IJARE
International Journal of Academic Research in Education (IJARE)
Volume 8, Issue 1, ss. 1-14, December 2022
Turkish JournalPark ACADEMIC

Problem-Oriented Mathematical Creativity Self-Efficacy Perception Scale: Validity and Reliability Studies[1]

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Abstract: *The study aims to develop the Problem-Oriented Mathematical Creativity Self-Efficacy Perception Scale to determine the pre-service mathematics teachers' problem-oriented mathematical creativity self-efficacy perceptions in a valid and reliable way. The exploratory sequential mixed method was preferred for the research. In the research, while qualitative procedures were followed during the item pool preparation, the scales' psychometric properties were researched using quantitative methods. The convenience sampling method was used to determine the participants. The research was conducted with pre-service mathematics teachers studying in four state urban universities in three different regions (Black Sea Region, Eastern Anatolia Region, Southeastern Anatolia Region) of Turkey. The first study group constituted of three hundred eleven pre-service mathematics teachers while the second study group three hundred sixty-four pre-service mathematics teachers. As a result of the research, a 3-factor structure consisting of fluency, flexibility, and originality factors, and explaining 61.527% of the total variance was obtained. Validity and reliability calculations of the scale consisting of 21 items in 5-point Likert type resulted positively.*

Keywords: *Pre-service teachers, mathematical creativity, scale development, self-efficacy perception.*

Suggested Citation: Aksungur Altun, Ş., & Açıkgül, K. (2022). Problem-oriented mathematical creativity self-efficacy perception scale: Validity and reliability studies. *International Journal of Academic Research in Education*, *8*(1), 1-15. DOI: 10.17985/ijare.1201283

Article History: Submitted 8 November 2022; Revised 10 December 2022; Accepted 14 December 2022

INTRODUCTION

The creativity that is stated as one of the most essential skills, caught the attention of researchers due to the pioneer studies of Guilford and Torrance (Ghonsooly & Showqi, 2012). Huang et al. (2017) highlighted the importance of creativity in education and stated that education institutions are searching for effective ways to strengthen students' creativity. Akgul and Kahveci (2016) indicated that creativity is a skill that gains importance in designated fields such as science and mathematics, and that evaluating students' creativity in these fields is important to design the curriculum to the needs of creative students. Creativity was generally considered as mathematical creativity and focused on organizing students' problem-solving processes to evaluate and develop creativity in educational settings (e.g., Haylock, 1987; Lee et al., 2003; Sriraman, 2009). In this process, many researchers (e.g., Aljughaiman & Mowrer-Reynolds, 2005, Leikin, 2009; Luria et al., 2017; Nadjafikhah et al., 2012; Sriraman, 2009) placed the responsibility in improving students' creativity on teachers' shoulders. However, teachers' low self-efficacy perceptions hinder creative activities' development at the desired level (Panaoura & Panaoura, 2014). The mathematical creativity self-efficacy perceptions of pre-service mathematics teachers

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(PSMT) who will be the teachers of the future are essential to establish environments to encourage and develop mathematical creativity. Despite the mentioned necessary of creative self-efficacy, there is limited study related to self-efficacy perceptions of PSMT. The mathematical creativity research focus more on students' ability to solve mathematical creativity problems (e.g., Lin, 2010; Pham, 2014; Shoimah et al., 2018). Studies conducted with PSMT generally researched the mathematical creativity levels of the pre-service teachers (Safitri et al., 2018; Wahyudi et al., 2018), their views (Bolden et al., 2010; Dündar, 2015), and their awareness (Panaoura & Panaoura, 2014; Shriki, 2010). Açıkgül and Aksungur Altun (2022) developed a scale for determining pre-service teachers' self-efficacy perceptions regarding general mathematical creativity. On the other hand, focusing on the problem-solving process in determining mathematical creativity (e.g., Haylock, 1987; Lee vd., 2003; Sriraman, 2009) reveals the importance of determining pre-service teachers' problem-oriented mathematical creativity self-efficacy perceptions. Based on this information, it is thought that the development of valid, reliable, and useful measurement tools in determining the problem-oriented mathematical creativity self-efficacy perceptions of PSMT will contribute to the literature.

