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DEVELOPING A MODEL TO EXPLAIN THE MATHEMATICAL CREATIVITY OF GIFTED STUDENTS

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Abstract:
The aim of this study is to investigate the relationships among students' mathematics self-efficacy, their metacognitive skills in mathematics and their mathematics achievement in relation to their mathematical creativity. The study's sample consisted of 445 gifted and talented middle school students who attended grades 5, 6, 7, and 8 at 13 Science and Art Centers in 11 cities. For such a correlational study, Mathematics Self-efficacy Scale, Mathematical Creativity Scale, Young Pupils' Metacognitive Abilities in Mathematics Scale were used. The research findings indicated that mathematical creativity is significantly correlated with mathematical achievement, mathematical metacognition skills and self-efficacy in mathematics, including the three sub-dimensions of self-efficacy, positive self-efficacy, negative self-efficacy and self-efficacy in the use of mathematics in daily tasks. Because the adaptive values of the model are within reasonable boundaries, the model can be regarded as valid. The research model suggests that students' mathematical creativity is significantly predicted by mathematics self-efficacy, mathematical achievement and mathematical metacognition skills.

Keywords: mathematics self-efficacy, mathematical metacognition skill, mathematical creativity, mathematically gifted and talented

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1. Introduction

Global competition and rapidly advancing technology require countries and societies to cultivate highly equipped and educated individuals. We are currently in the innovation age. National policymakers often emphasize the significance of education for the economy of a country and address these issues in national development plans in Turkey. The strategy of the Ninth Development Plan (2007-2013), prepared by the Turkish Grand National Assembly (2006), emphasizes the significance of a qualified education under the subtitles "*increasing competitiveness*", "*increasing employment*", "*increasing the quality and activity of public services*" and "*strengthening human development and social solidarity*". According to many scholars of economics, education constitutes the essential point of economic development (Lucas, 1988; Tuna, 2003).

As Singh (1985) stated, "*Mathematical creativity is one of the greatest assets of the nation*" (p. 32). By rephrasing his words and at the same time considering that his definition of mathematical creativity mainly targeted gifted and talented learners in the Indian context, gifted and talented children can also be seen as the great human resources, not only of countries but also of the world at large. However, Clark (2012) cites the National Council of Teachers of Mathematics (NCTM) emphasized that gifted students were the group whose full potential was the most disregarded. It is difficult to say that we sufficiently give opportunities to gifted students to maximize their potential (Clark, 2012).

Recent research on gifted students and the field of education in mathematics has focused on the factors that affect students' progress in mathematics and the types of educational interventions and factors that may result in mathematical success (Yabas, 2008; Mann, 2009; Pitta-Pantazi, Christou, Kontoyianni, & Kattou, 2011). Recent studies have asserted that the complex and dynamic interaction of many cognitive, affective and motivational variables are related to mathematical success. These variables include self-efficacy, attitude and perception, socio-economic level, the family and peer interactions of students and factors related to schools (Baykul, 1999; Hammouri, 2004; Maker, 1982). Recent research on gifted students has started to examine the factors that affect mathematical creativity and mathematical success, as well as their mutual interaction.

New approaches in the teaching of mathematics claim that gifted students' education may actively gain high level thinking skills (Yabas, 2008). In such a learning environment, that involves high expectations of all students, students should believe that they can achieve mathematics, suggest new ideas and be aware of their own learning processes (Yabas, 2008). Taking into consideration of possible relationships, mathematical success, self-efficacy, metacognitive skills and creativity may have been important notions in the teaching of mathematics (Carr, Alexander, & Folds-Bennett, 1994; Pajares & Miller, 1999).

Much of the research related to the area of creativity has arisen from the desire to determine which children can benefit from skill-improving programs and to identify adults who can make a difference in the fields of science, business and industry due to their innovative natures (Kerr & Gagliardi, 2003). In this context, general creativity, along with mathematical creativity, is a key factor in identifying and educating gifted students. As mentioned above, examining the explanatory and predictive relationships among the notions that have become significant in the teaching of mathematics, such as mathematical self-efficacy, metacognitive skills and mathematical success, will provide significant knowledge for national education policymakers, experts in the field, administrators, teachers, families and students (i.e., all of the related actors) in preparing programs for gifted students and determining the aim, content, process and evaluation of their education (Pajares, 1996; Leikin & Pitta-Pantazi, 2013).

