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RESEARCH ARTICLE

Development of the Pattern Skills Scale for 4-7-Year-Old Children

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Abstract

The current study aimed to develop a valid and reliable scale to evaluate the pattern skills of children between the ages of 4 and 7. For this purpose, the study adopted a survey model. The participants consisted of 572 children between the ages of 4 and 7 who continued their preschool education and who continued their education in the first grade and had not received preschool education. The researchers used Microsoft Office Excel, Factor 12, Lisrel 8.8, and Statistical Package for the Social Sciences Statistics software, version 24, in the analysis of the data. During the development of the scale, the researchers consulted expert opinions for face validity, used the Lawshe technique for content validity, and performed exploratory and confirmatory factor analyses to ensure construct validity. In order to ensure reliability, the researchers calculated Cronbach's alpha, Kuder-Richardson (KR-20) internal consistency coefficients, and examined two-half test reliability. In order to test item analysis, the researcher used item difficulty and biserial correlation tests. The results indicated a valid and reliable pattern skills scale, consisting of four dimensions and 19 items, with a KR-20 value of 0.83, a two-half test reliability of 0.92, and a Cronbach's alpha value of 0.87.

Keywords: Children, early childhood, pattern concept, pattern skills, scale development

Introduction

At an early age, children have a natural love of mathematics. Children also have informal knowledge about mathematics before starting formal education (Akman, 2002). Mathematics skills in early childhood are a predictor for children's academic success in later years (Aunio et al., 2005; Duncan et al., 2007; Jordan et al., 2009). One of the foundations of preschool children's mathematical thinking skills is the concept of "pattern" (NCTM, 2000). A body of research (i.e., Öztürk & Güler, 2020; Steen, 1998; Zazkis & Liljedahl, 2002) refers to mathematics as the "science of patterns" because patterns form the heart, soul, and essence of mathematics. Pattern refers to predictable regularity that includes numerical, spatial, or logical relationships. Therefore, the power of mathematics lies in the relationships and transformations that enable patterns and generalizations (Mulligan & Mitchelmore, 2009). Patterns can be defined as a systematic arrangement of numbers or shapes that follow a certain rule (Montague-Smith, 2014). Patterning is the ability to define rule(s) in a predictable sequence of elements (Pasnak, 2017). Research has determined that a child's ability to create patterns is one of the best indicators of future success in mathematics (Rittle-Johnson et al., 2019). If a child is not proficient in recognizing patterns and determining the rule that directs the pattern, algebraic reasoning becomes difficult (Lee et al., 2011).

While patterns improve children's skills such as matching, sorting, and classifying, they can also improve their ability to identify shapes, create graphs, and analyze (Samuelsson & Fleer, 2008; Yuhasriati & Yuriansa, 2018). Patterns play an important role in children's acquisition of high-level reasoning skills such as prediction, evaluation, analysis, and synthesis (Akman, 2019; Waters, 2004). In addition, patterns form the basis of many complex mathematical skills such as sequences, series, and functions (NCTM, 2000, 2022; Seeley, 2004). Pattern awareness is defined as early algebraic thinking, which includes noticing mathematical properties, determining the relationship between elements, and observing regularities (Kieran et al., 2016). Children who learn patterns at an early age develop algebraic problem-solving strategies in later periods (Herbert & Brown, 1997). Because patterning is such an important component of pre-algebra thinking, the National Council for the Teaching of Mathematics (NCTM) has determined that algebra is not a stand-alone course but rather the culmination of experiences that contribute to developing algebra skills. Learning patterns helps children recognize regularities and then make predictions about how the relevant pattern will continue (Carpenter, 2020). When children learn to recognize and create patterns, they have the opportunity to acquire many skills. Identifying the underlying meaning of patterns is important for identifying many different types of mathematical relationships. For example, patterns support memorization of counting order and understanding number operations. In this way, children know that the sum of the numbers will remain the same even when they add the numbers in a different order (Gifford, 2019). Pattern is associated with algebraic thinking because it allows children to notice similarities and differences and then create rules that govern the pattern. When patterning is introduced in early mathematics education, children are more likely to develop the skills necessary to understand the relationships within a pattern and eventually use symbols to represent these relationships (McGarvey, 2013).

The relevant literature has divided pattern types into two as repeating and expanding patterns (Tanışlı & Olkun, 2009) and three as repetitive, expanding (changing), and relational/spatial patterns (Clements

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et al., 2004; Sperry-Smith, 2012). Researchers, who divide pattern types into two, argue that other pattern types are included in the expanding pattern. Some researchers have considered patterns as numbers and geometric patterns according to the element of the set used in the pattern. They further divide numbers and geometric patterns into sub-steps as repeating and expanding patterns (Öztürk & Güler, 2020; Tsamir et al., 2018; Yıldırım-Hacıibrahimoğlu, 2019). However, generally speaking, research has seen repeating and expanding patterns as the basis.

Three-year-old children can notice patterns and copy a pattern by looking at a model (Akman, 2021). Four- and five-year-old children often use pattern skills in their games. In American kindergartens, children spend 20–40% of their time doing pattern-related activities (Ginsburg et al., 1999, 2003). The majority of 4-year-old children demonstrate the ability to copy the pattern, and half of 4-year-olds demonstrate the ability to continue the pattern. In addition, 4-year-old children have the ability to show the unit that makes up the pattern and to transform the pattern (Rittle-Johnson et al., 2013; Sarama & Clements, 2008). Children generally demonstrate the skills of finding the smallest unit of a repeating pattern, transforming the pattern, and continuing it around the ages of 6 and 7. However, success varies depending on the complexity of the pattern (Ginsburg et al., 1999, 2001, as cited in Ginsburg et al., 2003).