Several researchers suggested criteria to evaluate creative products of mathematics due to the complexity of defining structure and features of creativity. In this study, the criteria for evaluating mathematical creativity were considered while developing the Problem-Oriented Mathematical Creativity Self-Efficacy Perception Scale. Many researchers (Huang et al., 2017; Pitta-Pantazi et al., 2013; Silver, 1997; Singh, 1987; Wessels, 2014) stated that fluency, flexibility, and originality criteria should be considered while evaluating mathematical creativity. Fluency is defined as total number of appropriate solutions given to a mathematical task and shows students' ability to produce different responses in a short time (Chesimet et al., 2016; Leikin, 2013; Sriraman et al., 2013; Silver, 1997; Wahyudi et al., 2018). Flexibility means different response types or different response categories or methods to a particular mathematical task (Chesimet et al., 2016; Pitta Pantazi et al., 2013). Originality is expressed as the ability to generate extraordinary, new, and unique answers in mathematics (Chesimet et al., 2016; Leikin & Lev, 2013; Pitta-Pantazi et al., 2013). Wherefore, the aim of this study is to develop the Problem-Oriented Mathematical Creativity Self-Efficacy Perception Scale consisting of fluency, flexibility, and originality factors to assess the problem-oriented mathematical creativity self-efficacy perceptions of PSMT in a valid and reliable manner.

Conceptual Framework

Creativity

There are many definitions of creativity in the literature. In general, in these definitions, creativity is expressed as creating new and unique products, ideas, or inventions and have technological, scientific, aesthetic, and social values. For example, Smith (2005) defined creativity as the novelty of products. Vernon (1989) described creativity as an individual's capacity to think up new ideas, views, and inventions on social, aesthetic, scientific, and technological values. Isbell and Raines (2013) defined that creativity is "the ability to think in unique ways, produce unusual ideas, or combine things in different ways (p. 3)".

Švecová et al. (2014) mentioned creativity's significance that creativity is an important feature of individuals in daily life and allows us to be flexible when dealing with real-life situations. Guilford (1973) described the traits of creative individuals as elaboration, fluency, flexibility, originality, curiosity, concentration and persistence, sensitivity, reflection, independence, action, commitment, sense of humor, expression of total personality, breadth of interest, tolerance of ambiguity.

Mathematical Creativity

Mathematical creativity is a skill that is potentially within all students and can be developed with structured activities (Pelczer & Rodriguez, 2011). Shen (2017) put forward that creativity is crucial for mathematics, and creative developments in mathematics create a foundation for other developments and advancements in different disciplines, including science and social sciences.

In the definitions of mathematical creativity, the mathematical problem-solving process is emphasized. For example, Chiu (2009) associated mathematical creativity with the ability to solve extraordinary problems. Laycock (1970) defined mathematical creativity as the skill of analyzing a problem from different aspects, distinguishing similarities, and differences, producing different ideas, and deciding on a method suitable for mathematical statements. Sriraman (2009), on the other hand, explained as a process of producing insightful and unusual results to a problem.

Creative individuals in mathematics are described as skilled individuals. They are persistent and willing to apply various methods of solutions, use information flexibly, solve problems through original approaches, act rationally while analyzing the causes of problems, taking risks, having high motivation, using time well, and having experience (Carlton, 1959; Lin, 2010; Sheffield, 2008). Despite the importance of these features, mathematical creativity is generally neglected in mathematics education (Chesimet et al., 2016). Therefore, the necessity of creating learning environments where students can exhibit and develop their mathematical creativity is emphasized (Havold, 2016; Huang et al., 2017).

Researchers (e.g., Aljughaiman & Mowrer-Reynolds, 2005; Nadjafikhah et al., 2012; Safitri et al., 2018; Sriraman, 2009) put forward that it is vital for mathematics teachers to identify, develop and encourage mathematical creativity ability. Despite expectations, Bolden et al. (2010) stated that the opinions of PSMT on creativity are mostly limited to the use of resources and technology and depend on the idea of "creative teaching" rather than "teaching creativity". Panaoura and Panaoura (2014) associated PSMT who prefer using routine mathematical activities when asked to develop lesson plans on creativity, with their low self-efficacy perception. However, creative self-efficacy is considered very important for the development of creative skills (Choi, 2004; Mathisen, 2011). Self-efficacy perception is defined as the perception regarding a person's capacity to plan and practice the actions to overcome situations (Bandura, 1977). Creative self-efficacy means a person’s belief to achieve creative results (Tierney & Farmer, 2002). Therefore, it can be said that mathematics teachers’ self-efficacy perceptions for mathematical creativity are essential to create environments to support and develop mathematical creativity.

