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DEVELOPING A MATHEMATICAL CREATIVITY SELF-EFFICACY PERCEPTION SCALE FOR PRE-SERVICE MATHEMATICS TEACHERS

Abstract: The aim of this research is to develop a Mathematical Creativity Self-Efficacy Perception Scale for Pre-Service Mathematics Teachers. In the research, the exploratory sequential mixed method in which the qualitative and quantitative procedures are used, respectively, is preferred. The 5-point Likert type measurement tool consists of fluency, flexibility, and originality factors. A structure consisting of 27 items and explaining the 64.028% of the total variance was obtained due to the exploratory factor analysis (EFA). The 3-factor structure obtained through EFA was validated using confirmatory factor analysis (CFA). In addition, it was determined that the convergent, discriminant, and nomological validity are provided. The reliability analysis of the measurement tool resulted acceptably. The research concluded that the Mathematical Creativity Self-Efficacy Perception Scale for Pre-Service Mathematics Teachers is valid, reliable, and useful for pre-service mathematics teachers.

Keywords: pre-service teacher, scale development, mathematical creativity, self-efficacy perception.

Introduction

Creativity is a must-have skill for individuals in their daily life (Švecová, Rumanová, & Pavlovičová, 2014). In the 21st century, this skill is in the scope of the interest of industries, scientists, politicians, and educators (Harpen & Sriraman, 2013). Emphasizing the importance of creative skills, especially in educational environments, results in searching effective methods to improve learners' creativity (Huang, Peng, Chen, Tseng & Hsu, 2017). Nadjafikhah and Yaftian (2013) stated in their study that we owe technological developments to mathematicians and scientists' creativity by highlighting the vital role of mathematical creativity that enables us to create new mathematical perceptions and ideas. Similarly, many studies (e.g., Anyor & Omenka, 2015; Havold, 2016; Huang et al, 2017; Pelczer & Rodriguez, 2011) declared that mathematical creativity is an essential skill for all students and emphasized that all learning environments should be developed in a way to help students to strengthen their creativity and learn new mathematical information. The most significant responsibility in strengthening mathematical creativity lies on teachers' shoulders (Aiken, 1973; Nadjafikhah, Yaftian & Bakhshalizadeh, 2012). These responsibilities imposed on teachers made it essential to increase future teachers' knowledge and mathematical creativity skills (Panaoura & Panaoura, 2014). However, Panaoura & Panaoura (2014) showed that pre-service teachers could not plan lessons for developing students' mathematical creativity and they preferred routine and typical mathematical activities because of their low self-efficacy perceptions. Similarly, researchers (e.g., Choi, 2004;

Mathisen, 2011; Tierney & Farmer, 2002) emphasized that self-efficacy perception is a must-have feature in the development of creative skills. When the mathematical creativity studies conducted with the pre-service mathematics teachers' participation were perused, it was determined that these studies researched the awareness of pre-service mathematics teachers about their mathematical creativity (Panaoura & Panaoura, 2014; Shriki, 2010), their conceptions (Bolden, Harries & Newton, 2010), their opinions (Dündar, 2015) and their mathematical creativity levels (Safitri, Wijayanti, & Masriyah, 2018; Wahyudi, Waluya, Rochmad, & Suyitno, 2018). No studies are identifying the self-efficacy perceptions for mathematical creativity, despite the importance of self-efficacy. It is thought that this may be due to the lack of measurement tools that can determine the self-efficacy perceptions for mathematical creativity as valid and reliable. When the literature is perused, it is seen that the only measurement tool is the Problem-Oriented Self-Efficacy Scale for Mathematical Creativity developed by the Aksungur Altun (2020) to measure the self-efficacy perceptions for mathematical creativity of pre-service mathematics teachers. The scale in question transformed the mathematical creativity problems into self-efficacy perception statements, and the research aimed to determine the perceptions of pre-service mathematics teachers on solving creativity problems. It can be said that this measurement tool is problem-oriented (Aksungur Altun, 2020). For this reason, it is thought that developing a measurement tool, which can determine the general self-efficacy perceptions for mathematical creativity of pre-service teachers validly and reliably will contribute to the literature.