Clements et al. (2004) state that three types of patterning abilities develop in children in early childhood: repetitive, growing, and relational patterns, but children do not understand other types of patterns before the age of 7 or 8. At the primary level, patterns are not only an object of study but also a tool. As children develop their number understanding skills, they can use patterns in arrays of dots or objects to help them understand what 6 is or whether 2 is greater than 3 (Seeley, 2004). The problem is that, although research has established the importance of patterning and its relationship to future mathematical achievement, the research has failed to demonstrate it as an integral part of children's mathematical development and is therefore not taught as thoroughly as it should be.

In order to make an evaluation in the process of determining children's interests and needs, comparing the obtained measurement with a criterion becomes a necessity. In order for this evaluation process to be healthy, using a valid and reliable measurement tool is a prerequisite. However, the tools prepared to evaluate children's pattern skills (Güven et al., 2019; Kesicioğlu, 2013; Papic et al., 2011; Sertsöz, 2017; Tarım, 2017) suffer from several limitations regarding not scoring a repeating and expanding pattern as a separate skill for the skill of creating original patterns, lack of pilot study, giving a limited number of pattern skill types, and the validity of the tools, and the failure to comply with the rule of repeating the pattern unit at least 3 times in the patterns given according to the logic of proof and deduction, which is the basis of the pattern. This study is important in terms of developing a valid and reliable measurement tool that determines children's patterning skills. The aim of the study was to develop a valid and reliable measurement tool to evaluate the pattern skills of children between the ages of 4 and 7.

Methods

The study used a screening model to develop a valid and reliable scale to determine the pattern skills of children between the ages of 4 and 7. According to Karasar (2009), screening models aim to describe a past or present situation, the event, individual, or object that is the subject of research, as it exists within its own conditions. This study aimed to develop a valid and reliable measurement tool to determine the pattern skills of children.

Universe and Sample

Universe

The universe of the research consists of children between the ages of 4 and 7 who continue their education in independent kindergartens, nursery classes, and first grade primary schools and who do not receive preschool education, and are affiliated to the Ministry of National Education in the city center of Sivas.

Sample

The researchers used convenience sampling and snowball sampling methods, which are among the purposeful sampling methods, in the sample selection for the research.

The researchers selected a total of four children, one from each age group between the ages of 4 and 7, for the pretrial application. The pretrial application was carried out only to obtain data on whether the scale items were understandable by children. The result of the application indicated that the scale items were understandable for children, and then the pilot application study started. The researchers collected data from 161 children between the ages of 4 and 7 for the pilot study phase and from 572 children (292 girls and 280 boys) between the ages of 4 and 7 for the main study. Additionally, 116 of 572 children did not receive preschool education.

Development of the Scale

During the development process of the Pattern Skill Scale (PSS), the study followed the following scale development steps suggested by Baykul (2010), Erkuş (2012), and Seçer (2015):

- Determining the general purpose of the scale
- Determining the qualities to be measured
- Defining the qualities to be measured and determining the guidelines
- Writing test items for the specified instructions
- Submission of trial items to expert opinion
- Review of trial items
- Conducting trial application
- Conducting a pilot study
- Elimination of items, conducting an item analysis from pilot study results
- Creating the final form of the scale for the main application
- Estimating the statistics of the final form of the scale

First, the researchers determined the general purposes and characteristics of the scale by examining the literature, defining the qualifications, and determining the instructions. Later, they developed an item pool for the determined guidelines and calculated the content validity rate of the items suitable for the Lawshe technique by submitting it to expert opinion. The content validity criterion for the KVR value should be at least 0.51 for 14 experts (Veneziano & Hoper, 1997, as cited in Yurdugül, 2005). In line with expert opinions regarding PSS, the KVR values for each item were between 0.57 and 1 by applying the formula given above using the Microsoft Office Excel program. In preparing the materials for the scale, the researchers took appropriateness to the child's developmental level, being durable and ergonomic, being expandable and accessible, being striking in terms of formal features, and general design principles (balance, emphasis, integrity, ratio/proportion, and closeness) into consideration. Circles, triangles, squares, and rectangles were cut from the counter plate. Preschool children prefer red, yellow, and blue colors (Elibol et al., 2006). In this context, the shapes created were painted with the colors that children pay attention to. Drawings were made on A3-sized paper and coated to make them long-lasting. The creation and editing of the visuals, organization of the content, and page editing were done by

the researchers using the Corel Draw 15 program. A caterpillar figure was presented so that children could perceive and embody it more easily. In addition, a caterpillar story was written by the researchers to cover each item in order to attract children's attention and keep the focus of attention for a long time. A preliminary trial was conducted with four children to ensure the understandability of the instructions. In the trial application, the researchers did not conduct any statistical analysis on the data; they only examined the understandability of the instructions and application. After the preliminary trial application, the researchers determined the "Pilot Study Group," which included children between the ages of 4 and 7, for the pilot study. A pilot study was conducted with 161 children from each age group between the ages of 4 and 7. The results of the pilot study indicated that the items "i1, i2, i3, and i20," whose item discrimination was below .30, were not successful in distinguishing between those who knew and those who did not know. For this reason, the researchers deemed it appropriate to remove the 4 items from the 26-item PSS. Within the scope of validity studies for the Pilot Study group, the researchers performed the Kaiser–Meyer–Olkin (KMO) and Bartlett sphericity test and exploratory factor analysis, which are included in construct validity. The results of the exploratory factor analysis indicated that there was only one item (i24) that showed overlapping. The final form of the scale, which consisted of 21 items with a total explained variance ratio of 0.52 and four dimensions, was created by removing the item showing overlapping features. After the researchers evaluated the data obtained from the pilot study using appropriate statistical analysis, the main application study was carried out with 341 children (175 girls and 166 boys) for exploratory factor analysis (EFA) and 231 children (119 girls and 112 boys) for confirmatory factor analysis (CFA). The data collected after the application was subjected to item analysis with a statistical package program.