Purpose of the study

The study aims to develop the Problem-Oriented Mathematical Creativity Self-Efficacy Perception Scale to determine the pre-service mathematics teachers’ problem-oriented mathematical creativity self-efficacy perceptions in a valid and reliable way. In order to develop problem-oriented mathematical creativity self-efficacy perceptions of mathematics teachers and to design learning-teaching environments that will develop mathematical creativity in the future, it is vital to assess the current self-efficacy perception levels in a valid and reliable manner. Accordingly, designing a measuring tool to assess the self-efficacy perception of PSMT regarding problem-oriented mathematical creativity in a valid and reliable manner was important for this study.

METHOD

Research Design

Exploratory sequential mixed method was preferred in this study to develop the scale for PSMT. This method is a two-phase model; the researcher explores the issue using qualitative methods in the first phase and continues the study using quantitative methods (Creswell & Plano Clark, 2011). Literature was reviewed to develop the item pool for the qualitative phase of this study. Next, the expert opinions obtained to test the content and face validity were evaluated qualitatively and quantitatively. In addition, the psychometric features of the test were evaluated in the quantitative phase through construct validity and reliability studies.

Research Participants

The validity and reliability studies of this research were conducted with two study groups. The convenience sampling method was used to determine the participants. Convenience sampling allows the researcher to work with the most accessible sample that will economize the most (Cohen & Morrison, 2007).

The first study group constituted of three hundred eleven PSMT studying in a state university in eastern Turkey. 93 (29.9%) of the participants were male, 218 (70.1%) were female. 67 (21.5%) of the PSMT were seniors, 90 (28.9%) were juniors, 98 (31.5%) were sophomores, and 56 (18.1%) were freshmen.

Three hundred sixty-four PSMT studying in four state universities in eastern, southern, and northern Turkey constituted the second study group. 117 (32.1%) of the participants were male, and 247 (67.9%) were female. 59 (16.2%) of the pre-service teachers were seniors, 107 (29.4%) were juniors, 111 (30.5%) were sophomores, and 87 (23.9%) were freshmen.

At the beginning of the research, the participants were informed about the purpose of the research. The scale was filled by pre-service teachers who volunteered to participate in the research. Scientific and ethical principles were complied with during the data collection, analysis, and reporting of the article. It has been confirmed by the İnönü University Social and Human Sciences Scientific Research Ethics Committee that the research process does not pose an ethical problem.

Scale Development Process

Preparing the item pool : First, the studies about mathematical creativity were researched during the literature review. Creativity was assessed using three criteria as fluency, flexibility, and originality in the literature (Chesimet et al., 2016; Huang et al., 2017; Pitta-Pantazi et al., 2013; Silver, 1997; Singh, 1987; Sriraman, Haavold, & Lee, 2013; Torrance, 1974; Wessels, 2014). An item pool consisting of fluency, flexibility, originality components was created accordingly.

Many mathematical creativity problems to determine the students' mathematical creativity can be found in the literature (e.g., Akgul & Kahveci, 2016; Alkan, 2014; Harpen & Sriraman, 2012; Haylock, 1987; He, 2016; Kavgacı, 2016; Kıymaz, 2009; Lin, 2010; Pham, 2014; Pitta-Pantazi et al., 2013; Safitri et al., 2018; Shoimah et al., 2018; Vale et al., 2012). Utilizing the studies in the literature, 35 mathematics creativity problems were presented to experts for their opinions. After all, 27 items that could determine self-efficacy perceptions of PSMT and grouped as follows: 9 items on fluency (e.g., I can measure multiple lengths using three sticks of 2, 3, and 7 cm in length); 9 items on flexibility (e.g., I can get the same result each time by using the same numbers and doing different operations); and 9 items on originality (e.g., I can discover mathematical rules in nature that the others do not notice.)