Conceptual Framework

Self-Efficacy Perception

The self-efficacy perception, which is an important element of Social Learning Theory developed by Bandura (1997), is explained as the belief of an individual on her/his capacity to plan and implement necessary actions and to cope with future situations (p. 2). It is the self-confidence of an individual, and the belief develops over time through experiences (Lee, 2005). Self-efficacy relates to the perception or judgment about realizing a specific goal (Zulkosky, 2009). It states the judgments about performing an activity, instead of an individual's physical, psychological or personality traits (Zimmerman, 1995). High levels of self-efficacy are stated as high-performance prediction (Bong & Skaalvik, 2003). Students with high self-efficacy levels must work harder and longer to realize a task than students with low levels of self-efficacy (Schunk, 1989).

Tierney and Farmer (2002) put forward the concept of creative self-efficacy. Researchers declared that creative self-efficacy is the belief in an individual's ability to produce creative results. Tan, Li, and Rotgans (2011) explained that creative self-efficacy points out the features of idea generation, concentration, independence, working style, and tolerance of ambiguity.

Creativity

Creativity is explained broadly as the skill to produce different products, inventions, and ideas (Isbell & Raines, 2003; Shaw & Runco, 1994; Vernon, 1989). Sternberg and Lubart (1999) explained creativity as the skill to produce useful works compatible with new and different situations. According to Rogers (1954), creativity refers to the process of revealing the activity and originality of an individual in creating a new product. Üstündağ (2002) stated that creative individuals are curious, ask questions, state their opinions easily, and give authentic and smart answers to problems. In addition to these traits, creative individuals also possess mathematical creativity (Akgül & Kahveci, 2016; Ardiansyah & Asikin, 2020).

Mathematical Creativity

Nadjafikhah et al. (2012) stated that mathematical creativity is hard to explain, and there is not a traditional definition of it. When the literature was perused, various definitions, which address different aspects of mathematical creativity, were found in support of this view. Singh (2006) put forward that mathematical creativity is the ability to produce unique and unusual methods and solutions to problems and argued that the development of science and technology depends on mathematics.

Leikin and Kloss (2011) stated that creativity within the mathematics class at school is generally linked to solving problems or posing problem. Similarly, Kwon, Park, and Park (2006) highlighted the link between problem-solving and mathematical creativity and put forward that mathematical creativity is formed by creating new information and flexible problem-solving.

Tyagi (2016) stated that individuals possessing mathematical creativity also have the highest level of thinking in the cognitive domain. Chamberlin and Moon (2005) put forward that individuals with mathematical creativity are students who show extraordinary abilities to create new and useful solutions to complex and simulated real-life problems through mathematical modeling. In addition, researchers pointed out that creative students can give new and useful answers to mathematical application problems. Sriraman (2009) stated that the common features of individuals with mathematical creativity are social interaction, heuristics, imagination, intuition, and the ability to prove. Leikin and Lev (2013) put forward that individuals with mathematical creativity explore original actions, products and ideas.

Many studies are focusing on mathematical creativity in the literature. Many of these studies (e.g. Ardiansyah & Asikin, 2020; Lin & Cho, 2011; Saragih, 2014; Tyagi, 2016) focus on the students' ability to solve mathematical creativity problems. Students' answers are generally assessed based on the fluency, flexibility, and criteria (Huang et al, 2017; Pitta-Pantazi, Sophocleous, & Christou, 2013). Sriraman, Haavold, and Lee (2013) stated that fluency is the number of solutions; flexibility is the number of different solution categories; and originality means finding relative unique solutions. Wahyudi et al. (2018) explained fluency as the students' ability to give correct answers in a short time; flexibility as the students' ability to create different ideas and approaches to solve problems; and originality as the students' ability to use new, extraordinary or unique solutions. Similarly, Shoimah, Lukito, & Siswono (2018) stated that fluency is used for controlling the variety of ideas in problem-solving, flexibility for controlling the variety of problem-solving methods, and originality for controlling the different and new methods or solutions.

It is thought that evaluating the solutions of mathematical creativity problems in terms of fluency, flexibility, and originality criteria provide a more in-depth, valid, and reliable evaluation opportunity regarding creativity. Therefore, it was important that the scale, which was to determine the self-efficacy perceptions for mathematical creativity of pre-service teachers, be developed to comprise the statements about fluency, flexibility, and originality criteria. The measurement tool is planned to comprise fluency, flexibility, and originality.

