therefore, in their assessment, it is also important for them to gain the ability to use techniques, tools and formulas that are best suited to the object or situation being assessed. Data analysis and probability, which are the last content standard, include children formulating questions and developing data collection, editing and visualization skills in order to answer them. In addition, it includes analyzing data, making predictions by syllogizing, and using the basic concepts of probability appropriately by understanding them (NCTM, 2000, 2009).

Second are the process standards which include children's usage of content information and the ways in which they obtain it. Process standards are determined as; (1) problem solving, (2) reasoning and proof, (3) connections, (4) communication, and (5) demonstration (NCTM, 2000, 2009). The NCTM states that children's learning is more permanent in terms of mathematics learning processes (such as problem solving, reasoning, and proofing) and content areas (numbers and processing, geometry, etc.) when these standards are applied together with the achievements and the indicators and/or concepts planned in accordance with the programs (Shwartz, 2005).

Teachers should therefore plan mathematical activities in accordance with learners' existing mathematical knowledge. Whilst planning, teachers should first determine a goal related to mathematics by considering the age, the developmental characteristics of the learners and also their individual differences, and then ensure that the children are able to learn by appropriately organizing the learning environment and by applying the correct methods and techniques in line with this purpose (Zhang, 2015). In other words, the primary starting point for teachers is to know what and how children learn in mathematics during the preschool period (Gifford, 2005), hence the concept of pedagogical content knowledge related to mathematics comes to the fore (Jang, 2013). Pedagogical content knowledge in education was first introduced by Shulman (1986), and it can be expressed as knowing what to teach to which age group and integrating this with knowledge of how to teach it. Pedagogical knowledge relates to teachers being equipped to create an effective and efficient learning and teaching environment for children. Teachers with a high degree of pedagogical content knowledge should possess significant content knowledge about the lessons that they teach and the activities that they use, develop problem-solving strategies, use different learning experiences within the classroom environment, possess high levels of decision-making skills, and most importantly, should be both sensitive and respectful to the children they

teach and to their opinions within the classroom environment (Guerriero, 2014). Pedagogical field knowledge of mathematics is the knowledge of how to plan activities in making it easier for children to learn mathematics, and how to use the right methods and techniques in order to implement mathematics education both easily and effectively. Math teaching knowledge includes mathematical concept knowledge as well as pedagogical knowledge that teachers require in math teaching (Ball, Thames, & Phelps, 2008). In this regard, and as illustrated in Figure 1, McCray (2008) shows that the intersection area of "Who will teach?", "What will be taught?" and "How will it be taught?" is the pedagogical field knowledge of mathematics.

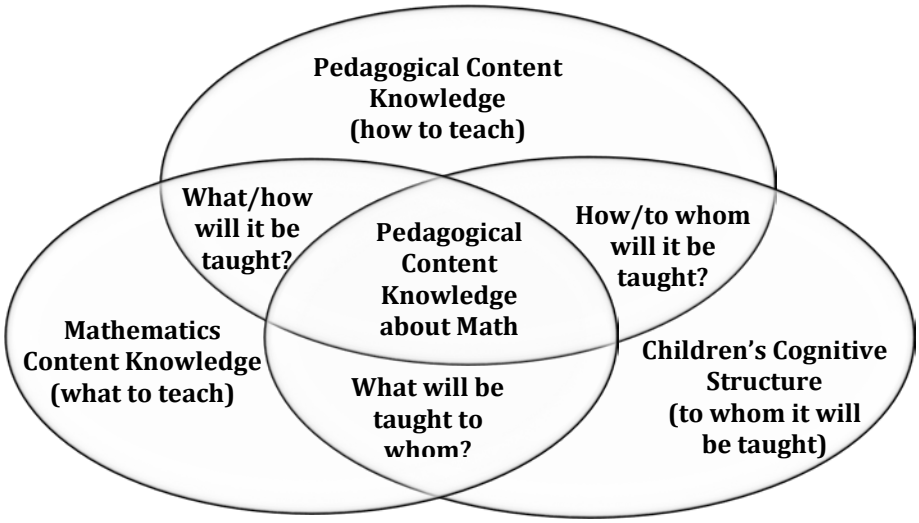

FIGURE 1. *Components of pedagogical content knowledge related to mathematics (McCray, 2008)*