Testing content and face validity: Experts were consulted to determine the scale's content and face validity consisting of 27 items. The expert opinions obtained for content validity were evaluated using qualitative and quantitative methods (Davis (1992) Method). Hence, statistical proof of the content validity of the draft scale was obtained. An expert panel consisting of 5 experts (three experts on mathematics education and two experts on educational sciences) was formed to determine the content validity. The experts were asked to evaluate each item by marking "Appropriate", "The item should be slightly revised", "The item should be reviewed", and "The item is not appropriate" considering the clarity, comprehensibility, being appropriate for the target audience, and the degree to which the item represents the sub-dimensions of creativity (fluency, flexibility, originality). According to the Davis (1992) technique, the number of experts who marked "Appropriate" and "The item should be slightly reviewed" was divided by the total number of experts, and each item's Content Validity Index (CVI) was calculated. The items with a CVI value above 0.80 were decided to be included in the draft scale.

Preparing online scale form: Online scale form was used for applying the scale since it provides convenience and practicality in data collection and allows reaching a large number of participants in a short time. The online scale form consisted of 2 stages. The first stage was the Personal Information Form (university, grade level, and gender); the second stage consisted of the scale items. The answer options in the scale were arranged using a 5-point Likert-type rating such as 5 = Fully Agree, 4 = Mostly Agree, 3 = Moderately Agree, 2 = Slightly Agree, and 1 = Strongly Disagree.

Testing construct validity and reliability: The scale was applied to the first (N = 311) and second (N = 364) study groups, respectively, to test the scale's construct validity with exploratory and confirmatory factor analysis. In addition, the nomological, discriminant, convergent validity were analyzed using the confirmatory factor analysis results. Independent samples t-test results regarding the difference of 27% lower and 27% upper group mean scores and corrected item-total correlation values for construct validity were reported. Cronbach's Alpha, Composite Reliability (CR), and AVE (Average Variance Extracted) were analyzed for the scale's reliability.

Interpreting the Scores Obtained from the Scale

As a result of the validity and reliability analysis, the scale's features, scoring the data obtained from the scale, and how the scores will be interpreted were explained.

FINDINGS

Content Validity

CVI values for each item (n=27) were calculated in accordance with the expert opinions. The CVI of 25 items was perfect (CVI=1.0), CVI of 2 items was appropriate (CVI=0.80). Accordingly, it can be said that the content validity is provided statistically (Davis, 1992).

Construct Validity

Exploratory Factor Analysis (EFA): The factor structure was deduced by using EFA in the SPSS program to test the scale's construct validity (Hair et al., 2014). Before starting the analysis, the suitability of the data set obtained from 311 PSMT for factor analysis was examined. z-values ranging between ± 3.29 ($p<.001$) showed that there were no outliers (Tabachnick & Fidell, 2013). The skewness values ranging between -1.088 and 0.205 and kurtosis values ranging between -.851 and 0.679 showed that item scores were close to a normal distribution (Hair et al., 2014). The fact that the relationships between items in the correlation matrix were between 0.30 and 0.90 was interpreted as the scale items did not have multicollinearity (Field, 2009) and singularity problems (Tabachnick & Fidell, 2013). The results of Bartlett Sphericity test ($\chi^2 = 5154.999$; $df = 351$; $p = .000 < .05$) and Kaiser-Meyer-Olkin

(KMO) = 0.944 showed sampling adequacy (Hutcheson & Sofroniou, 1999; qtd: Field, 2009). The anti-image correlation coefficients ranging between 0.917 and 0.966 proved each item's sampling adequacy (Field, 2009).

EFA was conducted using principal component analysis after obtaining the evidence on the suitability of the data set for factor analysis. The analysis was started using the Direct Oblimin oblique rotation technique. During the analysis, it was seen that the inter-factor correlation coefficient of the correlation matrix was r= ≥ .32, in many cases, so the analysis was conducted using the Direct Oblimin oblique rotation technique, from start to finish (Tabachnick & Fidell, 2013).

During EFA, item 12 was removed from the analysis since it is not within the flexibility factor that it should theoretically be. Item 5 was removed since it had similar factor loadings (<.10) in two factor, item 10 was removed since its factor load was below 0.50, and item 26, item 4, and item 1 were removed since their communalities were below 0.50. Table 1 presents the analysis results.