The aim of this research is to develop the Mathematical Creativity Self-Efficacy Perception Scale for Pre-Service Mathematics Teachers to determine the pre-service mathematics teachers' self-efficacy perception levels of mathematical creativity. The answers to the following questions were sought in line with this aim:

1. Does the scale developed to determine the self-efficacy perceptions for mathematical creativity of pre-service teachers sufficiently meet the validity criteria?

2. Does the scale developed to determine the self-efficacy perceptions for mathematical creativity of pre-service teachers sufficiently meet the reliability criteria?

Method

Research Model

The exploratory sequential mixed method was used to develop the Mathematical Creativity Self-Efficacy Perception Scale for Pre-Service Mathematics Teachers in this research. First, the scale's development process started with using qualitative methods, and the relevant literature was evaluated to prepare the item pool, and scale items were prepared. Experts were asked about their opinions by using qualitative and quantitative methods to evaluate the draft scale items' face and content validity. Next, construct validity and reliability studies were conducted using quantitative methods.

Study Participants

The validity and reliability studies of the measurement tool developed in this research were conducted using the data of two different study groups during the fall semester of 2020-2021. The Exploratory Factor Analysis (EFA) was conducted with the first study group data. Confirmatory Factor Analysis (CFA) was conducted with the second study group data, and the reliability studies of the measurement tool were conducted. The convenience sampling method was used for determining the study participants, as this method saves time and allows working with easily accessible pre-service teachers (Cohen & Morrison, 2007). The first study group consisted of 266 pre-service teachers studying in a state university in Southern Turkey, 79 (29.7%) males, and 187 (70.3%) females. 56 (21.1%) of the pre-service teachers were freshmen, 82 (30.8%) were sophomores, 67 (25.2%) were juniors, and 61 (22.9%) were seniors. The second study group consisted of 287 pre-service teachers studying in a state university in Eastern Turkey, 89 (31%) males, and 198 (69%) females. 62 (21.6%) of the pre-service teachers were freshmen, 81 (28.2%) were sophomores, 98 (34.1%) juniors, and 46 (16%) were seniors.

Developing Data Collection Tools and Data Analysis

In this study, the development process of the scale started with the item pool preparation. It was determined that the mathematical creativity problems in the literature are evaluated based on fluency, flexibility, and originality criteria (e.g., Huang et al, 2017; Pitta-Pantazi et al., 2013; Singh, 1987; Sriraman et al, 2013). Therefore, it was decided that the measurement tool should consist of items related to these three criteria.

The studies that aim to determine the awareness and opinions of pre-service mathematics teachers about mathematical creativity and the scales that aim to measure creativity and mathematical creativity were appraised during the preparation of the item pool (e.g., Bolden, et al., 2010; Dündar, 2015; Panaoura & Panaoura, 2014; Shriki, 2010; Tortop & Sağlar, 2018). An item pool of 30 items included ten items on fluency, ten items on flexibility, and ten items on originality, was prepared.

Experts were asked about their opinions to determine the face and content validity. The expert pool consisted of two experts on educational sciences and three experts on mathematics education. They evaluated the items in terms of suitability to the target audience, clarity, and whether the items reflect the fluency, flexibility, and originality factors. The experts were asked to evaluate each item as follows: "Item is not appropriate", "Item should be reviewed", "Item should be slightly revised", and "Appropriate". The Content Validity Index (CVI) was calculated by dividing the number of experts who chose the "Item should be slightly revised" or "Appropriate" answers for each item in pursuant to the Davis (1992) method technique. It was decided to include CVI value items above 0.80 in the draft scale (Davis, 1992).

The online scale form was used in a pilot application because of its practicality and convenience for data collection in the process of Covid-19 pandemic. At the beginning of the online scale, a participation consent form was included and the study was conducted with prospective teachers who were voluntary to participate in the study. The participants were asked to fill in the information about their gender and class levels and answer the scale items. The answers of the 5-Likert type scale were as follows: I do not agree (1), I slightly agree (2), I moderately agree (3), I mostly agree (4), I agree completely (5).