Data Collection

In the research, first, ethical commission permission was obtained from the Hacettepe University Ethics Committee, and then the necessary permissions were obtained from the Sivas Provincial Directorate of National Education for the schools in the study group determined by the researchers. In the first phase of the research, which constituted the quantitative dimension, the data collection process was carried out between April 12 and August 5, 2022. Due to the age of the study group, parental consent forms containing the purpose of the study, content, application process, and informing that children could withdraw from the study at any time were prepared and sent to the children's parents in writing, and the necessary permissions were obtained for the application. The researchers interviewed school administration and teachers, who were other stakeholders of the children studying in educational institutions. Before starting the application, the researchers conducted interviews with the children's teachers to obtain data on the children's demographic information. The researchers received permission from the school administrations to use empty classrooms with equipment similar to other classrooms, where children would feel more comfortable and safer. In schools with no empty classrooms, practice locations were chosen in line with the common opinions of the guidance counselors and the children, and in the applications to be carried out at home with children who did not receive preschool education, the application locations were chosen in line with the common opinions of the parents and children. During the application, the researcher used a tone of voice and expressions with which children could feel comfortable. One-on-one practice was carried out with children in accordance with social distance, mask, and hygiene rules. After the application with each child, the room was ventilated. When determining the children, the purpose of the research was first mentioned, and especially considering the age characteristics of the children, a caterpillar toy was shown and their consent was obtained by asking the question, "This caterpillar will go on the adventure of becoming a butterfly; do you want to help it?" In order for children to feel safer, in the practices carried out in schools, the researchers ensured that the guidance counselor or assistant staff that the children knew was present in the same place, and in the home environment, one of the child's parents was present in the same place. However, these people were specifically asked not to intervene or comment on the children's practices, to stay in the background, and to just wait in a place further away from the table where the application was taking place.

The children who consented to participate in the research were directed to where they would sit at the table and were directed to examine the materials previously prepared on the table. To get down to the children's level, the researcher sat on the same chair as the child and tried to make eye contact. During the application, the researcher did not give any feedback, such as right or wrong, on the children's work. In order to avoid making the children feel like they were being evaluated, they were made to think that they were doing a play activity. Due to the age characteristics of the children, the researcher took attention spans into consideration and made sure that the applications did not exceed an average of 20 minutes. In order to maintain their attention for a longer period of time, the researcher used stories prepared using caterpillar puppets for children, paying attention to gestures, facial expressions, and tone of voice. In the skill of completing the missing piece in the pattern, the researcher told the following story: "The adventurous caterpillar started walking on a bridge to cross the street. At that moment, a very strong wind arose, and the caterpillar began to swing from side to side on the bridge, but eventually he managed to cross the bridge. However, he took one look at his body, and what did he see? The wind blew away some of the colors as it passed over the bridge. Now, would you like to replace the missing colors of the caterpillar by following the rule?" Through this, the researcher tried to increase the motivation of the children to focus on the research and continue the research with short explanations. Necessary markings were made on the evaluation forms in a place outside the children's field of vision. The data collected by the researcher on a one-to-one basis with the children and based on performance as 1-0 were transferred to the Microsoft Office Excel program. To protect the privacy of children, codes were given instead of their names. In addition, after the application was carried out with all the children in the class, care was taken to protect the children's personal data, and general opinions were shared about the pattern skills of all the children in the class instead of individual feedback about the children who participated in the study.

Obtaining Children's Consent and Ethical Considerations

Taking into account the ethical elements included in the research guide with children and young people prepared by Shaw et al. (2011) and Flewitt's (2005) study on ethical principles to be considered when conducting research with young children, the ethical processes carried out for the current study are listed below:

- The purpose of the research was explained to the children.
- Consent was obtained from the children regarding whether or not to participate in the study.
- The application process was started when the children were willing to participate.
- Children were informed that they could take a break from the practice whenever they wanted to.
- Children's opinions were consulted in choosing the environment where the application would take place.
- During the application process, the child was made to feel comfortable by sitting on the same chair as the child.
- Codes such as "C1, C2, ..." were used for each child.

Data Analysis

In the data analysis of the research, the researchers used Microsoft Office Excel, Factor 12, Lisrel 8.8, and Statistical Package for the Social Sciences Statistics software, version 24. In order to conduct exploratory factor analysis, varimax rotation based on the principal components method was applied on the tetrachoric correlation matrix with the Factor 12 program, since the scale was scored as 1-0. The Lisrel 8.8 program was used in confirmatory factor analysis.

Validity and Reliability

In order to test the validity, the researchers used face validity (obtaining expert opinions), content validity (Lawshe technique (content validity rates [CVR]), and construct validity (EFA and CFA). To test the reliability, the researchers used KR-20, Cronbach's alpha, split-half test reliability (Spearman–Brown), and item analysis (item difficulty, item discrimination, point biserial correlation coefficient, and *t*-test between the lower and upper groups of 27%).

Results

This section includes the results, validity, and reliability obtained after the main application of PSS.

Main Application Study

The validity and reliability analyzes of the main application are given below.

Validity Tests Conducted for Main Application

To test the construct validity of the scale developed, the researchers applied KMO and Bartlett sphericity test, scree plot, EFA, and CFA.

Construct Validity

For the construct validity of the research, first EFA and then CFA were conducted.

Table 1 indicated that the sample size was excellent according to the KMO coefficient (0.913). Further, Bartlett's Test of Sphericity highlighted that exploratory factor analysis could be performed for the data.

Figure 1 highlighted that the eigenvalues in the scree plot fell below the value of 1, which is required for the formation of a dimension, after the fourth dimension. In this context, the results indicated that PSS had 4 dimensions.

Table 2 indicated that 58.823% of the total variances can be explained in the scale consisting of 4 dimensions with eigenvalues higher than 1. This result indicated that PSS consisted of 4 dimensions.

Table 3 showed that PSS consisted of four subdimensions and the total variance explained was 59%.