Table 1. *Exploratory factor analysis results*

Items	Factors				
	Communalities	Factor 1 (fluency)	Factor 2 (originality)	Factor 3 (flexibility)	Corrected item-total correlations
2	.516	.616			.610
3	.678	.755			.737
6	.592	.644			.675
7	.689	.718			.717
8	.603	.796			.608
9	.588	.560			.672
19	,590		-.682		.680
20	.680		-.765		.754
21	.606		-.694		.709
22	.660		-.761		.741
23	.678		-.795		.742
24	.605		-.647		.708
25	.671		-.769		.724
27	.643		-.855		.676
11	.579			.514	.659
13	.616			.770	.652
14	.646			,868	.643
15	.647			.723	.700
16	.597			.712	.668
17	.513			.553	.623
18	.520			.603	.640

Items	Factors			
	Communalities	Factor 1 (fluency)	Factor 2 (originality)	Factor 3 (flexibility)	Corrected item-total correlations
Eigenvalue		9.507	2.185	1.229	
Explained variance =61.527%		45.271%	10.403%	5.853%	

A structure consisting of three factors and 21 items that explain 61.527% of the total variance as it can be seen from the Table. The first factor consists of items about fluency, the second one about originality, and the third one about flexibility. Factor loadings (>.50), communalities (>.50), corrected item-total correlation (>.30) are favorable values.

Confirmatory Factor Analysis (CFA): Second order CFA analysis was made to test the validity of the 3-factor 21-item structure obtained through EFA. The analysis was conducted out using the LISREL software. Table 2 shows the p-value and goodness of fit values.

Table 2. *Confirmatory factor analysis results*

Goodness of fit value	*p*	χ^2/df	RMSEA	SRMR	GFI	AGFI	NFI	NNFI	CFI	RFI	IFI
Pre-modification	.0000*	3.24	.079	.048	.86	.83	.97	.98	.98	.96	.98
Post-modification	.0000*	3.00	.074	.048	.87	.84	.97	.98	.98	.97	.98

*p<.05

The first analysis revealed the difference between the expected and observed covariance matrix (χ^2 = 602.86, *df* = 186, p= .0000 <.01). Therefore, other goodness of fit values were analyzed to confirm the model (Çokluk et al., 2010). χ^2/df ratio below 3 means a perfect fit, the same ratio below 5 means an acceptable fit; values of RMSEA, RMR and SRMR being below 0.05 indicate a perfect fit, the same values being above 0.08 indicate an acceptable fit; the indexes of GFI, AGFI, NFI, NNFI, CFI, RFI, and IFI being above 0.95 indicates a perfect fit, the same values being above 0.90 indicates an acceptable fit (e.g., Brown, 2006; Çokluk et al., 2010; Jöreskog & Sörbom, 1996; Tabachnick & Fidell, 2013). It can be seen in the Table 2 that (see pre-modification values) χ^2/df (<5) and RMSEA (<.08) values were acceptable, SRMR, NFI, NNFI, CFI, RFI, and IFI (>.95) values indicated perfect fit values. However, GFI=.86 and AGFI=.83 were not within the acceptable value range. At this stage, the suggested modifications were conducted and the error variances of the item 21 and item 25 in the originality factor and the item 2 and item 3 in the fluency factor were correlated. As it is seen from the Table 2, the post-modification values of χ^2/df (<5) and RMSEA (<.08) were acceptable, and the SRMR, NFI, NNFI, CFI, RFI, and IFI (>.95) values showed perfect fit. GFI=.87 and AGFI=.84 values were close to the acceptable value. It can be said that the 3-factor structure was verified at an acceptable level. Table 3 shows the standardized factor loadings after the modifications and the explained variance (R^2) values.

Table 3. *Standardized factor loadings and explained variance (R^2) values*

Item	Standardized factor loadings	R^2
2	0.66	0.44
3	0.76	0.58
6	0.78	0.61
7	0.80	0.64
8	0.66	0.44
9	0.76	0.58
11	0.73	0.53
13	0.79	0.62
14	0.80	0.64
15	0.76	0.58
16	0.73	0.53
17	0.68	0.46
18	0.71	0.50
19	0.76	0.58
20	0.83	0.69
21	0.84	0.71
22	0.82	0.67
23	0.83	0.71
24	0.76	0.58
25	0.83	0.71
27	0.77	0.59

It can be seen from Table 3, the standardized factor loadings, and the explained variance (R^2) values indicated acceptable results.