Mathematical self-efficacy, which may be possibly related to mathematical creativity, has been examined in the literature. Self-efficacy is defined as one's own judgment of his or her capacity to organize and perform the necessary activities to understand something (Bandura, 1997). Mathematical self-efficacy has been defined by Hackett and Betz (1989) as an individual's assessment of his or her confidence in achieving a task or overcoming a problem regarding mathematics. Maier and Curtin (2005) have suggested that there are positive relationships of mathematical self-efficacy with mathematical success, mathematical grades, mathematical interest, the desire to take courses in mathematics and the choice to study mathematics and science in college and a negative relationship between perception of mathematical self-efficacy and mathematical anxiety. Furthermore, researchers such as Benbow (1988), Halpern et al. (2007) and Lubinski and Benbow (1992) have asserted that increasing the self-efficacy perception of girls and ethnic minorities will have the positive effect of directing them toward the fields of science and mathematics for their future careers.

In addition, metacognitive skills are also important for success in mathematics (Cornoldi, 1997). Metacognitive skills can be defined as individuals' tracking, monitoring and control of their own thoughts (Hacker, 1998; Moores, Chang, & Smith, 2006; Yi & Davis, 2003). Metacognitive skills come into play at different levels of the process of mathematical problem solving (Downing, 2009; Nelson, 2012). The role of metacognitive skills is also important in utilizing learned knowledge intentionally (Cornoldi, 1997). Research has asserted that students' self-efficacy perceptions, creativity and metacognitive skills directly affect the process of learning mathematics (Pajares, 1996; Mann, 2005; Mann, 2009; Nelson, 2012).

It is emphasized that mathematical success, along with mathematical self-efficacy perception and metacognitive skills, enables better performance in situations that require mathematical creativity and provides different alternatives and divergent thinking styles for problem solving (Mann, 2009; Pitta-Pantazi, Christou, Kontoyianni, & Kattou, 2011).

Usiskin (2000) divided mathematical skills into 8 levels (0-7). Usiskin (2000) described these eight level as, Level 0 "no talent", Level 1 "basic talent", Level 2 as "honors students", development 3 as "terrific student", development 4 as " the exceptional student", development 5 as the "productive mathematician", level 6 the "exceptional mathematician", and level 7 "all-time mathematician" greats. Mathematical creativity corresponds to the sixth and seventh levels of this hierarchical ranking. It is possible to reach the following conclusion from Usiskin's study, which specified that students who are gifted in mathematics correspond to the fifth level while mathematically creative students are in 6th and 7th levels. Sriraman (2005) extends Usiskin's (2000) ideas: An individual with mathematical creativity also has mathematical giftedness, but not vice versa (Sriraman, 2005). That is, a student can have giftedness in mathematics, but might not have mathematical creativity. In other words, Usiskin (2000) proposes that while all creative individuals are gifted individual, on the other hand it does not necessarily means the same for gifted individuals. Some mathematicians have stated that succeeding in mathematics and creating inventions require creative skills rather than academic success (Hadamard, 1945; Halmos, 1968; Muir, 1988), which is one of the reasons that mathematical creativity is included in this study.

