Early Years

An International Research Journal

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ceye20

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To cite this article: Binnur Yıldırım Hacıibrahimoğlu & Berrin Akman (2021): Evaluating Turkish preschool teachers' knowledge of early mathematical development, Early Years, DOI: 10.1080/09575146.2021.1948506

To link to this article: https://doi.org/10.1080/09575146.2021.1948506

EARLY YEARS
https://doi.org/10.1080/09575146.2021.1948506

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Evaluating Turkish preschool teachers' knowledge of early mathematical development

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ABSTRACT

This study aimed at evaluating preschool teachers' knowledge of early mathematical development. To this end, the validity and reliability of the 'Knowledge of Mathematical Development (KMD) Survey,' were determined by adapting it to Turkish culture, and using this tool, the participants' KMD was examined with different variables. The research study was carried out with preschool teachers working at public and private preschools in the city of Giresun, Turkey. The data on preschool teachers' knowledge of early mathematical development were collected through the KMD survey. The findings of this study indicate that the Turkish version of the KMD survey was determined to be a valid and reliable measurement instrument. KMD scores varied significantly, depending on the age of teachers and teachers' duration of service.

ARTICLE HISTORY
Received 12 September 2020
Accepted 23 June 2021

KEYWORDS
Early childhood education; early numeracy; early mathematical development; preschool teacher; teacher knowledge

Introduction

In early childhood, mathematical thinking develops as children discover the environment physically and cognitively and, especially in infancy, their interaction with the environment and using the objects around them helps them to learn basic mathematical concepts (Brannon 2003). The development of early mathematical skills is based on a stimulating learning environment and support, and preschool teachers are primarily responsible for providing this support (Dunekacke, JenBen, and Blömeke 2015; Klibanoff et al. 2006).

The role of the teacher in early childhood mathematics

It is argued that providing suitable environments for children in preschool education and using rich and appropriate activities and methods for all age groups contribute positively to children's knowledge, thoughts, and attitudes related to mathematics (Klibanoff et al. 2006; Platas 2008). Preschool mathematics teachers' competence is also important in this process (Anders and Rossbach 2015; Torbeyns, Verbruggen, and Depaepe 2020). Björklund and Barendregt (2016) stressed that preschool teachers must provide high-

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Supplemental data for this article can be accessed online at http://dx.doi.org/ 10.1080/09575146.2021.1948506

quality and effective mathematical experiences in order for children to gain a solid footing in mathematics.

The preschool education program mandated by The Ministry of National Education (MoNE) in Turkey involves contributing to the cognitive development of children developing a positive attitude toward mathematics among children, and helping children understand why and how mathematical concepts are used (Ministry of National Education of Turkey [Milli Eğitim Bakanlığı] 2013). Teachers plan their activities to accord with the program outcomes and indicators. However, in the process of learning mathematics and carrying out mathematical activities, it is not enough for the teacher to consider only the outcome. Teachers also need to consider the order of development of mathematical skills when they plan activities.

Preschool teachers' mathematical pedagogical content knowledge

Pedagogical content knowledge (PCK) is defined as the knowledge that teachers are required to have in order for them to teach a subject in the related field effectively (Ball, Thames, and Phelps 2008). PCK is described as the integration of content knowledge and pedagogical knowledge related to the subject area in the learning process (Depaepe, Verschaffel, and Kelchtermans 2013; Keung and Fung 2020). PCK is considered one of the important elements of teacher competencies (Kleickmann et al. 2013; Torbeyns, Verbruggen, and Depaepe 2020; Van Driel and Berry 2010). Particularly in recent years, mathematical content knowledge has been among the more discussed topics in early childhood mathematics education. Gasteiger and Benz (2018) stated that it is important for preschool teachers to conduct early mathematics education effectively and to know the structure of mathematical concepts in order to support children's future school success. Björklund and Barendregt (2016) explained that mathematical content knowledge involves the manner in which children learn the concept of mathematics and in which teachers organize teaching the relevant concepts for children to learn. Gasteiger (2012) defined PCK in early mathematics education as knowledge of mathematics teaching and explained that it contains good examples, visuals, tools, and explanations that will help children gain mathematical knowledge. He also explained that preschool teachers need content and pedagogical knowledge to plan and implement early mathematics education.