Figure 2 shows how the 19 observed variables and 4 latent variables of the Pattern Skills Scale were explained. According to CFA, the factor loadings of the items and the loadings were found to be statistically

Table 1.
Kaiser–Meyer–Olkin and Bartlett's Test of Sphericity Results of the Main Study Group

Kaiser–Meyer–Olkin and Bartlett Test		
Kaiser–Meyer–Olkin measure of sampling adequacy		0.913
Bartlett's test of sphericity	Approximate chi square	2570.027
	SD	171
	Significance	<.001

*p is significant at the .05 level.

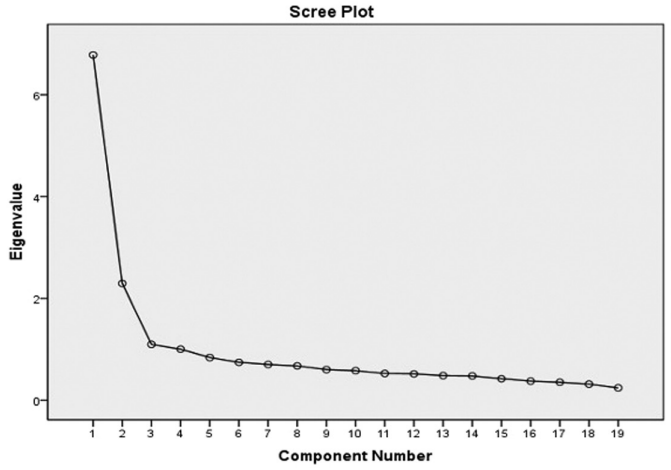

Figure 1.
Scree Plot.

significant for all items. Since the obtained factor correlations were less than 0.85 (Çelik & Yılmaz, 2013), the results concluded it as a factor in itself without any action on the factors.

Table 4 indicated that the following fit values of the model, such as χ^2/SD (1.647), non-normed fit index (96) and root mean square residual (0.01) showed good (perfect) fit while goodness fit index (0.90), adjusted goodness fit index (0.86), normed fit index (0.92), root mean square error of approximation (0.055), and standardized root mean square residual (0.056) values showed acceptable fit.

Table 5 indicated that the KR-20 and half-test reliability values were above 0.70. Cronbach's alpha values were very high (excellent) for EFA and high for CFA.

Table 6 contains information about the analyses, coefficients, reference ranges, and referenced sources for all reliability and item analysis studies conducted on the PSS.

Table 7 included subdimension items, and the skills of copying, finding the unit that forms the pattern, continuing the pattern, and finding the missing piece in the pattern were in the first subdimension; the ability to transform the pattern into another color, shape, or object was in the second subdimension; the items of continuing the hopscotch pattern and creating a hopscotch pattern were in the third sub-dimension; and the items related to the ability to correct the faulty pattern, continue the expanding pattern, and create the expanding pattern were in the fourth subdimension. In naming the factors, the common characteristics of the items that load on the subdimension are named by looking at the item with the highest loading value (Altunışık et al., 2007; Erkuş, 2012; Seçer, 2015). While naming the items, the researchers took item difficulties, conceptual structure, expert opinion, and common characteristics of the items loading on the sub-dimension into consideration.

Discussion

The aim of this research was to develop a measurement tool to determine the patterning skills of children between the ages of 4 and 7. For this purpose, this section includes the discussion regarding the validity and reliability results of the developed scale.

In line with scale development, the researchers followed the scale development stages according to the related literature (Baykul, 2010; Erkuş, 2012; Gül & Sözbilir, 2015; Seçer, 2015). As the first step in

Table 2.
Total Explained Variance Table After Exploratory Factor Analysis

Total Variance Explained

	Initial Eigen Value			Inference Sums of Square Charges			Spin Sums of Square Loads		
Component	**Total**	**Percentage of Variance**	**Cumulative Percentage**	**Total**	**Percentage of Variance**	**Cumulative Percentage**	**Total**	**Percentage of Variance**	**Cumulative Percentage**
1	6.786	35.717	35.717	6.786	35.717	35.717	4.523	23.806	23.806
2	2.294	12.075	47.791	2.294	12.075	47.791	2.401	12.636	36.442
3	1.095	5.765	53.557	1.095	5.765	53.557	2.363	12.438	48.879
4	1.001	5.266	58.823	1.001	5.266	58.823	1.889	9.943	58.823
5	0.838	4.408	63.231						
6	0.743	3.908	67.139						
7	0.700	3.684	70.823						
8	0.672	3.534	74.358						
9	0.600	3.156	77.513						
10	0.578	3.042	80.555						
11	0.524	2.759	83.314						
12	0.515	2.711	86.025						
13	0.481	2.531	88.556						
14	0.475	2.502	91.058						
15	0.421	2.214	93.272						
16	0.373	1.965	95.237						
17	0.352	1.850	97.087						
18	0.313	1.650	98.737						
19	0.240	1.263	100.000						

these stages, the researchers examined national and international studies and created a pool of 26 items. To ensure the content validity of the scale items in the item pool, they were presented to expert opinion using the Lawshe technique and statistical method. Necessary arrangements were made in line with the experts' suggestions regarding the substances. Materials were prepared for the application process of the scale items. Then, a preliminary trial was conducted with 4 children to determine the understandability and applicability of the scale. After the preliminary trial application, the scale consisting of 26 items was applied to 161 children, and a pilot study was conducted. For the main study, exploratory factor analysis was conducted with 341 children, and confirmatory factor analysis was conducted with 231 children.