Following on from McCray (2008), Lee (2017) argued that preschool teachers' pedagogical content knowledge consists of three components: Recognizing mathematical situations involving children, interpreting the nature of math activities in which children participate, and developing children's mathematical thinking and understanding. To put it another way, teachers come to the fore by planning what to teach in order to recognize mathematical situations, by designing how they can best teach in order to interpret emerging situations, and by observing the characteristics of their learners in terms of pedagogical content knowledge. Therefore, educators with a good working knowledge of mathematics are generally more focused on the children's thinking and understanding, making statements that are appropriate to a child's cognitive level, responding to the needs of the child with examples or by using various teaching methods and strategies, which makes it easier for children to understand and interpret mathematics by presenting content more accurately, at the right time, and in the most appropriate way (Aksu & Kul, 2017; Gess-Newsome et al., 2019; Smith & Neale, 1989).

When looking at studies conducted in this area in the international literature, numerous studies (Clermont, Krajcik, & Borko, 1993; Cox, 2011; Gervasoni, Hunter, Bicknell, & Sexton, 2012; Gifford, 2005; Kilday, 2010; Lee, 2017; McCray, 2008; McCray & Chen, 2012; Platas, 2008; Smith, 1998, 2000; Smith & Neale, 1989; Zhang, 2015) can be found regarding pedagogical field knowledge in mathematics education. When the literature in Turkey is examined, research has focused more on teachers' attitudes, beliefs and self-efficacy regarding mathematics education (Aksu, 2008; Aydın, 2009; Bülbül, 2016; Dede & Karakuş, 2014; Gömleksiz & Serhatlıoğlu, 2013; Güven, Karataş, Öztürk, Arslan, & Gürsoy, 2013; Karakuş, Akman, & Ergene, 2018; Koç, Sak, & Kayri, 2015; Şeker, 2013; Şeker & Alisinanoğlu, 2015). However, when studies conducted in Turkey on pedagogical field knowledge related to mathematics education are examined, only a few examples can be found (Aksu & Kul, 2017; Dağlı, Dağlıoğlu, & Atalmış, 2019; Parpucu & Erdoğan, 2017). It is therefore considered that the findings of the current study will provide valuable information about the pedagogical content knowledge levels of preschool teachers, and

provide clues about which variables this information can be related to. In this context, answers to the following research questions are sought in the current study:

1. What are the pedagogical content knowledge levels of preschool educators regarding mathematics?
2. Is there a relationship between the education levels of preschool educators and their level of pedagogical knowledge related to mathematics?
3. Is there a difference between preschool educators' pedagogical field information levels related to mathematics based on the type of institution in which they work?

METHODS

Research Model

The current study concerns the pedagogical field knowledge levels related to mathematics education of preschool educators working in public or private kindergartens affiliated to the Turkish Ministry of National Education (MoNE), and nurseries or daycare nurseries affiliated to the Turkish Ministry of Family, Labor and Social Services (MFLSS). The study was conducted via using the screening pattern to examine the pedagogical field knowledge of the aforementioned participants in detail. According to Büyüköztürk, Çakmak, Akgün, Karadeniz, and Demirel (2010), screening studies are research studies conducted on larger samples, in which the participants' opinions or interests, skills, abilities, attitudes and similar characteristics related to a subject or event are determined.

Workgroup

The study group of the research consists of 153 preschool educators working in either nursery classes or daycare centers affiliated to the MFLLS, in private kindergartens and in either public kindergartens or elementary classes at primary schools affiliated to the MoNE, in Elazig provincial center, Turkey.