Studies reveal the importance of teachers' PCK in mathematics for providing high-quality early mathematics education to young children (Björklund and Barendregt 2016; Dunekacke, JenBen, and Blömeke (2015); Lee (2017); Torbeyns, Verbruggen, and Depaepe 2020). Lee (2010) presented an example to show that a preschool teacher with good knowledge of basic addition and subtraction is not necessarily able to convey this knowledge effectively to children. In other words, he stated that teachers should know how to pass on information to children through teaching; that is to say, teachers should have pedagogical knowledge. He explained that this is considered PCK of basic addition and subtraction. Dunekacke, JenBen, and Blömeke (2015) found preschool teachers' mathematical content and pedagogical knowledge to be highly correlated. It is seen that mathematics PCK is highly correlated with mathematics teaching skills, teaching competence, students' positive attitudes toward mathematics, and mathematics achievement (Empson and Junk 2004; Hill, Rowan, and Ball 2005).

Preschool teacher education in Turkey

In Turkey, teacher training is carried out by faculties of education affiliated to the Institution of Higher Education (IHE). Student selection for the faculties of education is carried out by the Student Selection and Placement Center (SSPC) through the Higher Education Institutions Examination (HEIE), which is a central examination. The scores obtained from the HEIE are valid for student admission to all teaching departments in Turkey. The early childhood education undergraduate program is of 4 years' duration. There are three types of courses in the program: field education, professional teaching knowledge, and general knowledge. There is one course in the program called 'Mathematics Education in Early Childhood,' and the conduct of this course is theory-oriented. Teacher candidates take a 12-week teaching practice course in the last two semesters. Students who successfully complete the program at the end of the 4-year training obtain an undergraduate degree (IHE 2018). Candidates who graduate from the early childhood education program must pass a central examination to be able to work as teachers in public institutions. According to the central examination result listings, the state appoints the required number of teachers to work (IHE 2007). It can, therefore, take a long time, even years, before graduates are able to start working.

Current study

There were only three studies (Aksu and Kul 2017; Dağlı, Dağlıoğlu, and Atalmış 2019; Parpucu and Erdoğan 2017) addressing the PCK of mathematics in Turkey. When the studies were examined, it was determined that the measurement tools used included all contents of the National Council of Teachers of Mathematics (NCTM) standards. The current study, however, was aimed at evaluating only the subdimensions related to numbers and operations. Also, research findings of the national literature (Baki and Hacısalihoğlu-Karadeniz 2013; Pekince and Avcı 2016; Tarım and Bulut 2006; Yazlık and Öngören 2018) reveal that preschool teachers mostly conduct activities related to numbers in mathematics education. In this context, revealing the mathematical development knowledge of preschool teachers on numbers is considered important. Therefore, this study was conducted to evaluate preschool teachers' knowledge of early mathematical development knowledge. To this end, the following questions were asked. (a) Is the Turkish version of the KMD survey valid and reliable? (b) Does preschool teachers' knowledge of mathematical development differ significantly according to their demographic characteristics?