Table 3.
Exploratory Factor Analysis Results

		Factor			
Dimensions	**Item No**	**1**	**2**	**3**	**4**
First dimension	M4	0.69			
	M5	0.67			
	M6	0.61			
	M7	0.74			
	M8	0.70			
	M10	0.75			
	M11	0.63			
	M13	0.71			
	M14	0.65			
Second dimension	M17		0.83		
	M18		0.83		
	M19		0.73		
Third dimension	M12			0.83	
	M23			0.65	
	M26			0.68	
Fourth dimension	M16				0.52
	M21				0.66
	M22				0.75
	M25				0.74
		Total variance 0.59			

There are different opinions in the literature regarding sample size. It is a generally accepted approach that the number of participants should be four times (MacCallum et al., 2001) or five times (Büyüköztürk et al., 2014; Tavşancıl, 2019) of the number of items. Tabachnick and Fidell (2007) and DeVellis (2014) evaluate the sample size as medium for 200 participants, good for 300 participants, very good for 500 participants, and excellent for 1000 and above. Comrey and Lee (2013) state that 50 participants are very poor, 100 participants are poor, 200 are average, 300 are good, 500 are very good, and 1000 are excellent. Another criterion to test the suitability of the sample size is the KMO test result. The KMO test results indicated that the sample sizes were sufficient for the pilot study (KMO=0.876) and the main study (KMO=0.913). A KMO value greater than 0.80 indicates a sufficient sample size (Comrey & Lee, 2013; Şencan, 2005), while a KMO value

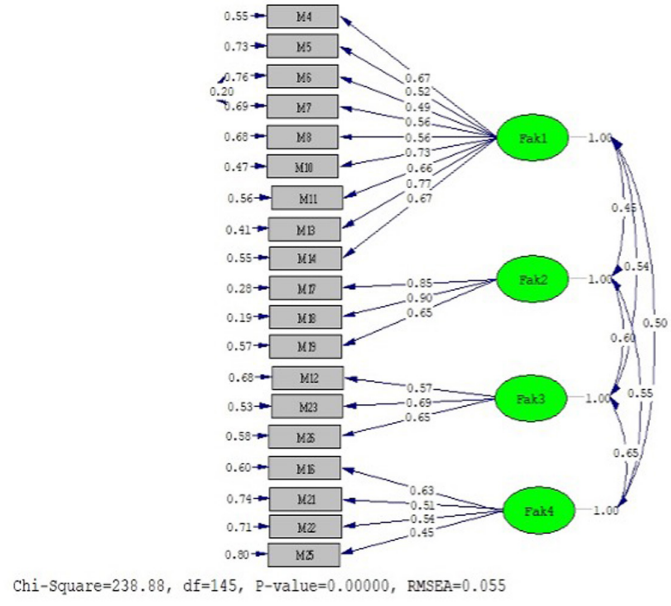

Figure 2.
Pattern Skill Scale Path Diagram

Table 4.
Model Fit Indices

Fit Indices	Goodness of Fit Indices	Acceptable Fit Indices	CFA Results
Ki-Kare/SD	$0 \leq \chi^2/SD \leq 2$	$2 \leq \chi^2/SD \leq 3$	1.647
GFI	$95 \leq GFI \leq 1.00$	$0.90 \leq GFI \leq 95$	.90
AGFI	$0.90 \leq AGFI \leq 1.00$	$0.85 \leq AGFI \leq .90$	.86
CFI	$0.95 \leq CFI \leq 1.00$	$0.90 \leq CFI \leq .95$	.97
NFI	$0.95 \leq NFI \leq 1.00$	$90 \leq NFI \leq .95$	.92
NNFI (TLI)	$0.95 \leq NNFI\ (TLI) \leq 1.00$	$0.90 \leq NNFI\ (TLI) \leq .95$	.96
RMR	$0 \leq RMR < 0.05$	$0.05 \leq RMR \leq 0.10$	.01
RMSEA	$0.00 \leq RMSEA \leq .05$	$0.05 < RMSEA \leq .08$	.055
SRMR	$0.00 \leq SRMR \leq .05$	$05 < SRMR \leq .10$	.056

Note: AGFI=Adjusted goodness-of-fit index; CFI=Comparative fit index; GFI=Goodness fit index; NFI=Normed fit index; NNFI (TLI)=Non-normed fit index (Tucker–Lewis Index); RMR=Root mean square residual; RMSEA=Root mean square error of approximation; SRMR=Standardized root mean square residual

Table 5.
Internal Consistency and Split-Half Reliability Results of the Pattern Skill Scale

KR-20	Split-Half Reliability	Cronbach's Alpha	Reliability Analysis (Before Factor Analysis)	Number of Items
0.85	0.93	0.89	0.89	21
			Reliability Analysis (After Exploratory Factor Analysis)	
0.85	0.93	0.90	0.90	19
			Reliability Analysis (After Confirmatory Factor Analysis)	
0.83	0.92	0.87	0.87	19

of 0.90 or above (Kline, 1994) indicates an excellent sample size. For the suitability of the data set for factor analysis, the Barletlett's test of sphericity result is significant at the $p < .05$ level, and it is stated that the data show a normal distribution in this direction (Comrey & Lee, 2013; Çokluk et al., 2012).

After the sample size criteria were met, item difficulty and item discrimination were calculated for the data collected during the pilot study phase. Items "i1, i2, i3, and i20," whose item discrimination was less than 0.30 (Özçelik, 2010), were removed because they were not successful in distinguishing between those who knew and those who did not know, and 22 items remained in the scale. Since the scale was scored in two categories after the analysis of the item predictions, EFA was performed with a varimax rotation application based on the principal components method on the tetrachoric correlation matrix.

Table 7.
Naming and Scoring of Scale Subdimensions

Subdimensions	Items	Lowest Point	Highest Point
General pattern skills	4, 5, 6, 7, 8, 10, 11, 13, 14	0	9
Transformation	17, 18, 19	10	12
Hopscotch	12, 23, 26	13	15
Expanding	16, 21, 22, 25	16	19

As a result of EFA, item load values of at least 0.30 (Büyüköztürk et al., 2014; Çokluk et al., 2012) were determined as the criterion. In line with this criterion, items "i24" in the pilot study and "i9 and i15" in the main study were removed, leaving 19 items in the final form of the scale.