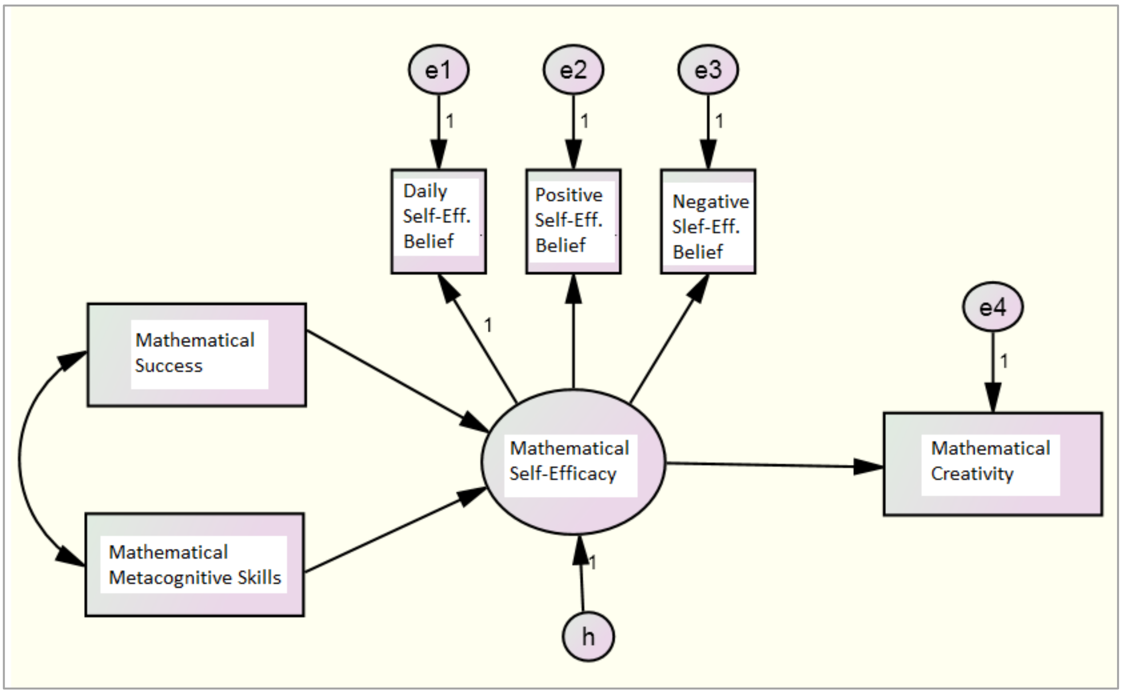
Consequently, the main goal of this study is to determine how mathematical success, mathematical self-efficacy perception and metacognitive skills in mathematics among gifted students are related to their mathematical creativity.

With regard to one of the significant counterparts of mathematical creativity, learners' self-efficacy, we should revisit the phrase "*definition in self-efficacy*". Sternberg, Kaufman, and Grigorenko (2008) proposed that the best predictor of success for students is not their skill but, the skill that they believe they possess. Even though their statement is not based on an empirical data Sternberg, Kaufman, and Grigorenko (2008) stated that self-efficacy should be improved to improve creativity. Their statement on self-efficacy clearly emphasized that the need to increase students' belief in self-efficacy to improve creativity could also be applied to creativity in any area. In this respect, we can hypothesize that mathematical self-efficacy is a variable that directly affects mathematical creativity. Considering the aforementioned self-efficacy relationships between mathematical self-efficacy and the mathematics education, the self-efficacy of learners can be considered a variable that may affect mathematical creativity.

Mathematical success is also a subject of research because it is an important variable for mathematical creativity, although there are varying opinions regarding its relationship with mathematical creativity. Usiskin (2000) placed outstanding mathematical success one level below mathematical creativity in his study, which means mathematical success is prerequisite of mathematical creativity. It is possible to reach the following conclusion: Mathematical creativity is not possible without mathematical success. However, the study mentioned above and other studies have concluded that mathematical success does not directly predict mathematical creativity (Livne & Milgram, 2006). When the relationship between mathematical success and mathematical self-efficacy is examined, there is a strong correlation. Direct experience is defined as the most effective of the four basic sources of the self-efficacy beliefs (namely performance accomplishment, vicarious experience, verbal persuasion and physiological states) of Bandura (1997), who stated that success constructs people's beliefs in their self-efficacy, whereas failures weaken their self-efficacy. In light of these explanations, it could be concluded that mathematical success may be a predictor of mathematical self-efficacy. The fact that studies have concluded that mathematical success does not directly predict mathematical creativity suggests that mathematical success may influence mathematical creativity due to its influence on a different variable. Mathematical self-efficacy was considered an intervening variable in the model designed by the researcher is related to the prediction potency of this variable, as mentioned above. In other words, while mathematical self-efficacy is predicted by mathematical success, mathematical self-efficacy also predicts mathematical creativity.

Usher (2009) has discovered that sources of self-efficacy are important for students' mathematical self-efficacy, but other sources affect mathematical self-efficacy as well. These sources include trial-and-error methods, teaching strategies and learning by self-evaluation. However, it could be that the relationships of mathematical metacognitive skills with mathematical self-efficacy and mathematical creativity may be similar to mathematical success. Therefore, in the model, mathematical metacognitive skills were considered an independent variable that predicts mathematical self-efficacy, similar to mathematical success.