Method

The study group

The study group of the present study comprised 177 preschool teachers working in preschools under public primary schools, independent preschools, and private preschools in the city of Giresun. Preschool education in Turkey covers the education of children between 36 and 68 months of age (MoNE 2021). Therefore, children who are taught in this study group are between the ages of three and five. All preschool teachers in the study group were women. 148 of the participant teachers had a bachelor degree, 26 had an associate's degree, and 3 had a master's degree. When the distribution of teachers by age was analyzed, it was found that 89 (50.3%) teachers were aged '21–30', 74 (41.8%) were '31–40', and 14 (7.9%) were '41–50'. 145 (81.9%) of the teachers in the study were working at public preschools while 32 (18.1%) were working at private institutions. Considering the professional experiences of teachers, the majority of teachers (n = 74) had been working for '6–10 years', 66 teachers for '1–5 years', 22 teachers for '11–15 years', and 15 teachers for '16–20 years'. The age groups of the students the participants worked with were 5-year-olds (n = 64), 4-year-olds (n = 100), and 3-year-olds (n = 13). All teachers in the study stated that they had taken a course on mathematics education in the preschool period during their undergraduate studies. None of the teachers had participated in any workshops or in-service training on mathematics education.

Data collection tools

Teacher personal information form

An information form was developed by researchers to collect the participants' demographic information.

Knowledge of Mathematical Development (KMD) survey

Developed by Platas (2008) to measure teachers' knowledge of how early mathematical skills develop in the preschool period, the 'KMD survey' comprises 20 items (see supplemental materials). The items developed in the domains of counting and operations in early childhood covered the subdimensions of verbal counting, cardinal counting principle, sequential counting, addition/subtraction, division, and spelling numbers using symbols and words (Platas 2008, 2014). The items in the measurement tool regarding counting and operations cover all of the mathematical learning outcomes of the cognitive development field (Ministry of National Education of Turkey [Milli Eğitim Bakanlığı] 2013) in Turkey's preschool education program.

The adaptation process for the scale started after the researcher was granted permission to use it via email on 16 February 2016. To avoid conceptual errors in the translation of the tool into Turkish, two experts in the field of early childhood with expertise in English-language skills were consulted. For significant differences in expert translations, the consultation was repeated, and the translation work was completed. The final version of the measurement instrument was applied to four teachers by the researcher. Following this piloting, the items on the original scale and their Turkish translation were found to have conceptual and linguistic equivalence.

After the linguistic adaptation studies of the KMD survey were conducted, a content validity analysis was conducted. Platas (2008, 50) stated that the survey has not been examined for construct validity but it has a well-defined and structured content area so content validity was the most appropriate measure of validity. The survey items were developed after extensive review of current mathematical assessments of young children and of the literature and the content validity was analyzed with a group of 20 people (Platas 2008, 42–43). In the current study, content validity was again examined with 20 preschool teachers. A minimum value of 0.42 should be used for 20 participants to ensure statistical significance when measuring content validity (Yurdugül 2005). As no item got below 0.42 on the 20-item measuring instrument, all items were incorporated into the administration form.

Data collection process

The preschool educational institutions that agreed to support the study were visited; the researcher was introduced to the teacher of the class where the study would be conducted and general information was given about how the survey would be administered. However, in order not to affect the process, the statements of mathematical skills in the tool were not communicated to the teachers. The information inviting teachers to participate was given through announcements at each school. After each teacher who wanted to participate in the study signed the participation form, the survey was carried out on a voluntary basis on a day and at a time when the teachers were available. The teachers were interviewed in an empty classroom or area (such as a dining hall or meeting room) at the school. Participants were given the opportunity to withdraw from the study at any time. The researcher was present with the teachers while they responded to the survey.

Data analysis

In the study, item statistics were calculated first. The highest score on the survey is 20, while the lowest is 0. First, the survey statistics were calculated with the data from all participants. Next, the total points received by the participants were ranked from the highest score to the lowest, and the 27% groups (with the highest 48 scores and the lowest 48 scores) were formed. With this data set, item statistics were calculated. For the reliability of the survey, the split-half reliability was calculated by the Kuder-Richardson (KR-20) coefficient. To determine the validity of the survey, a confirmatory factor analysis (CFA) was performed using the weighted least squares with mean and variance adjusted (WLSMV) for categorical indicators method, using the Mplus 8.5 software package.