Considering the criterion that when the eigenvalues start to be less than 1 in the scree plot, the factors start to become indistinguishable (Aksu et al., 2017), the study concluded that the scale consisted of four dimensions. According to the criterion that the cutoff scores should not be below 0.30 (Büyüköztürk et al., 2014), the results indicated that the items were at an acceptable level since the common variances of the items varied between 0.41 and 0.82. The study concluded that the total variance of the measurement tool consisting of four dimensions was 52% for the pilot study and 59% for the main study. In multifactor scale development studies, the total explained variance must be over 30% (Büyüköztürk et al., 2014), 40% (Çokluk et al., 2012), or 50% (Güriş & Astar, 2015). In this context, the results indicated that the total variance ratio of the scale was at a sufficient level.

The CFA (Seçer, 2017) was conducted to test the four-dimensional structure that emerged as a result of the EFA and to examine to what extent this structure was confirmed with the collected data. In CFA, the Lisrel 8.8 program was used to verify the structure of 19 items belonging to the four subdimensions of the scale. The results concluded that all t values were significant (Çokluk et al., 2012; Jöreskog & Sörbom, 1996) and factor load values were between 0.57 and 0.89. Among the fit indices observed in the scale model, χ^2/SD (1.647), NNFI (96), and RMR (0.01) values showed good (perfect) fit (Kelloway, 1998; Schermelleh-Engel et al., 2003).

To test the reliability of the scale developed, Cronbach's alpha, KR-20 internal consistency, and two-half test reliability (Spearman Brown) studies were conducted for PSS. In two-value (1-0) measurements, KR-20 or Cronbach's alpha values can be used in internal consistency reliability estimations (Atılgan, 2019; Bademci, 2011). According to Özdamar (2015), if Cronbach's alpha values are between 0.61 and 0.80, the scale is considered to have medium reliability, and between 0.81 and 1.00, the scale is considered to be highly reliable. George and Mallery (2003) interpret Cronbach's alpha values as acceptable between 0.60 and 0.70, as good between 0.70 and

Table 6.
Summary of Reliability and Item Analysis Results of the Pattern Skill Scale

Results of the Reliability Analysis			
Name of the Analysis	**Coefficient**	**Range**	**Reference**
KR-20	0.83	>0.70	Atılgan, 2019; Turgut and Baykul, 2010; George and Mallery, 2003; Özçelik, 2010; Tavşancıl, 2019
Cronbach's alpha	0.92	0.90 and above	
Split-half reliability	0.87	>0.70	
Results of the Item Analysis			
Parameters examined		Range	Reference
Item difficulty	0.13–0,88	Around 0.50	Atılgan, 2019; Turgut and Baykul, 2010; Büyüköztürk et al., 2014; Erkuş, 2012; Tabachnick and Fidell, 2007
Point biserial correlation coefficient	0.40–0.65	.29 and above	
t-Test between the lower and upper groups of 27%	6.75–31.78	Significant	

0.90, and as excellent for 0.90 and above. The KR-20 value ranges between 0 and 1, and the closer it gets to 1, the more reliable the scale is (Özçelik, 2010). In general, KR-20 and Spearman Brown values are expected to be greater than 0.70 (Erkuş, 2012; Field, 2009). In this regard, the results indicated that the scale had high reliability according to KR-20 (0.83), Spearman Brown (0.92), and Cronbach's alpha (0.87) values.

In naming the four subdimensions formed after factor analysis, the common characteristics of the items loading on the subdimension (Altunışık et al., 2007; Seçer, 2015) were taken into account. In addition, while naming, studies on the subject, conceptual structure, and recommendations of expert opinions were taken into consideration.

The study concluded that the PSS for the children between the ages of 4 and 7, which consists of 4 dimensions and 19 items, had a total explained variance of 59% and a Cronbach's alpha value of 0.87, was a reliable and valid measurement tool.

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Informed Consent: Written and oral informed consent was obtained from the participants who agreed to take part in the study.

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References

Akman, B. (2002). Okul öncesi dönemde matematik. *Hacettepe Üniversitesi Eğitim Fakültesi Dergisi*, *23*, 244–248.

Akman, B. (2019). Erken çocuklukta matematik eğitimi. içinde B. Akman & M. Ünal (Eds.). *Erken çocuklukta fen ve matematik eğitimi* (ss. 169–305). İstanbul Üniversitesi Açık ve Uzaktan Eğitim Fakültesi. http://auzefkitap.istanbul.edu.tr/kitap/cocukgelisimilisans_ao/erkencocukluktafenvme.pdf

Akman, B. (2021). *Erken çocuklukta matematik eğitimi*. PEGEM Akademi.

Aksu, G., Eser, M. T., & Güzeller, C. O. (2017). *Açımlayıcı ve doğrulayıcı faktör analizi ile yapısal eşitlik modeli uygulamaları*. Detay Yayıncılık.

Altunışık, R., Coşkun, R., Bayraktaroğlu, S., & Yıldırım, E. (2007). *Sosyal bilimlerde araştırma yöntemleri SPSS uygulamalı*. Sakarya Yayıncılık.

Atılgan, H. (2019). *Eğitimde ölçme ve değerlendirme* (12. Baskı). Anı Yayıncılık.

Aunio, P., Hautamäki, J., & Van Luit, J. E. H. (2005). Mathematical thinking intervention programmes for preschool children with normal and low number sense. *European Journal of Special Needs Education*, *20*(2), 131–146. [CrossRef]

Baykul, Y. (2010). *Eğitimde ve psikolojide ölçme: Klasik test teorisi ve uygulaması*. PEGEM Akademi.

Büyüköztürk, Ş., Çakmak, E., Akgün, Ö., Karadeniz, Ş., & Demirel, F. (2014). *Bilimsel araştırma yöntemleri* (10. Baskı). PEGEM Akademi.