The literature regarding students' belief in mathematical self-efficacy, mathematical success and mathematical metacognitive skills made it possible for us to create and test the following model (Figure 1). The proposed model is an attempt to present evidence regarding the relationship between these factors and mathematical creativity of students. The model also offers significant explanations for mathematical creativity performance by focusing on students' mathematical metacognitive skills, mathematical self-efficacy and mathematical success.



Within this framework, this study proposes a model of a "*relationship of the mathematical creativity of gifted students with their mathematical self-efficacy, metacognitive skills and mathematical success*". In the Figure, arrows explain the directions of relationships in the model.

2. Method

This study aims to reveal the relationships among the mathematical self-efficacy, mathematical metacognitive skills and mathematical creativity of gifted middle school students and to test whether there are predictive and explanatory relationships among these variables. The relationship of the variables tested in the study creates a mechanism that is proposed as a model explaining mathematical creativity. Therefore, this study employs relational screening model to determine the extent of relationships among two or more variables (Airasian, Gay, & Mills, 2000).

2.1 Research Sample

The population of the research consisted of 10.807 gifted middle school students, 5656 of whom were male (52%) and 5151 of whom were female (48%), who were in one of 57 Science and Art Centers that offer education to gifted students in Turkey (Ministry of National Education, 2012). This figure was obtained from the 2011-2012 statistics of the Ministry of National Education. In a cluster sampling method, the population is divided into groups called clusters, and each cluster is defined as one sampling unit. Randomly selected clusters are combined, and the sample is formed (Comlekci, 2001).

This research aimed to use cluster sampling. Seventeen, Science and Art Centers were randomly clustered from each district in Turkey to conduct the study. Researchers received approval from Ministry of National Education to conduct the study at 17 Science and Art Centers mentioned above. However, four of the seventeen centers' managers did not allow the researchers to conduct the study in their schools. Therefore, it can be said that the sampling in this research was convenience sampling.

Convenience sampling involves taking sample components that the researcher can easily obtain. This type of sampling is used when designing or obtaining a sampling is too difficult or when it is impossible to determine all of the components of the population. Convenience sampling may be preferred because it is practical and economical (Monette, Sullivan, & De Jong, 1990). Drawing upon the sampling was held in the study, generalizing of study results can be stated as a one of the limitations of the study.

The sample of the research consisted of 445 middle school students, 251 of whom were male (56%) and 194 of whom were female (44%), from the fifth, sixth, seventh and eighth grades who were students in one of 13 randomly selected Science and Art Centers for the spring term of the 2013 academic year (Table 1).

Table 1: Research Sample Table

City	Number of Students
Malatya	52
Adana	35
Gaziantep	36
Elazıg	29
Bursa (BTSO)	38
Kocaeli	30
Antalya	25
Ankara	26
Ankara, (Yasemin, Karakaya)	34
Kayseri	53
Izmir	23
Bursa (MKP)	33
Yalova	31
Total	445

2.2 Research Instrument and Procedure

A. Mathematical Self-Efficacy Scale

The Mathematical Self-Efficacy Scale (Appendix 1), which was developed by Akgül (2014), was used to measure the mathematical self-efficacy of the students. The scale was designed as a 4-point Likert scale with, lowest and highest possible scores of 25 and 100, respectively. The scale, which was developed after studying the literature, was submitted to five experts to solicit their opinions. These experts have conducted studies on mathematics education, special education and guidance and counseling. During the pre-test phase, the 53-item scale was administered to 50 middle school students. Necessary changes -such readability and clarity to understand questions asked- were made based on feedback from students, and the scale was modified. During the next phase, the scale was administered to 260 middle school students, and analyses were performed to determine the distribution of the scale scores.