KMD scores did not have a normal distribution in the sub-groups based on the teacher's age, since the Kolmogorov–Smirnov (KS) values were 0.135 ($p = 0.000$) and 0.201 ($p = 0.000$), respectively. KMD scores did not have a normal distribution in the sub-groups based on the age groups of children, since the KS values were 0.189 ($p = 0.000$) and 0.194 ($p = 0.000$), respectively. Therefore, Mann–Whitney U tests were used for these two variables. KMD scores did not have a normal distribution in the sub-groups based on professional experience, since the KS values were 0.145 ($p = 0.001$) and 0.145 ($p = 0.001$), respectively, and the Shapiro–Wilk value was 0.878 ($p = 0.001$).

Results

The statistics for the KMD survey, which was used after adaptation within the present study, are presented in Table 1.

Table 1 shows that the mean success score of the group comprising 177 participants was 8.37. The lowest score on the 20-question survey was 0 and the highest score was 16. The proximity of the mode, median, and arithmetic mean indicates that the distribution

Table 1. KMD survey statistics.

Statistics on Total Points	Value
N	177
Mean	8.3729
Median	9.0000
Mode	11.00
Std. Deviation	3.62080
Skewness	−.656
Kurtosis	−.136
Minimum	.00
Maximum	16.00

was close to normal distribution. Based on the median, it can be interpreted that half of the scores were higher than 9, and the other half were lower than 9.

Standard deviation (3.62) is the extent to which the scores of the participants in the group aggregate around the arithmetic mean. If the coefficients of skewness and kurtosis are interpreted, it appears that both were lower than zero (negative). The coefficient of skewness is an indicator of whether the distribution of scores is symmetrical. The distribution is slightly distorted to the left (negative), which means the participants who completed the survey were collected around the lower scores. The kurtosis coefficient helps researchers comment on the range of the distribution. By being kurtic or pointed, it provides information about the accumulation around the middle part in the distribution of scores, which is far removed from a normal distribution. In the present study, the distribution was somewhat flattened. However, the fact that these values were within the ±1 range indicates that the data set was suitable for normal distribution.

Considering the rates of correct answers given to the scale items in Table 2, it appears that for the items listed from 13 and below, teachers had progressively more incorrect answers than they had correct answers.

Table 2. The percentages of correct and incorrect answers given to the scale items on KMD.

	Correct answers		Incorrect answers	
Item number	f	%	f	%
12	142	80.2	35	19.8
3	138	78	39	22
2	127	71.8	50	28.2
15	124	70.1	53	29.9
1	123	30.5	54	69.5
20	119	67.2	58	32.8
16	113	63.8	64	36.2
6	112	63.3	65	36.7
10	106	59.9	71	40.1
11	95	53.7	82	46.3
13	80	45.2	97	54.8
14	68	38.4	109	61.6
4	45	25.4	132	74.6
9	41	23.2	136	76.8
5	29	16.4	148	83.6
17	22	12.4	155	87.6
18	15	8.5	162	91.5
7	14	7.9	163	92.1
8	12	6.8	165	93.2
19	5	2.8	172	97.2

Table 3. Item statistics.

	s1	s2	s3	s4	s5	s6	s7	s8	s9	s10
Difficulty	0,552	0,583	0,708	0,354	0,208	0,604	0,115	0,115	0,333	0,521
Discrimination	0,563	0,625	0,417	0,458	0,292	0,583	0,146	0,063	0,625	0,708
Mean	0,695	0,718	0,780	0,254	0,164	0,633	0,079	0,068	0,232	0,599
Std. Deviation	0,462	0,451	0,416	0,437	0,371	0,483	0,271	0,252	0,423	0,492
Skewness	−0,854	−0,975	−1,361	1,138	1,832	−0,556	3,146	3,468	1,283	−0,407
Kurtosis	−1,286	−1,062	−0,149	−0,712	1,372	−1,711	7,986	10,141	−0,358	−1,856
	s11	s12	s13	s14	s15	s16	s17	s18	s19	s20
Difficulty	0,438	0,677	0,375	0,083	0,625	0,573	0,198	0,115	0,042	0,604
Discrimination	0,708	0,646	0,500	0,167	0,500	0,729	0,271	0,104	0,000	0,583
Mean	0,537	0,802	0,452	0,113	0,701	0,638	0,124	0,085	0,028	0,672
Std. Deviation	0,500	0,399	0,499	0,317	0,459	0,482	0,331	0,279	0,166	0,471
Skewness	−0,149	−1,531	0,195	2,466	−0,883	−0,581	2,297	3,008	5,743	−0,741
Kurtosis	−2,001	0,347	−1,985	4,127	−1,234	−1,681	3,314	7,126	31,341	−1,468