Nomological, Discriminant, and Convergent Validity

Table 4 presents square root of AVE value, inter-factor correlation coefficients, AVE, Average Shared Variance (ASV), Maximum Shared Variance (MSV), CR coefficients calculated to assess the nomological, discriminant, and convergent validity of the measuring tool.

Table 4. *Square root of AVE, Inter-factor correlation, AVE, ASV, MSV, and CR values*

Factor	Fluency	Flexibility	Originality	AVE	ASV	MSV	CR
Fluency	.74**			.55	.44	.53	.878
Flexibility	.73*	.74**		.55	.48	.53	.896
Originality	.59*	.65*	.81**	.65	.39	.42	.937

* Inter-factor correlation coefficients = r, *p<.05, ** Square root of AVE

The correlation values in Table 4 show that the relationship between the factors was positive and statistically significant (p<.05). Therefore, it can be said that the nomological validity of the scale was established (Hair et al., 2014). It can be seen from Table 4 that the square root of AVE values calculated for each factor was higher than each item's correlation value between other factors. In addition, all factors were found to be AVE>MSV and

AVE>ASV. Hence, it can be said that the discriminant validity of the scale was established (Fornell & Larcker, 1981; Hair et al., 2014). As it can be seen from Table 4, CR values were calculated as >.70, and AVE values were calculated as >.50. In addition, most of the factor loadings were close to 0.70 (>.50) (see Table 3). In this case, it can be said that the convergent validity of the scale was established (Fornel & Larcker, 1981; Hair et al., 2014).

Independent Samples t-test on the Difference of Mean Scores of 27% Lower and 27% Upper Groups

The difference of 27% lower and 27% upper group mean scores for construct validity was reported. Since the normality assumptions of all items for the both lower and upper groups were adequately satisfied (skewness and kurtosis <±1), scores were tested with the independent samples t-test. Table 5 presents the independent samples t-test results.

Table 5. *Independent samples t-test results of the difference between the mean scores of 27% lower and 27% upper groups*

Factor	Item	$\overline{X}$		*t*	*p*
		27% lower group	27% upper group		
Fluency	2	2.97	4.47	-11.77	.000*
	3	3.01	4.50	-12.58	.000*
	6	2.54	4.45	-14.34	.000*
	7	2.80	4.58	-9.76	.000*
	8	3.22	4.55	-15.11	.000*
	9	2.60	4.38	-15.11	.000*
Flexibility	11	2.80	4.54	-15.66	.000*
	13	2.73	4.58	-16.38	.000*
	14	2.59	4.38	-16.05	.000*
	15	2.69	4.39	-14.69	.000*
	16	2.54	4.45	-15.25	.000*
	17	2.82	4.53	-13.33	.000*
	18	2.83	4.58	-14.82	.000*
Originality	19	2.06	3.99	-15.18	.000*
	20	2.19	4.16	-19.37	.000*
	21	2.01	4.13	-19.99	.000*
	22	2.17	4.14	-19.08	.000*
	23	2.14	4.15	-16.84	.000*
	24	2.38	4.33	-18.11	.000*
	25	2.10	4.12	-15.82	.000*
	27	2.09	3.90	-13.67	.000*

*p<.05

When Table 5 is examined, it can be seen that there is a significant difference in favor of the upper groups among the 27% lower and upper groups for all items in the scale consisting of 21 items (p <.05).

Reliability Results

Table 6 presents the Cronbach's Alpha, and CR coefficients.

Table *6. Reliability analysis results*

Factor	Cronbach's Alpha	CR
Fluency	.886	.878
Flexibility	.898	.896
Originality	.936	.937
Total	.951	.968

When the Cronbach's Alpha, and CR reliability coefficients and AVE values (see Table 4) are analyzed, it can be said that that the measuring tool resulted in a good reliability level in subscales (fluency, flexibility, originality) and in general of the scale (Kline, 2011).