Table 1. *Frequency analysis of the working group (N = 153)*

		f	%
Educational level	Vocational high school	14	12.4
	Associate degree	42	27.5
	Bachelor's degree	87	56.9
	Postgraduate degree	5	3.2
	Total	153	100.0
Age groups (years)	18-22	14	9.2
	23-30	57	37.1
	31-40	59	38.6
	41-50	15	9.8
	51+	8	5.3
	Total	153	100.0
Experience (years)	0-5	63	41.1
	6-10	50	32.7
	11-15	24	15.7
	16+	16	10.5
	Total	153	100.0

Table 1 shows that 84.4% of the preschool educators are university graduates, 75.7% are aged between 23-40 years old, and that 73.8% have 0-10 years of experience.

Table 2. *Educational status of educators working in preschool institutions*

			Vocational high school	Associate degree	Bachelor's degree	Postgrad degree	Total
Workplace institution type	Public kindergarten	# employees	1	2	66	4	73
		%	1.4	2.7	90.4	5.5	100.0
	Private kindergarten	# employees	3	17	17	1	38
		%	7.9	44.7	44.7	2.6	100.0
	Nursery / daycare	# employees	15	23	4	0	42
		%	35.7	54.8	9.5	0.0	100.0
	Total	# employees	19	42	87	5	153
		%	12.4	27.5	56.9	3,3	100.0

When Table 2 is analyzed, it can be seen that 90.4% of the preschool educators working in public kindergartens and 44.7% of the preschool educators working in private kindergartens are university graduates, compared to only 9.5% of educators working in nursery or daycare centers.

Data collection tools

An Information Form and the Pedagogical Content Knowledge Scale (PCKS) in Preschool Mathematics Education were applied in the study. The Information Form developed by the researchers was used to capture relevant features about the preschool educators, including their age, gender, seniority (years of experience), level of education, and the type of institutions at which they work.

Pedagogical Content Knowledge Scale in Preschool Mathematics Education

In a study conducted by Smith (1998), a scale named "Pedagogical Content Knowledge for Early Childhood Mathematics" was developed in order to determine pedagogical content knowledge related to mathematics education of preschool teachers. In the scale, analyses were determined by Smith (1998 as cited in xxx) based on 6 sub-dimensions (number, pattern, ranking, shape, spatial, and comparison), with a total score obtained from the scale. The scale consists of 15 multiple-choice items, with three questions each for the number, pattern, and spatial perception sub-dimensions, and two for each of the ordering, shape, and comparison sub-dimensions. A high score obtained from the scale indicates that the teacher has a high level of pedagogical knowledge of mathematics.

Aksu and Kul (2017) conducted a validity and reliability study on a sample of 190 students, 80 preschool teachers, and 110 candidate preschool teachers, and adapted the original scale to the Turkish context. Confirmatory factor analysis was used to demonstrate the compatibility of the adapted assessment tool with the original scale, and also to test its construct validity. Kuder Richardson-20 Reliability Coefficient was calculated to determine the reliability of the scale since the data of the adapted assessment tool was scored as 1-0. The Cronbach Alpha value of the scale was calculated as .71, and the correlation coefficient was found to be .81.

As a result of the data obtained by Aksu and Kul (2017) from the participant teachers and teacher candidates, it was revealed that the scale adapted to the Turkish context was found to be in harmony with the original, and that the sub-dimensions of the scale were sufficient and served the purpose of the original scale.

For the current study, the researchers determined how adequate the scale items were in distinguishing from the data collected in this study which was conducted in Elazig province, Turkey. The data showed that the item-total correlation coefficients ranged between .37 and .59, and that all items were found to be statistically significant.

The level of reliability for each of the sub-dimensions of the scale was found to be; .69 for the number perception, .66 for pattern, .65 for ranking, .67 for shape, .67 for spatial perception, and .65 for the comparison sub-dimension, whilst the reliability mean of the total scale was

calculated as .68. Therefore, the scale applied in the current study was found to be similar to the Turkish adapted version of the scale.

Data Collection Process

In the process of collecting the research data, the relevant permissions were first obtained for each institution from the Elazig Provincial Directorate of National Education. Pedagogical field knowledge levels related to mathematics were determined through the scale, with the data collected from 170 educators in an environment in which the volunteer participant educators were able to provide data outside of their working hours, when they were physically and mentally able to do so of their own free will. Analysis was conducted on the data from 153 of the participants' data, which was deemed to have been completed accurately, and as a result of the validity and reliability study applied to the data collected from a total of 170 educators. After reliability and validity checks on 170 participants' data, it was decided on conducting the further analyses with the data from 153 participants.