Carpenter, L. (2020). *Pattern awareness an important early math skill. Kids in transition to school*. https://kidsintransitiontoschool.org/pattern-awareness-an-important-early-math-skill/

Çelik, H. E., & Yılmaz, V. (2013). *Lisrel 9,1 ile Yapısal Eşitlik Modellemesi Temel Kavramlar Uygulamalar Programlama* (2. Baskı). Anı Yayıncılık

Clements, D. H., Sarama, J., & DiBiase, A. M. (Eds.) (2004). *Engaging young children in mathematics: Standards for early childhood mathematics education*. Lawrence Erlbaum Associates.

Çokluk, Ö., Şekercioğlu, G., & Büyüköztürk, Ş. (2012). *Sosyal bilimler İçin çok Değişkenli İstatistik SPSS ve LISREL uygulamaları*. PEGEM Akademi.

Comrey, A. L., & Lee, H. B. (2013). *A first course in factor analysis*. Psychology Press.

Confrey, J., & Smith, E. (1995). Splitting, covariation, and their role in the development of exponential functions. *Journal for Research in Mathematics Education*, *26*, 66–86. https://www.jstor.org/stable/749228

DeVellis, R. F. (2014). *Ölçek geliştirme kuram ve uygulamalar*. (3. Baskı). Nobel Yayıncılık.

Duncan, G. J., Dowsett, C. J., Claessens, A., Magnuson, K., Huston, A. C., Klebanov, P., Pagani, L. S., Feinstein, L., Engel, M., Brooks-Gunn, J., Sexton, H., Duckworth, K., & Japel, C. (2007). School readiness and later achievement. *Developmental Psychology*, *43*(6), 1428–1446. [CrossRef]

Elibol, G. C., Kılıç, Y., & Burdurlu, E. (2006). Okul öncesi çocuk oyuncaklarında malzeme kullanımı ve 4–6 yaş çocuklarının renk tercihleri. *Sosyal Politika Çalışmaları Dergisi*, *9*(9), 35–44. https://dergipark.org.tr/en/pub/spcd/issue/21102/227255

Erkuş, A. (2012). *Psikolojide ölçme ve ölçek geliştirme*. PEGEM Akademi.

Field, A. (2009). *Discovering statistics using SPSS*. Sage.

Flewitt, R. (2005). Conducting research with young children: Some ethical considerations. *Early Child Development and Care*, *175*(6), 553–565. [CrossRef]

George, D., & Mallery, P. (2003). *SPSS for Windows step by step: A simple guide and reference. 11.0 update* (4th ed). Allyn & Bacon. https://wps.ablongman.com/wps/media/objects/385/394732/george4answers.pdf

Gifford, S. (2019). *Developing pattern Awareness with young children*. https://nrich.maths.org/13362

Ginsburg, H. P., Inoue, N., & Seo, K. H. (1999). Young children doing mathematics: Observation of every day activities. In J. Copley (Ed.). *Mathematics in the early years* (pp. 88–99). National Council of Teachers of Mathematics.

Ginsburg, H. P., Lin, C., Ness, D., & Seo, K. H. (2003). Young American and Chinese children's everyday mathematical activity. *Mathematical Thinking and Learning*, *5*(4), 235–258. [CrossRef]

Gül, Ş., & Sözbilir, M. (2015). Fen ve matematik eğitimi alanında gerçekleştirilen ölçek geliştirme araştırmalarına yönelik tematik içerik analizi. *Eğitim ve Bilim*, *40*(178), 85–102. [CrossRef]

Güriş, S., & Astar, M. (2015). *Bilimsel araştırmalarda SPSS ile istatistik*. Der Yayınları

Güven, Y., Dİbek, E., Bayindir, D., & Saçkes, M. (2019). Okul öncesi örüntü becerileri testinin geliştirilmesi: Geçerlik ve güvenirlik çalışması. *Necatibey Eğitim Fakültesi Elektronik Fen ve Matematik Eğitimi Dergisi*, *13*(2), 545–563. [CrossRef]

Herbert, K., & Brown, R. H. (1997). Patterns as tools for algebraic reasoning. *Teaching Children Mathematics*, *3*(6), 340–344. [CrossRef]

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. [CrossRef]

Jöreskog, K. G., & Sörbom, D. (1996). *LISREL 8: User's reference guide*. Scientific Software International.

Karasar, N. (2009). *Bilimsel araştırma yöntemi*. Nobel Yayıncılık.

Kelloway, E. K. (1998). *Using LISREL for structural equation modeling: A researcher's guide*. Sage.

Kesicioğlu, O. S. (2013). Okul öncesi dönem çocuklarının matematiksel örüntü becerilerinin incelenmesi. *Akdeniz Eğitim Araştırmaları Dergisi*, *13*, 19–26. https://mjer.penpublishing.net/files/10/manuscript/manuscript_329/mjer-329-manuscript-133616.pdf

Kieran, C., Pang, J., Schifter, D., & Ng, S. F. (2016). *Early algebra: Research into its nature, its learning, its teaching*. Springer Nature.

Kline, P. (1994). *An easy guide to factor analysis*. Routledge.

Lee, K., Ng, S. F., Bull, R., Pe, M. L., & Ho, R. H. M. (2011). Kalıplar önemli mi? Kalıplar, hesaplama, yürütme işlevi ve cebirsel kelime problemlerindeki yeterlilikler arasındaki ilişkilerin araştırılması. *Eğitim Psikolojisi Dergisi*, *103* (2), 269–281. [CrossRef]

MacCallum, R. C., Widaman, K. F., Preacher, K. J., & Hong, S. (2001). Sample size in factor analysis: The role of model error. *Multivariate Behavioral Research*, *36*(4), 611–637. [CrossRef]

McGarvey, L. M. (2013). Is it a pattern? *Teaching Children Mathematics*, *19*(9), 564–571. https://eric.ed.gov/?id=EJ1020121. [CrossRef]

Montague-Smith, A. (2014). *Mathematics in nursery education*. Routledge. [CrossRef]

Mulligan, J., & Mitchelmore, M. (2009). Awareness of pattern and structure in early mathematical development. *Mathematics Education Research Journal*, *21*(2), 33–49. [CrossRef]

National Council of Teachers of Mathematics (NCTM) (2000, 2022). *Principles and standards for school mathematics*. The National Council of Teachers of Mathematics.