A 2-stage pilot application was carried out, and data were collected since EFA and CFA studies were planned to be carried out, respectively, while testing the scale's construct validity. The data sets were analyzed to determine whether the data were pure from outliers, and in terms of the normal distribution, the correlation between variables, and sampling adequacy before factor analysis (Pallant, 2007; Tabachnick & Fidell, 2013). A second-level CFA was conducted to test the construct validity after EFA and to obtain total points from the developed scale. Whether the model was valid as a result of CFA was determined by examining the goodness of fit values. In the literature (Brown, 2006; Çokluk, Şekercioğlu, & Büyüköztürk, 2010; Tabachnick & Fidell, 2013) $\chi2$ /df <3, RMSEA, SRMR<. 05, GFI, CFI, NFI, IFI, RFI>.95 is accepted as perfect goodness of fit, and $\chi2$ /df <5, RMSEA, SRMR<. 08, GFI, CFI, NFI, IFI, RFI>.90 is accepted as acceptable goodness of fit. In addition, the corrected item-total correlation values and the mean score differences of 27% upper and lower groups were analyzed within the scope of construct validity. The convergent, discriminant, and nomological validities of the measurement tool were evaluated using the CFA data. The scale's reliability was determined with Cronbach's Alpha, Guttman split-half reliability coefficients, and composite reliability coefficients. A reliability coefficient of 0.70 and above indicates that the measurement tool is adequately reliable (Hair, Black, Babin, Anderson, & Tatham, 2014; Kline, 2011).

Findings

Content Validity

The CVI values of each item, which were included in the draft scale based on expert opinions of the expert panel consisting of five experts, in the 30-item draft scale, were calculated. While CVI values were calculated as 1.0 for 24 items, reflecting the perfect fit among expert opinions, CVI values for six items were calculated as .80 and reflected adequate fit among expert opinions. Thus, it can be said that the content validity of the 30-item draft scale was statistically proven (Davis, 1992).

Construct Validity

Exploratory Factor Analysis

EFA was conducted to determine the factor structure of the scale within the construct validity studies. First, the appropriateness of the data set obtained for the factor analysis was researched. The z values calculated in the range of ±-3.29 for all the items showed that there were no univariate outliers in the data set (Tabachnick & Fidell, 2013). The items' skewness values ranging from -0.844 and 0.219, and kurtosis values varying between -0.773 ile 0.210 indicated that the distribution of each item's scores was close to a normal distribution (Hair et al. 2014). The relationships between the items in the correlation matrix were greater than 0.30 and lower than 0.90. Accordingly, it can be said that there is no singularity (Tabachnick & Fidell, 2013) and multiple correlation (Field, 2009) problems for the scale items. The KMO statistics (KMO= .955) and Bartlett Sphericity test ($\chi 2$= 6181.579; df=435; p= .000<.05) showed that the data set met the sampling adequacy. In addition, the values between 0.898 and 0.980 in the anti-image correlation matrix proved that each item met the sampling adequacy criteria (Field, 2009).

The principal components analysis was conducted while conducting EFA after obtaining the evidence proving that the data set was appropriate for factor analysis. Since the correlation values between factors were 0.32 and above, the Direct Oblimin technique, one of the oblique rotation techniques, was used (Tabachnick & Fidell, 2013). The variance ratio obtained from the first analysis (66.749%), and Kaiser criterion (eigenvalue 1st factor = 15.050; eigenvalue 2nd factor = 2.139; eigenvalue 3rd factor = 1.611; eigenvalue 4th factor = 1.224) and the scree plot graph indicated that the measurement tool can have a 4-factor structure. It was observed that there were items related to "originality" in the first factor, "flexibility" in the second factor, and "fluency" in the third factor in the matrix of components. It was determined that the fourth factor consisted of one item about fluency (item 6) and of one item about flexibility (item 13). Theoretically, due to the combination of items that should be included in different factors, item 6, which is in the 4th factor, was removed from the analysis, and the analysis was repeated. Next, the item 21 and item 12 were excluded from the analysis, respectively, since they had approximate load values (<.20) in different factors. As a result, a 3-factor structure consisting of 27 items and explaining 64.028% of the variance was obtained. Table 1 presents the EFA results.