Data Analysis

The data collection and extraction process of the current study consisted of three stages in examining the pedagogical field knowledge regarding mathematics education by preschool educators.

In the first stage, data were collected in accordance with the objectives and ethics of the research from a total of 170 preschool educators.

In the second stage, the collected data were subjected to frequency analysis and any blank/missing data was identified. Checks were also performed as to whether or not the data was considered to be normal, with extreme values extracted using *z*-scores. Data which were found to have a *z*-score larger than 3.29 were then excluded from the subsequent analysis (Tabachnick & Fidell, 2007). Accordingly, data from 17 participants were excluded from the dataset, leaving data from 153 preschool educators to be subjected to analysis.

In the third stage, normality tests were applied in order to determine which analyses would be the most appropriate. Kolmogorov-Smirnov and Shapiro-Wilk tests were used to identify any significant differences in questions, factors, and total points ($p = .00 \leq .005$) (Büyüköztürk, 2017). Since the data were not found to be distributed normally, Kruskal Wallis - H test was then applied, which is one of the nonparametric tests.

Statistical analysis of the obtained data were performed using IBM's SPSS (version 23) statistical software and the MS Excel program.

RESULTS

In this section, according to the answers given by the study's participant the study's participants to the scale to the scale questions, the pedagogical field knowledge status related to mathematics was analyzed for each sub-dimension and for the total scale. The aim of the analysis was to ascertain whether or not any significant variation exists based on the educational status of the participants or the type of institution at which they work.

Table 3. *Analysis of participating educators based on PCKS total and sub-dimension scores*

	N	***x̄***	***Median***	***Ss***	***Min***	***Max***
Number perception	153	1.28	1.00	1.079	.	3
Pattern	153	1.14	1.00	1.054	.	3
Ordering	153	1.45	2.00	0.707	.	2
Shape perception	153	1.44	2.00	0.647	.	2
Spatial perception	153	1.44	1.00	0.769	.	3
Comparing	153	1.58	2.00	0.614	.	2
Total	153	8.33	8.00	2.300	2	13

When Table 3 is examined, the pedagogical field information for mathematics knowledge of the participant educators was found to be moderate in some sub-dimensions, whilst the

perception of numbers, patterns, and spatial perception sub-dimensions as well as the total score were found to be low. Overall, the preschool educators were found to have a generally low level of pedagogical field knowledge related to mathematics.

Table 4. *Kruskal Wallis test on PCKS pattern sub-dimension scores based on the graduation school type*

		N	$\bar{x}$	*SD*	*Sort Avg.*	*DF*	*Chi-square*	*p*	*Diff.*
Graduation School type	Vocational high school	19	0.47	0.612	50.03	3	28.658	.000	3 > 1 3 > 2 4 > 1
	Associate degree	42	0.64	0.821	56.64				
	Bachelor's degree	87	1.52	1.077	91.93				
	Postgrad degree	5	1.40	0.894	90.70				

When Table 4 is analyzed, it can be seen that significant differences were found to exist between the type of school that the educators graduated from and their pedagogical content knowledge regarding the scale's pattern sub-dimension [$\chi 2$ (2) = 28.658; p = .000; p < .05]. When the educators' graduation school type is examined, it can be determined that those educators who graduated from a vocational high school or held an associate degree had significantly lower levels of pedagogical knowledge in the pattern sub-dimension than those with an undergraduate and postgraduate degree.