Item difficulty indices and item discrimination were examined within the validity analysis of the KMD survey, which was adapted within this study. Item statistics of the items in the survey are presented in Table 3.

Table 3 shows that the item difficulty indices varied from 0.042 to 0.708. The item difficulty index is the difficulty degree of the item. The closer it is to 0 the more difficult the item was and the closer it is to 1, the easier the item was. An item difficulty index around 0.50 is very convenient. The range of 0.00–0.40 for item difficulty indicates that the item is difficult, the range of 0.41–0.60 shows moderate difficulty, and the range of 0.61–1.00 means that it is simple (Fraenkel and Wallen 2008; Wiersma and Jurs 2005). In this study, it was seen that five items (3-6-12-15-20) were simple, five items (1-2-10-11-16) were moderate, and 10 items (4-5-7-8-9-13-14-17-18-19) were difficult.

Item discrimination shows how effectively the item measures the relevant construct and how well it distinguishes those who know from those who do not. Item discrimination varies in the range of −1 to +1. For item discrimination, a value of 0.40 and above means that the item is a very good discriminator; a value between 0.30 and 0.40 means that the item is a good discriminator; a value between 0.20 and 0.30 means that the item is a moderate discriminator, and negative values and values lower than 0.20 mean that the item should not be used (Wiersma and Jurs 2005). In this study, 13 items were very good discriminators, and 2 items (items 5 and 17) were moderate discriminators. Five items (items 7, 8, 14, 18, and 19), on the other hand, were very weak in discrimination in this study group, and it was shown that they should not be used. These items also had very low mean scores and very high skewness and kurtosis coefficients. Therefore, these items were excluded from the comparative analyses.

To determine the reliability of the survey, the split-half reliability was calculated by the KR-20 coefficient. The coefficient calculated for 20 items was 0.748. After the 5 items were removed from the survey, the KR-20 coefficient was calculated as 0.795 for the remaining 15 items. The split-half reliability coefficient of the survey was calculated at 0.787. The survey was found to be quite reliable (Kalaycı 2008).

Figure 1 presents the path diagram obtained because of the CFA performed to determine the validity of the survey.

When the model fit information obtained because of the analysis is examined, Chi-Square Test of Model Fit = 160.722, Degrees of Freedom = 90. The value of $X^2/df = 1.786$