Table 1: *EFA results of the scale*

	Communalites	Factors			Corrected item-total correlations
		Factor 1	Factor 2	Factor 3	
Item26	.760	.898			.714
Item24	.717	.864			.699
Item23	.675	.803			.701
Item22	.649	.780			.663
Item29	.735	.761			.761
Item25	.635	.706			.713
Item27	.662	.692			.738
Item30	.631	.687			.709
Item28	.630	.566			.739
Item14	.658		.881		.499
Item13	.593		.817		.516
Item15	.544		.712		.558
Item19	.636		.663		.679
Item17	.706		.643		.748
Item16	.683		.627		.735
Item18	.697		.584		.761
Item20	.607		.518		.715
Item11	.644		.510		.745
Item9	.696			.847	.691
Item4	.633			.801	.658
Item10	.625			.800	.655
Item3	.627			.768	.671

Item7	.598			.727	.669
Item5	.494			.698	.541
Item8	.644			.668	.705
Item2	.617			.624	.720
Item1	.498			.596	.628
Eigenvalue		13.605	2.075	1.607	
Explained variance ratio=64.028		%50.388	%7.687	%5.954	

Table 1 shows the items related to originality in the first factor, flexibility in the second factor, and fluency in the third factor. Factor loadings are between 0.510 and 0.898, common factor variance is between 0.494 and 0.760, and corrected item-total correlation values are between 0.499 and 0.761.

Confirmatory Factor Analysis

A second-level CFA was conducted using the Lisrel program to test the validity of the 3-factor (fluency, flexibility, originality) scale consisting of 27 items within another study group after EFA. Table 2 presents the goodness of fit values calculated as a result of the analysis.

Table 2: *Confirmatory Factor Analysis Results*

Goodness of fit values	*p*	X^2/df	RMSEA	SRMR	GFI	CFI	NFI	IFI	RFI
Pre-modification	.000*	3.01	.084	.047	.80	.98	.97	.98	.97
Post-modification	.000*	2.46	.071	.042	.83	.99	.98	.99	.97

The p-value (<.05) calculated as a result of CFA showed a statistically significant difference between the observed and expected covariance matrices. Therefore, the model's variability situation was decided by the assessment of other goodness of fit values. When the pre-modification goodness of fit values shown in Table 2 is examined, it can be seen that X^2/df value represents acceptable goodness of fit (<5), SRMR (<.05), CFI, NFI, IFI, and RFI (>.95) values represent perfect goodness of fit. However, it was observed that the RMSEA=.084 and GFI=.80 values were not between the acceptable value range (Brown, 2006; Çokluk et al. 2010; Tabachnick & Fidell, 2013). At this stage, to strengthen the 3-factor scale, the modifications suggested by the program were carried out. The error variance of the 23rd - 25th items in the originality factor and the 13th - 14th items in the flexibility factor were correlated. As it can also be seen in Table 2, RMSEA (<.08) value was at acceptable goodness of fit value, X^2/df (<3), SRMR (<.05) , CFI, NFI, IFI, and RFI (>.95) values were at perfect goodness of fit values after the modification. The GFI=.83 goodness of fit value was close to an acceptable value after the modification. Table 3 presents the standardized factor loadings and explained variance (R^2) values.

Table 3: *Standardized Factor Loadings and Explained Variance (R^2)*

Factor	Item No	Standardized Factor Loadings	R^2
Fluency	Item1	.70	.49
	Item2	.78	.61
	Item3	.78	.61
	Item4	.74	.55
	Item5	.64	.41
	Item7	.76	.58
	Item8	.82	.67
	Item9	.81	.66

	Item10	.82	.67
Flexibility	Item11	.82	.67
	Item13	.60	.36
	Item14	.60	.36
	Item15	.86	.74
	Item16	.88	.77
	Item17	.86	.74
	Item18	.86	.74
	Item19	.82	.67
	Item20	.74	.55
Originality	Item22	.77	.59
	Item23	.79	.62
	Item24	.81	.66
	Item25	.78	.61
	Item26	.84	.71
	Item27	.87	.76
	Item28	.83	.69
	Item29	.89	.79
	Item30	.86	.74

As it can be seen in Table 3, the standardized factor loadings and explained variance (R^2) resulted in acceptable.

Independent Samples T-Test Results Regarding the Differences between the Mean Scores of 27% Lower and 27% Upper Groups

Table 4 presents the independent samples t-test results regarding the differences between the mean scores of 27% lower and 27% upper groups.