Table 5. *Kruskal Wallis test on PCKS total scores based on graduation school type*

		n	$\bar{x}$	*SD*	*Sort Avg.*	*DF*	*Chi-square*	*p*	*Dif.*
Graduation school type	Vocational high school	19	7.26	1.939	55.53	3	13.963	.003	3 > 1 3 > 2 4 > 1 4 > 2
	Associate degree	42	7.81	2.015	65.88				
	Bachelor's degree	87	8.71	2.416	84.82				
	Postgrad degree	5	10.20	1.095	115.90				

When Table 5 is analyzed, it can be seen that significant differences exist between the pedagogical field knowledge based on the type of school from which the educators graduated and their total scale scores [$\chi 2$ (2) = 13.963; p = .003; p < .05]. When it was analyzed which school type the educators graduated from, it was determined that the pedagogical knowledge of the scale total scores of those educators who graduated from vocational high schools or held an associate degree were lower than those who held an undergraduate or postgraduate degree.

The pedagogical content knowledge of the participant educators regarding each sub-dimension of the scale was examined according to the type of school from which they graduated using the Kruskal Wallis test. From the results, it was seen that no significant differences were found between the preschool educators' scores based on their school of graduation:

- Number perception [$\chi 2$ (2) = 0.492; p = .921; p > .05]
- Sorting [$\chi 2$ (2) = 1.018; p = .797; p > .05]
- Shape perception [$\chi 2$ (2) = 4.681; p = .197; p > .05]
- Spatial Perception [$\chi 2$ (2) = 2.786; p = .426; p > .05]
- Comparison [$\chi 2$ (2) = 5.411; p = .144; p > .05]

When Table 6 is analyzed, it can be seen that significant differences were found between the pedagogical content knowledge in the number perception sub-dimension of the scale according to the type of institution where the preschool educators worked [$\chi 2$ (2) = 11.236; p = .004; p < .05]. The analysis compared educators working in private kindergartens or nurseries affiliated to the MoNE to those working in public kindergartens or nurseries affiliated to the MoNE and those working in nurseries or daycare centers affiliated to the MFLSS. According to the results, it was determined that the pedagogical content knowledge related to the perception of numbers sub-dimension of the educators working in private kindergartens or nurseries affiliated to the MoNE was found to be higher than those working in public kindergartens or nurseries affiliated to the MoNE in nurseries or daycare centers affiliated to the MFLSS.

Table 6. *Kruskal Wallis test on PCKS perception sub-dimension based on type of institution*

		n	$\bar{x}$	*SD*	*Sort Avg.*	*DF*	*Chi-square*	*p*	*Diff.*
Institution type	Public kindergarten or Nursery (MoNE affiliated)	73	1.22	1.083	74.486	2	11.236	.004	2 > 1 2 > 3
	Private kindergarten or Nursery (MoNE affiliated)	38	1.76	1.076	95.750				
	Nursery or daycare (MFLSS affiliated)	42	0.95	0.935	64.404				

Table 7. *Kruskal Wallis test on PCKS pattern sub-dimension based on workplace institution type*

		n	$\bar{x}$	*SD*	*Sort Avg.*	*DF*	*Chi-square*	*p*	*Diff.*
Institution type	Public kindergarten or Nursery (MoNE affiliated)	73	1.47	1.068	90.08	2	18.462	.000	1 > 3 2 > 3
	Private kindergarten or Nursery (MoNE affiliated)	38	1.16	1.151	76.43				
	Nursery or daycare (MFLSS affiliated)	42	0.57	0.630	54.79				

When Table 7 is analyzed, it can be seen that significant differences exist between the pedagogical content knowledge regarding the pattern sub-dimension of the scale according to the type of institution where the preschool educators work [$\chi 2$ (2) = 18.462; p = .000; p < .05]. It was determined that those educators working in nurseries or daycare centers affiliated to the MFLSS had lower levels of pedagogical knowledge for the pattern sub-dimension compared to those working at either public or private kindergartens or nurseries affiliated to the MoNE.