The item analysis indicated that each item was reliable. The results of the analyses indicated that the Kaiser-Meyer-Olkin (KMO) value of the scale was .95, and the Bartlett test was also significant (Chi-square=2730.34, df=300, p=.00, p<.001). After Exploratory Factor Analysis, 25 items were removed, and 25 remained in the test's final form. Three factors, called positive self-efficacy beliefs, negative self-efficacy beliefs and self-efficacy regarding daily use of mathematics, which explain 51.7% of the construct, were found. Negative self-efficacy beliefs scores were converted due to low scores obtained from this dimension, indicating high self-efficacy beliefs. Moreover, the Cronbach's Alpha reliability of the scale was found to be .92. The Cronbach's Alpha values for each sub-dimension were: positive self-efficacy beliefs, .90; negative self-efficacy beliefs, .88; and self-efficacy regarding daily use of mathematics, .75. Confirmatory Factor Analysis was performed. The results supported the model proposed by the researcher (X^2/sd= 1.88, FI = 0.96, GFI = 0.93, RMSEA = 0.06, MR = 0.05, CFI = 0.91 and NFI = 0.92) (Akgül, 2016). The scale's Cronbach's Alpha reliability of the scale was found to be .83 for the data in this study

B. Mathematical Success

Students' grade exams were accepted as mathematical success. School administration has provided the students access to learn their exams mean in percentile. These kind of school exam points, may provide authenticity of the scaling scores and also pragmatic and efficient for researches that including long time taking instruments like this study. In this study, mathematical success was measured by exams which developed by school teachers. Even though this approach has some advantages mentioned above, this approach has also limitation because of possibility of missing mathematically creative students who do not perform well on these standardized achievement tests. On the other hand, as Sternberg (1996), Pehkonen (1997), and Hong & Aqui (2004) acknowledged on distinction between mathematical success in school and out of school or later in life. This study aims to highlight a model explain mathematical success, mathematical creativity and giftedness is limited its research context and detachments of the notions that has been acknowledged above that is the limitation of the research at the same time. Use of Students' grades or exam scores is another limitation of the study.

C. Mathematical Creativity Scale

The Mathematical Creativity Scale (Appendix 2), which was developed by Akgül and Kahveci (2016), was used to measure the mathematical creativity of the students. The pilot study's sample consisted of 50 middle school students who attended the 5th, 6th, 7th, and 8th grades. The field study's sample consisted of 297 middle school students at 4 middle schools in Istanbul. The collected data were analyzed by means of a package program. The item analysis included the calculation of item discrimination, item total and item remainder values, showing that each item was consistent with the entire scale, and the distinctive powers of the items were at an acceptable level. For the test of internal consistency, the Cronbach's Alpha coefficient value was .80. Because it has a naturally subjective scoring process, the scale was rated by two scorers, and the same scorer re-rated it several times (Scoring reliability of two scorers for each items determined by Pearson product-moment correlation coefficients for each item were respectively: 1st: .81 2nd: .87, 3rd: .87, 4th :.91, 5th: .88, Scoring reliability of same scorer from different times determined by Pearson product-moment correlation coefficients for each item were respectively: 1st : .91 2nd : .91, 3rd: .88, 4th:.92, 5th : .96). The correlations indicated that the scale had inter-rater reliability and intra-rater reliability. The test-retest coefficient values (r = .70) showed that the scale measurements were consistent.

Questions were assessed by the scorers who have been qualified as mathematics teaching degree of MA, and working of gifted students in Math classes in formal school settings both having Master of Education and Ed. D. degrees of Gifted and Talented education specialization on Mathematics Education.

Content (experts' opinions were obtained), construct (all of the items loaded at .60 to .71 on a single factor, corresponding to 42% of total variance), and face validity studies were performed as part of the validation of the scale. For face validity, forty mathematical education researchers and mathematics teachers were asked the following question: "*Which of the items on the test are able to measure the mathematical creativity of a middle school student?*" Further, 80 students were asked, "*Which of the questions on the test do you find interesting?*" The study results revealed that this scale was an appropriate instrument to evaluate middle-school students' mathematical creativity (Akgül & Kahveci, 2016). Mathematics Creativity scale's Cronbach Alpha was found to be .77 for the data in this study.