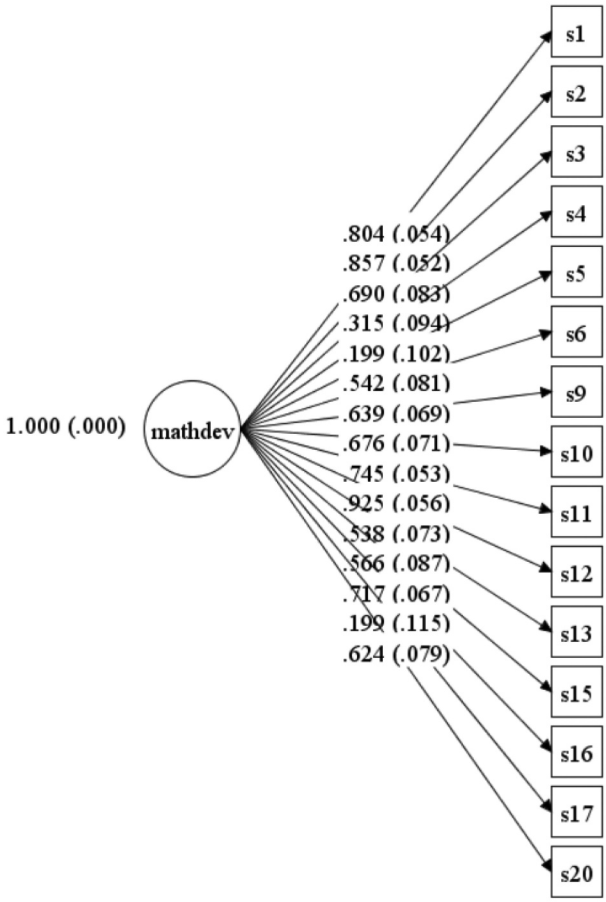

Figure 1. Path diagram.

(≤3) indicates a perfect fit (Kline 2005). The value of Root Mean Square Error Of Approximation (RMSEA, 90% C. I.) = 0.067 (0.050–0.083) being ≤0.07 indicates a good fit (Steiger 2007). The Standardized Root Mean Square Residual (SRMR) = 0.124, a value that does not meet the acceptable fit criteria (Hu and Bentler 1999). The CFI = 0.925 and TLI = 0.912 values show good fit (Bentler 1990; Bentler and Bonett 1980; Hu and Bentler

Table 4. The results of KMD scores based on the teacher's age and the age groups of children.

	Age	N	Mean rank	Mean square	U	*p*
Mathematical development	21–30	89	89,55	7970,00	2621,00	0,024
	31–40	74	72,92	5396,00		
	Total	163				
	Age group					
Mathematical development	Age 5	64	85,79	5490,50	2989,500	,475
	Age 4	100	80,40	8039,50		
	Total	164				

Table 5. The results of KMD scores based on the teachers' length of service.

	Length of service	N	Mean rank	X^2	Sd	p	Variance
Mathematical development	1–5 years	66	97,10	12,199	2	0,002	1–2
	6–10 years	74	73,63				2–3
	11 years and higher	37	105,30				
	Total	177					

1999). When the calculated statistics are evaluated together, it was concluded that the collected data are highly reliable.

Table 4 shows that mathematical knowledge scores varied significantly, depending on the age of teachers ($U = 2621.00$, $p < 0.05$). The KMD scores of participants between 21 and 30 were significantly higher than those of participants between 31 and 40. It was found that the KMD scores did not differ significantly on the age groups of the children the teachers worked with ($U = 2621.00$, $p > 0.05$).

Table 5 shows that the KMD scores varied significantly, depending on teachers' duration of service ($H_{(2)} = 12.199$, $p < 0.05$). To determine the groups that showed significant differences, they were compared through the paired Mann–Whitney U Test. The KMD scores of teachers with 6–10 years of professional service (= 73.63) were significantly lower than the scores of those with 1–5 years of service (= 97.10) and the scores of those with minimum 11 years of service (= 105.30).

Discussion

In this study, the validity and reliability of the KMD survey were analysed. The validity analysis of the measurement instrument was first examined through content validity as in the original version. Simultaneously, according to the findings obtained because of the CFA performed, it was determined that the collected data were highly reliable. Considering the analysis of KR-20 and split-half reliability coefficients calculated for reliability, the KR-20 coefficient of the scale was 0.79, and the split-half reliability was 0.78. Based on these results, the Turkish version of the KMD survey was determined a valid and reliable measurement instrument. The results obtained from the validity and reliability analyses support those obtained in the original study of the scale (Platas 2008, 2014) and another study conducted by Kim (2013).