When the Kruskal Wallis test for pedagogical field information at the lower end of the scale was examined according to the type of institution at which the educators worked, no significant differences were found between the pedagogical content knowledge sub-dimensions of the mathematics educators working at either public or private kindergartens or nurseries affiliated to the MoNE, and nurseries or daycare centers affiliated to the MFLSS:

- Sorting [$\chi 2$ (2) = 3.341; p = .188; p > .05]
- Shape Perception [$\chi 2$ (2) = 0.595; p = .743; p > .05]
- Spatial Perception [$\chi 2$ (2) = 0.818; p = .664; p > .05]
- Comparison [$\chi 2$ (2) = 3.199; p = .202; p > .05]

Table 8. *Kruskal Wallis test on PCKS total scores based on workplace institution type*

		n	$\bar{x}$	*SD*	*Sort Avg.*	*DF*	*Chi-square*	*p*	*Diff.*
Institution type	Public kindergarten or Nursery (MoNE affiliated)	73	8.64	2.330	83.36	2	17.017	.000	1 > 3 2 > 3
	Private kindergarten or Nursery (MoNE affiliated)	38	8.95	2.324	90.54				
	Nursery or daycare (MFLSS affiliated)	42	7.24	1.859	53.70				

When Table 8 is analyzed, it can be seen that significant differences exist between the total mathematics pedagogical content knowledge scores of educators working in public or private kindergartens or nurseries affiliated to the MoNE, and nurseries or daycare centers affiliated to the MFLSS [$\chi 2$ (2) = 17.017; p = .000; p < .05]. It is thereby determined that those educators working in nurseries or daycare centers affiliated to the MFLSS have lower levels of pedagogical content knowledge related to their total scores compared to those working in either public or private kindergartens or nurseries affiliated to the MoNE.

DISCUSSION and CONCLUSION

In this research study, the pedagogical content knowledge levels of preschool educators were reviewed, and the relationship between their education levels and pedagogical content knowledge related to mathematics examined. In addition, the study reviewed the differences between the preschool educators' pedagogical field knowledge levels of mathematics based on the type of institution at which they worked.

This research showed that the pedagogical field knowledge levels of the preschool educators that formed the study group were found to be low, and that when the scale's sub-dimensions were examined, above average scores were seen for comparison, ranking, and shape perception, whilst the scores were below average for number perception, pattern, spatial perception and the total score (see Table 3). When the literature on this subject area is reviewed, some studies also concluded that the pedagogical field knowledge levels of preschool educators for mathematics were found to be low (Gess-Newsome et al., 2019; Ma, 2010; Parpucu & Erdoğan, 2017; Tian & Huang, 2019; Zhang, 2015). In addition, McCray and Chen (2012) found that preschool educators possessed pedagogical knowledge levels related to mathematics that allowed children to at least understand mathematics within their environment. In addition, teachers were found to use expressions that contained more counting, numbers, time, shapes, quantity, and location concepts in the classroom environment, and that the field and content information related to mathematics teaching can be considered as conceptual (Diaz, 2008; Fırat & Dinçer, 2018; Piasta, Pelatti, & Miller, 2015). In this context, it can be said that the results of some field studies are thereby similar to the results obtained in the current research, whilst some differed. However, considering that some of the preschool educators scored above average in some math skills areas and below average in others, it can be said that all preschool educators are in need of support in order to further develop their mathematics-related content knowledge.

When the pedagogical content knowledge related to mathematics was examined according to the preschool educators' level of education, according to the scale sub-dimensions and total scores, no significant difference was found between the educators' levels of education in the number perception, ranking, shape perception, spatial perception, or comparison skills sub-dimensions (see Tables 4 and 5). However, when the arithmetic averages of the educators were analyzed according to the sub-dimensions, those who graduated from vocational high schools scored above average in the figure perception and spatial perception sub-dimensions. Those educators with an associate's degree only scored above average in the number perception and spatial perception skill sub-dimensions. When it comes to educators holding an undergraduate or postgraduate degree, their scores were only below average in the shape perception and spatial perception skill sub-dimensions. However, they scored above average in the comparison, ranking, perception of number, and pattern sub-dimensions, as well as for the total scale score. It was found that the educators with an undergraduate or postgraduate degree scored higher than the general arithmetic average across all mathematics skills sub-dimensions. On the other hand, in the scale's pattern sub-dimension, the pedagogical knowledge level of those educators with an undergraduate degree was higher than those having graduated with an associate's degree or from a vocational high school. It was also revealed that those educators who graduated from postgraduate programs achieved significantly higher scores than those who graduated from vocational high schools, but with no significant difference to those having completed an associate or undergraduate degree program related to mathematics (see Tables 4 and 5). In the light of these findings, it can be seen that significant differences exist between the total points that the