Table 4: *Independent Samples T-test Results Regarding the Differences Between the Mean Scores of 27% Lower and 27% Upper groups*

Factor	Item No	$\overline{X}$		t	p
		27% lower group	27% upper group		
Fluency	Item1	2.56	3.96	11.368	.000*
	Item2	2.48	4.02	14.441	.000*
	Item3	2.5	4.24	13.455	.000*
	Item4	2.60	4.29	12.900	.000*
	Item5	3.21	4.46	8.915	.000*
	Item7	2.39	4.20	14.317	.000*
	Item8	2.30	4.05	15.221	.000*
	Item9	2.51	4.31	15.315	.000*
	Item10	2.52	4.23	15.852	.000*
Flexibility	Item11	2.65	4.43	16.346	.000*
	Item13	3.16	4.48	9.510	.000*
	Item14	3.20	4.45	8.326	.000*
	Item15	2.66	4.45	16.061	.000*
	Item16	2.60	4.52	16.724	.000*
	Item17	2.67	4.46	16.085	.000*
	Item18	2.67	4.35	15.645	.000*
	Item19	2.57	4.43	15.098	.000*
	Item20	2.56	4.20	13.805	.000*
Originality	Item22	1.91	3.77	14.605	.000*
	Item23	1.99	4.02	15.093	.000*

Item24	2.04	4.07	16.561	.000*
Item25	2.00	4.06	15,549	.000*
Item26	2.04	4.09	16.928	.000*
Item27	2.23	4.30	17.618	.000*
Item28	2.33	4.32	16.211	.000*
Item29	2.06	4.17	18.094	.000*
Item30	2.18	4.17	16.721	.000*

*p<.05

When Table 4 is examined, it can be seen that there is a significant difference in favor of the upper groups in terms of all items (p<.05).

Findings of Convergent, Discriminant, and Nomological Validity

Table 5 presents the correlation coefficients between factors, CR, AVE, square root AVE, MSV, and ASV values to evaluate the convergent, discriminant, and nomological validity of the scale.

Table 5. *Correlation coefficients between the factors, CR, AVE, square root AVE, MSV, and ASV values*

Factor	Fluency	Flexibility	Originality	CR	AVE	MSV	ASV
Fluency	.76**			.93	.58	.59	.58
Flexibility	.766*	.79**		.94	.62	.59	.54
Originality	.753*	.708*	.83**	.95	.68	.57	.53

CR= composite reliability; AVE = average variance extracted; MSV = maximum shared variance; ASV = average shared variance, *p<.05, *r= Inter-factor correlation coefficients ** Square root of AVE

When Table 3 is examined it can be seen that all factor loadings are close to ≥.60 (>.50). It can be seen from Table 5 that AVE values were calculated as >.50, and CR values were calculated as >.70. Accordingly, it can be said that the measurement tool has convergent validity (Fornell & Larcker, 1981, p.46; Hair et al. 2014). It was determined that the square root AVE values were higher than the correlation of each factor with other factors, and AVE>MPV and AVE>ASV in factors. These findings point out that the scale has discriminant validity (Fornell and Larcker, 1981, p.46; Hair et al. 2014, p.605). In addition, the positive and statistically significant relationships (p<.05) between the factors can be interpreted as the measurement tool having nomological validity (Hair et al. 2014).

Reliability Studies

Table 6 presents the reliability coefficients calculated for the general scale and its sub-factors.

Table 6: *Reliability coefficients*

Factor	Cronbach Alpha	Guttman Split-Half	Composite Reliability
Fluency	.927	.891	.93
Flexibility	.939	.919	.94
Originality	.952	.887	.95
Total	.970	.907	.98

As it can be seen from Table 6, the reliability coefficients for the general scale are above 0.90. Therefore, it can be said that the measurement tool is perfectly reliable (Kline, 2011).

Results, Discussion and Recommendations

The aim of this research is to develop a scale for mathematical creativity to determine the pre-service mathematics teachers' self-efficacy perception levels reliably and validly. This study is the first study that aims to develop a scale for mathematical creativity to determine the general self-efficacy perception levels of pre-service teachers, and one of the limited studies that research the self-efficacy perception regarding mathematical creativity. Therefore, the developed scale is believed to contribute to the researchers who would like to study the pre-service mathematics teachers' self-efficacy perception levels of mathematical creativity, and the relevant field literature.