Overall, teachers gave correct responses for about half of the items on the survey. Items 12 and three, which had the highest percentage of correct answers in the study, were consistent with two studies (Cox 2011; Kim 2013) that also investigated teachers' knowledge level in mathematical development. In both studies, these items were indicated as ones with the highest rate of correct responses. Items with a high rate of incorrect responses in the study were also items in the category of 'difficult' in the item difficulty index. When these items are examined, it appears that the teachers did not have enough knowledge of the developmental order in teaching mathematical skills. This situation seems to be related to the fact that preschool teachers do not receive practice-based mathematics education during their training. For question 4, most teachers chose, 'Ayşe counts seven forks in a row' as the skill learned earlier, rather than, 'Ayşe matches seven forks in one-to-one correspondence with seven plates' (see supplemental materials). In the acquisition of the concept of numbers in the preschool period, one-to-one matching skill is shown as one of the prerequisite skills. The matching skill is considered one of the earliest skills to be acquired and is associated with children's counting accuracy (Aunio and Räsänen 2016; Charlesworth and Lind 2013).

According to the item difficulty index, item seven, item 13, and item 14 were included in the difficult category. When examining the answers that teachers gave for item seven, most indicated that being able to answer, 'How many buttons are there?' is learned earlier than the ability to count six buttons lined up in order. The children who give the correct answer when asked, 'How many?', are represented to have gained the principle of cardinal number (Paliwal and Baroody 2018). For the cardinal number principle, children must be able to count with objects one-by-one and in the right order (Cross, Woods, and Schweingruber 2009; Haylock and Cockburn 2008; Aunio and Räsänen 2016).

In item 13, a verbal problem related to the strategy used in the addition process is presented. A majority of the teachers indicated that both verbal strategies are learned in the same developmental order. The strategy of counting on in the addition process develops after the strategy of counting all. The strategy of counting on requires cognitive skills that are more advanced (Sarama and Clements 2009). In item 14, teachers stated that the operations of addition and subtraction, were at the same developmental level. Aunio and Räsänen (2016) stated that for knowledge of basic arithmetic operations, younger children should first understand the part–whole relationship. In order for children of preschool age to comprehend the subtraction process, they must first gain the ability to add. The subtraction process requires an ability to count backward, and it is more complicated than the addition process (Sarama and Clements 2009).

Considering the responses given to items eight and nine, both identified in the difficult category, it was seen that teachers did not have sufficient knowledge of the stages of development of counting. Teachers identified counting with objects and meaningful counting stages as skills learned earlier than rote counting. Children first begin rote counting without using any objects. Rote counting is seen in the stage of verbal counting (Ginsburg and Amit 2008; Polignano 2014). At initial stages, children perceive verbal counting as a pattern of sounds without noticing that the numbers represent an amount, and over time, they learn that a number defines a certain amount (Polignano 2014). Hence, it is at the next stage, during the preschool period, as children come to understand that numbers represent quantity, they begin to use and make sense of number words when counting objects.

Another important result obtained in the study was that in item 17, a majority of the teachers indicated that the ability to write a single-digit number was acquired earlier than the ability to recognize written numbers. Recognizing and writing numbers are different skills. The process of writing calls for the development of fine muscle skills in writing, such as holding a pencil and hand–eye coordination, the concepts of right-hand side and left-hand side, memory, and sight. Therefore, writing numbers is a more difficult process for children than recognizing and reading them (Cross, Woods, and Schweingruber 2009).

Mathematical development scores varied, depending on the age and duration of service of the teachers participating in the study. In the literature, no insights regarding the age variable were found in studies examining the knowledge levels of teachers in preschool mathematics education (Anders and Rossbach 2015; Cox 2011; Dağlı, Dağlıoğlu, and Atalmış 2019; Dunekacke, JenBen, and Blömeke 2015; Kim 2013; Lee 2010, 2017;