educators obtained from the scale in favor of those having graduated from undergraduate and postgraduate education programs. Therefore, as the learning status of preschool educators' increased, there was a corresponding increase seen in the level of their pedagogical field information in mathematics. In parallel with this result, some of the results obtained by other researchers in the field found that educators who graduated from undergraduate programs exhibited higher levels of mathematics knowledge than pedagogical field knowledge (Dağlı, 2019; Ünal & Akman, 2006). In this context, given that the knowledge level of teachers related to mathematics positively affects their behavior, attitudes and the success of their students (Botha, Maree, & De Witt, 2005; Brown, 2005; Dağlıoğlu, Genç, & Dağlı, 2017), it may be said that educators graduating from undergraduate and postgraduate programs can provide more qualified mathematics education than those having graduated with an associate degree or from a vocational high school.

The current study examined the pedagogical field knowledge of preschool educators in terms of the type of institutions they work in, as public or private kindergartens or nurseries affiliated to the MoNE and nurseries or daycare centers affiliated to the MFLSS. The results showed that no difference was found in terms of the sorting, shape, spatial perception, or comparison sub-dimensions, whilst significant differences were found in pedagogical field knowledge levels according to institution type in terms of the number perception and pattern sub-dimensions as well as the total scale scores (see Tables 6, 7, and 8). These differences were determined to be due to the educators working in private institutions affiliated to the MoNE having obtained significantly higher scores in the number perception sub-dimension than those working for public institutions affiliated to either the MoNE or the MFLSS. When the pattern sub-dimension was analyzed, it was concluded that the pedagogical knowledge level of educators working in private and public kindergartens or nurseries affiliated to the MoNE was significantly higher than for educators working in nurseries or daycare centers affiliated to the MFLSS. When the pedagogical content knowledge of the educators was analyzed on the basis of their total scale scores, there were no significant differences found between educators working in public kindergartens or nurseries affiliated to the MoNE and those educators working in private kindergartens or nurseries affiliated to the MoNE, but was significantly higher than educators working in nurseries or daycare centers affiliated to the MFLSS.

Preschool education institutions support many areas of children's development, and prepare them for starting primary school and for their future social life. This task is performed largely with the support of the children's parents in order to provide the necessary education as and when necessary. Qualified educators are therefore one of the most important factors that enables preschool education institutions to perform such a vital function (Eğitim Reformu Girişmi [(Turkish) Education Reform Initiative], 2015; Gess-Newsome et al., 2019; Organisation for Economic Co-operation and Development, 2015; TEDMEM, 2016). In public kindergartens and nurseries affiliated to the MoNE, the educators who are the graduates of Preschool Education or Child Development can work as "Teachers," whilst those who graduated from Child Development associate degree programs are employed as "Contract (temporary) Teachers." Meanwhile, in private nurseries and kindergartens affiliated to the MoNE, the graduates of Child Development undergraduate programs work as "Teachers," whilst the graduates of Child Development associate degree programs fulfil the role of "Expert Instructors," and vocational high school graduates from the department of Child Development are employed as "Master Educators." In private nurseries and daycare centers, which are monitored and supervised by the General Directorate of Child Services, and thereby affiliated to the MFLSS, the graduates of Child Development and Education of higher education institutions (Preschool Teaching, Kindergarten Teaching, and Child Development) with an undergraduate or associate degree work primarily in the field of child development at girls' vocational high schools (Aile ve Sosyal Politikalar Bakanlığından [Turkish Ministry of Family, Labor and Social Services], 2015, p. 17). However, it is observed that, mostly, it is vocational high school and associate degree graduates that work in preschool institutions affiliated to the MFLSS. This situation also was supported in this study, with the majority of educators working in institutions affiliated to the MFLSS holding an associate degree or are vocational high school graduates.