For this study, the exploratory sequential mixed method was preferred. The Mathematical Creativity Self-Efficacy Perception Scale consisted of the fluency, flexibility, and originality factors, suitable to the criteria used for evaluating the mathematical creativity problems (Huang et al, 2017; Pitta-Pantazi et al, 2013; Singh, 1987; Sriraman et al, 2013). The content validity was statistically ensured by evaluating the expert opinions on scale items using Davis (1992) technique. A 3-factor and 5-Likert type structure consisting of 27 items and explaining the 64.028% of the total variance was obtained as a result of EFA conducted within the scope of construct validity studies. The measurement tool consisted of nine items on fluency factor, nine items on flexibility factor, nine items on originality factor. The second-level CFA results showed that the 3-factor structure was also valid for a different study group. In addition, the corrected item-total correlations pointed out that the items measure the same behaviors with the factors that were in. The significant differences determined between the mean scores of 27% lower and upper groups showed that the distinctiveness levels of the items were high. The scale having convergent, discriminant, and nomological validity provided additional proof for the construct validity. The Cronbach's Alpha, Guttman split half, and composite reliability coefficients calculated for the general scale and its sub-factors indicated that the measurement tool was reliable. As a result of the research findings, it can be said that the Mathematical Creativity Self-Efficacy Perception Scale is useful, valid, and reliable for pre-service mathematics teachers.

Limitations and Future Directions

There are several limitations to this study. Since the study participants were determined using the random sampling method, the study results representing the population are weak. Therefore, it is recommended that the psychometric properties of the scale-to-be should be assessed with a sampling group randomly selected from the population. In addition, the psychometric properties of the scale can also be tested on different sampling groups, such as students and teachers. The perceptions of pre-service teachers were measured within only a specific period. The factor structure of the scale can be tested at different times with longitudinal studies. In future studies, the measurement tool developed in this study and the Problem-Oriented Self-Efficacy Perception Scale for Mathematical Creativity developed by the Aksungur Altun (2020) can be used together to determine the correlations between the pre-service mathematics teachers' self-efficacy perceptions on general and problem-oriented mathematical creativity.

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Appendix
Item Pool

Item No	Items
1	I can recognize various mathematical relationships within scientific events in a short time.
2	I can develop many solutions in a certain period of time by evaluating possible situations while trying to solve a mathematical problem.
3	I can find many solutions to mathematical problems in daily life in a short time.
4	I can create various mathematical problems that we can encounter within daily life.
5	I can evaluate different possible situations and make many choices while shopping.
6	I can design many materials using geometrical shapes.
7	I can create multiple problem statements that can be solved using the same arithmetic operations.
8	I can come up with multiple ideas about the reasons for a mathematical event.
9	I can identify many mathematical problems that we can encounter during daily life.
10	I can make many assumptions in a certain period of time about the consequences of a mathematical event.
11	I can solve mathematical problems using different solutions.
12	I can deal with a daily life problem from different mathematical perspectives.
13	I can make different geometric shapes by comparting one geometric shape.
14	I can correlate the items I encounter in daily life with different geometric shapes.
15	I can think more than one solution method to solve a mathematical problem.
16	I can use different strategies to find responses to a mathematical problem.
17	I can view the mathematical events of daily life from different perspectives.
18	I can evaluate different solutions to a mathematical problem.
19	I can quickly switch between different ideas while solving a math problem without getting stuck on a single idea.
20	I can determine the mathematical reasons in daily life from a multi-faceted perspective.
21	I can come up with original solutions for mathematical problems in daily life.
22	I can prove a given theorem by using a different method than other known proofs.
23	I can create new and unique products for mathematics projects.
24	I can use extraordinary solutions to solve mathematical problems.
25	I can design unique mathematical materials.
26	I can come up with non-traditional solutions for mathematical problems.
27	I can recognize the mathematical relationships among the daily-life events that everyone cannot notice.
28	I can perceive the causes of a mathematical problem in daily life differently than everybody else does.
29	I can put forward extraordinary ideas regarding the results of mathematical events in daily life.
30	I can solve a mathematical problem from a different perspective compared to my peers.