Parpucu and Erdoğan 2017; Platas 2008). The number of teachers in the age range 21–30 in the study was greater than that of teachers in the other groups. The professional experience of most of the teachers in this age group was in the range 1–5 years. This situation can be explained by differences in the content and/or recency of the training received by teachers in the different age groups. In the study, the KMD scores of teachers with a duration of service in the range 6–10 years were lower. In the literature, a significant relationship was determined between the professional experience of preschool teachers and their mathematics PCK. Teachers with more teaching experience achieved higher scores in general assessments that included mathematics PCK (Lee 2017, 2010). In addition, as noted in the literature review section of the study, in Turkey, teachers are assigned work on the basis of the exam score listings in a central examination and the requirement for teachers, which means that there is a limited number of vacancies. The situation of teacher employment is reflected in age and professional experience. Teacher candidates graduate at a young age, but because they prefer to work in a state institution, they start working at an older age. Therefore, the difference in scores between teachers with a service period between 6 and 10 years can be explained by the age variable. Teachers have professional experience, but they are older. When compared with the teachers with '11 years and more' professional experience, the number of teachers in this group is less than that in the other groups. This situation is seen as a factor for the difference in scores. The research study conducted in Turkey by Parpucu and Erdoğan (2017) has found that the pedagogical mathematical knowledge of preschool teachers varies according to professional experience at different points. All of the participants in this study stated that they had taken a course on mathematics education during their undergraduate years. However, it is believed that the quality of mathematics education that teachers receive within their undergraduate education is important here. The literature suggests that those graduating from teacher education programs have little or no experience of mathematics education in early childhood (Cox 2011; Ginsburg, Lee, and Boyd 2008; Platas 2008). Kim (2013) stated that the education levels and experience of preschool teachers influenced their mathematical knowledge levels and beliefs concerning mathematics education. In addition, Kim (2013) and Platas (2008) found that the KMD scores increased as teachers' educational levels and quantum of mathematics education received increased.

There is a compulsory theoretical course on mathematics education for three hours in all undergraduate programs of preschool teacher education in Turkey. The theoretical nature of the course means that it presents limited opportunities for implementation to teacher candidates, thereby affecting the quality of the course. In a study that examined the impact of experiences at university on the professional lives of preschool teachers, Ertürk et al. (2014) found that half of the teachers stated that the training they received in science and mathematics education at university was not effective in their professional lives. Teachers explained that they received advanced mathematics education in the course but that they did not do any practice. The findings of the study suggested that in their professional lives, preschool teachers had problems using most of the theoretical and practical knowledge they received during their undergraduate studies and that this was due to the content of the courses they took, the duration and quality of the practices, and the lack of instructors who are experts in the field. This was also discussed in a study that examined the attitudes and self-sufficiency beliefs of preschool teacher candidates toward mathematics (Dağlıoğlu 2017). The researcher argued that despite the theoretical nature of mathematics education, as well as the efforts to enhance higher education in Turkey, the number of students per faculty member is high, and education faculties do not have sufficient physical equipment and course materials.

Conclusion

This study concluded that the Turkish version of the KMD survey was determined a valid and reliable measurement instrument. Overall, preschool teachers gave correct responses for about half of the items on the survey. Therefore, it was seen that the relevant knowledge and skills of teachers should be developed to increase the quality of mathematics education in the preschool period. The results of this study offer theoretical and practical recommendations to teachers regarding mathematics education in the preschool period. Preschool teachers need to be informed about early mathematics education, and the curriculum should be organized such that it provides both theoretical and practical knowledge. Teachers should receive in-service training from field experts and learn new practices by seeing these practices being applied.

Although preschool teachers' KMD was evaluated in detail, whether they used their existing knowledge effectively in the teaching process could not be evaluated. This is considered a limitation of the study. Therefore, even though there was a conclusion about the level of KMD among teachers, more detailed information will be obtained in future studies as the mathematical activity plans of preschool teachers, their practices, and the teaching processes of these practices are observed. However, despite all its limitations, it is believed that the findings of the study should be considered and that the recommendations presented in light of the findings will be significant.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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