Educators working in preschool educational institutions directly affect the development of concepts and skills in children, both in terms of creating an environment suitable for the characteristics of the age group they serve, and more especially in terms of their mathematics education (Gess-Newsome et al., 2019; McCray & Chen, 2012). Research based on the physical and educational environments of both public and private preschool educational institutions in Turkey (Budunç & Haktanır, 2007; Çelik, 2012; Haktanır, Dağlıoğlu, & Güler, 2010; Kaçan, Halmatov, & Kartaltepe, 2017) has revealed that the children are provided with inadequate conditions in terms of an environment suitable for their development, and that educators working within these institutions are negatively affected by the physical limitations of these institutions (Aktan Kerem & Cömert, 2007; Kandır & Çaltık, 2006; Kandır, Özbey, & İnal, 2009). However, considering the developmental characteristics of preschool children among these institutions, it may be said that kindergartens, which are established specifically for the preschool age group, have better physical conditions compared to the other types of institutions, and provide better material support for their teachers. However, it should be taken into consideration that the individual and professional characteristics of teachers also affect the process in terms of preparing the right educational environment and planning appropriate educational activities. When the mathematics applications of Baki and Hacısalihoğlu Karadeniz's (2013) preschool education program were examined, it was seen that the teachers did not use active learning methods based on new approaches, but applied the program using teacher-based methods. In addition, Pekince and Avcı (2016) reported that teachers used ready-made plans, planned activities very similar to each other, used developmentally inappropriate activities for their own classes, and that the majority of activities were found to be teacher-centric in terms of the ways mathematics was handled for their in-class activity plans. In addition, Graham, Nash, and Paul (1997) found that preschool teachers' activities contribute to the development of children's mathematics ability, and that whilst teachers consider mathematics to be important, they apply very little math activity either directly or indirectly in their classrooms.

As a result of these various field studies, it is understood that educators can experience difficulties in practicing math activities due to both insufficiencies in the physical and educational environment as well as a lack of knowledge, skills and experience in preparing and applying math activities that are age-suitable and appropriate to the learners' developmental characteristics. On the other hand, when the diversity of educational institutions involved in Turkish preschooling are also taken into consideration, it can be anticipated that educators may differ in their pedagogical content knowledge related to mathematics education. In this context, the finding that educators working in public and private institutions affiliated to the MoNE found in the current study to possess higher levels of pedagogical knowledge than those working in preschool education institutions affiliated to the MFLSS goes towards explaining this variance. Thus, it may be stated that the results of other studies in the field are broadly parallel those of the current study.

In conclusion, the pedagogical content knowledge of preschool educators in Turkey were found to be generally low in the current study, and that educators working in either public or private kindergartens and nurseries affiliated to the MoNE have higher levels of pedagogical knowledge of mathematics than those working in nurseries or daycare centers affiliated to the MFLSS. The study also found that the pedagogical content knowledge of educators was higher for those with a higher level of education. However, in order to obtain more objective and generalizable results, the future studies should examine new and different variables in larger samples.

According to the results of the current study, the researchers put forward the following suggestions:

- Informing educators working in preschool education institutions about applied in-service training courses and seminars on mathematics education and training, and increasing their general awareness of the topic;
- Providing support to preschool educators by experts and through other resources in order that educators can better organize their classes to be more effective in terms of preschool mathematics education;

- Ensuring that newly employed preschool educators should hold undergraduate or postgraduate degrees in order to work at these institutions, thereby increasing the general qualification levels of educators working in private preschool institutions affiliated to the MoNE, as well as in nurseries and daycare centers affiliated to the MFLSS;
- Conducting further studies in which teachers' pedagogical content knowledge and children's mathematical abilities are analyzed within different institutions and age groups in terms of various variables. In addition, the status of mathematics teachers within their monthly programs can be examined in detail by considering various variables;
- It is recommended that educators graduating from vocational high schools or with an associate degree can work alongside teachers qualified at the undergraduate or postgraduate level so as to help them gain more experience and to improve their knowledge.

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