Özçelik, D. A. (2010). *Ölçme ve değerlendirme*. PEGEM Akademi.

Özdamar, K. (2015). *Paket Programlarla İstatistiksel Veri Analizi-1* (4. Baskı). Kaan Kitabevi.

Öztürk, M., & Güler, M. (2020). Örüntü ve süslemeler. In T. Ağırman Aydın & B. Küçük Demir (Eds.). *Geometri ve Öğretimi* (ss. 217–232). Pegem Akademi.

Papic, M. M., Mulligan, J. T., & Mitchelmore, M. C. (2011). Assessing the development of preschoolers' mathematical patterning. *Journal for Research in Mathematics Education*, *42*(3), 237–268. [CrossRef]

Pasnak, R. (2017). Empirical studies of patterning. *Grantee Submission*, *8*, 2276–2293.

Rittle-Johnson, B., Fyfe, E. R., McLean, L. E., & McEldoon, K. L. (2013). Emerging understanding of patterning in 4-year-olds. *Journal of Cognition and Development*, *14*(3), 376–396. [CrossRef]

Rittle-Johnson, B., Zippert, E. L., & Boice, K. L. (2019). The roles of patterning and spatial skills in early mathematics development. *Early Childhood Research Quarterly*, *46*, 166–178. [CrossRef]

Samuelsson, I. P., & Fleer, M. (Eds.) (2008). *Play and learning in early childhood settings: International perspectives* (Vol. *1*). Springer Science & Business Media.

Sarama, J., & Clements, D. H. (2008). Mathematics in early childhood. In O. N.Saracho & B.Spodek (Eds.). *Contemporary perspectives on mathematics in early childhood education*. Information Age Publishing, Inc.

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research*, *8*(2), 23–74. https ://www.scienceopen.com/document?vid=4c30cf93-535c-492f-bdf5-19a40 a6af21b

Seçer, İ. (2015). *Psikolojik test geliştirme ve uyarlama süreci; SPSS ve Lisrel uygulama süreci*. Anı Yayıncılık.

Seçer, İ. (2017). *SPSS ve Lisrel ile pratik veri analizi*. (3. Baskı). Anı Yayıncılık.

Seeley, C. (2004). A journey in algebraic thinking. *NCTM News Bulletin*, *41*(2), 3.

Şencan, H. (2005). *Sosyal ve davranışsal ölçümlerde güvenilirlik ve geçerlilik*. Seçkin Yayıncılık.

Sertsöz, A. (2017). *6 yaş çocuklarına öyküleştirme yöntemi ile verilen matematik eğitiminin çocukların matematik başarılarına olan etkisinin incelenmesi* (Yüksek Lisans Tezi, Tez No. 480213). Dumlupınar Üniversitesi-Kütahya, Yükseköğretim Kurulu Başkanlığı Tez Merkezi.

Shaw, C., Brady, L. M., & Davey, C. (2011). *Guidelines for research with children and young people*. National Children's Bureau Research Centre.

Sperry-Smith, S. (2012). *Early childhood mathematics* (5th ed.). Pearson.

Steen, L. A. (1998). Why numbers count: Quantitative literacy for tomorrow's America. *NASSP Bulletin*, *82*(600), 120–122. [CrossRef]

Tabachnick, B. G., & Fidell, L. S. (2007). *Using multivariate statistics*. Pearson.

Tanışlı, D., & Olkun, S. (2009). *Basitten karmaşığa örüntüler*. Maya Akademi.

Tarım, K. (2017). Pattern finding skills of pre-school children. *International Journal for Mathematics Teaching and Learning*, *18*(3), 346–358. [CrossRef]

Tavşancıl, E. (2019). *Tutumların ölçülmesi ve SPSS ile veri analizi* (6. Baskı). Nobel Yayınları.

Tsamir, P., Tirosh, D., Levenson, E. S., & Barkai, R. (2018). Early childhood teachers' knowledge and self-efficacy for evaluating solutions to repeating pattern tasks. In *Contemporary research and perspectives on early childhood mathematics education* (pp. 291–310). Springer. [CrossRef]

Turgut, M. F., & Baykul, Y. (2010). *Eğitimde ölçme ve değerlendirme*. PEGEM Akademi Yayıncılık.

Waters, J. (2004). Mathematical patterning in early childhood settings. The 27 th Annual Conference of the mathematics education of research group of Australasia 2, 321–328. Australia.

Yıldırım-Hacıibrahimoğlu, B. (2019). Matematik ilkeleri ve standartları. In İ. B. Akman (Ed.). *Erken çocuklukta matematik eğitimi* (8. Baskı, ss. 12–24). PEGEM Akademi.

Yuhasriati, Y., & Yuriansa, A. (2018). Patterns playing for early childhood education: Mathematics learning for early childhood education. *Journal of Physics: Conference Series*, *1088*(1), 012099. [CrossRef]

Yurdugül, H. (2005). Ölçek geliştirme çalışmalarında kapsam geçerliği için kapsam geçerlik indekslerinin kullanılması. XIV. *Ulusal Eğitim Bilimleri Kongresi*, *1*, 771–774. https://yunus.hacettepe.edu.tr/~yurdugul/3/indir/PamukkaleBildiri.pdf

Zazkis, R., & Liljedahk, P. (2002). Generalization of patterns: The tension between algebraic thinking and algebraic notation. *Educational Studies in Mathematics*, *49*(3), 379–402. [CrossRef]