DISCUSSION & CONCLUSION

In this study, the scale was developed to determine the self-efficacy perceptions of PSMT related to the solution of problems that require mathematical creativity. The scale was designed to comprise fluency, flexibility, and originality components based on the literature (Chesimet et al., 2016; Huang et al., 2017; Pitta-Pantazi et al., 2013; Silver, 1997; Singh, 1987; Torrance, 1974; Wessels, 2014). It is believed that the scale developed in this study will contribute to the related literature for the researchers who would like to research the mathematical creativity self-efficacy perception of the pre-service teachers.

Scale development steps were followed while developing the scale. The first step of the scale development was to evaluate the mathematical creativity problems in the literature, and the item pool consisting of 27 items was created. The content validity between the expert opinions obtained using the Davis (1992) method and the draft scale was statistically proven. EFA was conducted using the data obtained from the first pilot-study. A 21-item ($N_{fluency}$=6, $N_{flexibility}$=7, $N_{originality}$=8) structure that explains 61.527% of the total variance and consists of fluency, flexibility, and originality factors was obtained as a result of EFA. After EFA, the 21-item and 3-factor structure was tested using CFA on the second study group. As a result of CFA, it was determined that the χ^2/df, and RMSEA values had a good fit, SRMR, NFI, NNFI, CFI, RFI, and IFI values had a perfect fit (Brown, 2006; Çokluk et al., 2010; Jöreskog & Sörbom, 1996). It can be said that GFI and AGFI values were close to acceptable values (.90) (Çokluk et al., 2010). Accordingly, it can be said that the 3-dimensional model was verified through CFA. According to the values calculated from the confirmatory factor analysis results, nomological, discriminant and convergent validity of the scale were proved (Fornell & Larcker, 1981; Hair et al., 2014). Also, significant differences in favor of the upper groups regarding the difference of 27% lower and upper group mean scores and the corrected item-total correlations provided additional evidence for the construct validity of the scale (Büyüköztürk, 2010). According to these results, it can be said that the scale has the construct validity.

Values around .70 are acceptable for the reliability coefficients, values around .90 are considered perfect, and values around .80 are good (Kline, 2011, p.70). CR coefficient calculated with the values obtained from the confirmatory factor analysis to be over .70 and the AVE coefficient to be over .50 shows that the reliability is at a good level (Hair et al., 2014). Accordingly, Cronbach's Alpha, and CR (> .70), AVE (> .50) coefficients calculated within the scope of the reliability studies of the scale showed that the sub-factors' and overall, of the measuring tool's reliability were at a good level.

The study concluded that the Problem-Oriented Mathematical Creativity Self-Efficacy Perception Scale developed to determine the self-efficacy perceptions of PSMT about solving mathematical creativity problems, is a valid, reliable, and useful measuring tool.

Limitations and Implications

This study aims to develop a scale to assess mathematical creativity self-efficacy perception of PSMT in a valid and reliable way. The study groups were determined using the convenience sampling method, and PSMT studying in 4 universities in 3 geographical regions (north, south, east) of Turkey were included in the study. This situation limits the generalization of the results obtained for the scales developed in the research to the population. In this context, the developed scales' psychometric properties can be researched with a sample representing the population. On the other hand, the research was cross-sectional and measured the perceptions about a particular point. Repeated measurement studies can provide a better understanding of the factor structure of the scale and show the effect of any change in PSMT perceptions over time on the psychometric properties of the scale.

This study was conducted only with PSMT. The psychometric properties of the scale can be analyzed to assess the problem-oriented mathematical creativity self-efficacy perception of mathematics teachers, or students. In addition, validity and reliability studies can be conducted so that the scales can be used for determining the problem-oriented mathematical creativity self-efficacy perceptions of different field teachers (science, social sciences etc.).

Declarations on Ethical Standards

Financial support There is not received any financial support to conduct this research and/or publication of the article.

Conflicts of interest There is no conflict of interest regarding the publication of this article.

Ethical Approval At the beginning of the research, the participants were informed about the purpose of the research. The scale was filled by pre-service teachers who volunteered to participate in the research. Scientific and ethical principles were complied with during the data collection, analysis, and reporting of the article. It has been confirmed by Social and Human Sciences Scientific Research Ethics Committee that the research process does not pose an ethical problem.

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