Students had additional dot paper and sketch paper as desired. Scoring is based on these principles: Fluency was determined by giving one point for all true responses. For example, if student gives 5 correct answers to an item the fluency of this item is 5. Flexibility is scored according to categories of answers of an item. let's say the student answered 5 to the first question (fluency is 5 points), flexibility score is 1 if all of these 5 ideas are under one category. If 2 of them are in one category and 3 of them are in another category, flexibility is 2 points. Originality was scored according to frequency of each category. The number of thougths/answers in the category is not important. Originality sample score determined by formulating an exponential function based on giving the highest score to the rarest exceptional ideas. The originality score will be same for a category whether it has one or more answers (Akgül, Kahveci; 2016).

D. Metacognitive Skills Scale

To collect data regarding the mathematical metacognitive skills of students, the "*Mathematical Metacognitive Skills Scale for Students*" was used, which was developed by Panoura and Philippou (1990) and adapted to Turkish by Ozcan (2010). The scale was designed as a 5-point Likert scale with the lowest and highest possible scores of 14 and 70, respectively. Regarding the Turkish form of the Cognitive Strategy Use Scale, the Cronbach's Alpha value was 0.88. This value suggested that the scale was reliable. Although the scale originally had a two-factor structure, confirmatory factor analysis, performed at the end of the adaptation study, showed that the scale was more convenient for a single-factor structure. Scale's Cronbach Alpha was found to be .81 for the data in this study.

2.3 Implementation

The research was performed by the researcher in 13 Science and Art Centers, which are public schools, in 11 cities. Science and Art Centers are educational centers that were opened for the purpose of enabling gifted and talented students from primary school to high school to be aware of their talents and to develop and apply their potential. Science and Art Centers were not founded as alternative schools to the students' formal schools. Gifted and talented students who are identified by their high performance on IQ tests and achievement tests, according to the Special Education and Guidance Center's standard procedures for identifying gifted and talented students, attend Science and Art Centers regularly after or before their usual school schedules (Kahveci & Akgül, 2014). In this study, which aimed to create a model explains the relationships among mathematical self-efficacy; metacognitive skills and mathematical success regarding mathematical creativity for gifted students, an information form, Self-Efficacy Scale, Meta-Cognitive Skills Scale and Mathematics Creativity Scale booklets were distributed simultaneously to 5-10 children in an environment where the researcher was present. After necessary instructions were provided to the students, they were given 75 minutes to complete the booklet. Students were free to give break while session is in progress. While session in progress no fatigue is observed by applicants of the scales. Subsequently, the booklets were collected by the researcher.

2.4 Analysis and Interpretation of Data

SPSS 19.0 (SPSS Inc., 2010) and AMOS (SPSS Inc., 2010) package programs for Windows were used for all of the statistical processes throughout all of the research. An error level of .05 was used as a base in all of the statistical analyses. The methods utilized for the analysis of the data in the research were as follows.

In the research problem, the mathematical creativity of gifted middle school students was the dependent variable, and mathematical self-efficacy and mathematical metacognitive skills were independent variables.

The model test of the research was stated as follows: *"Is mathematical self-efficacy appropriate for the model that explains the relationship between metacognitive skills and mathematical success for the mathematical creativity of gifted students?"* Path analysis was used in the research to reveal the explanatory and predictive relationships between the independent variables, which were mathematical self-efficacy, mathematical metacognitive skills and mathematic success, and the dependent variable, which is mathematical creativity. Analysis of Moment Structures (AMOS) software, version 13.0, which is used for path analysis, was used for testing the default model. Path analysis tests the complex relationships between variables. The aim of AMOS software is to summarize the relationships between the variables to reflect the connections observed in the data as accurately as possible (Arbuckle, 2006; Cesur, 2008; Hoyle, 1995; Kline, 1998).

3. Results

First, the relationships among students' mathematical creativity, mathematical self-efficacy, mathematical metacognitive skills and mathematical success were determined. The results of the Pearson's correlation coefficient analysis that was performed to answer this question are presented in Table 2.

Table 2: Correlation Coefficients of Mathematical Creativity, Mathematical Self-Efficacy, Mathematical Metacognitive Skills and Mathematical Success Points (n = 445)

	Math success	Math meta-cognitive	Daily life self-eff.	Positive self-eff.	Negative self-eff.	Math creativity
Math success	1.000					
Math meta-cognitive	.263**	1.000				
Daily life self-eff.	.276**	.509**	1.000			
Positive self-eff.	.359**	.605**	.655**	1.000		

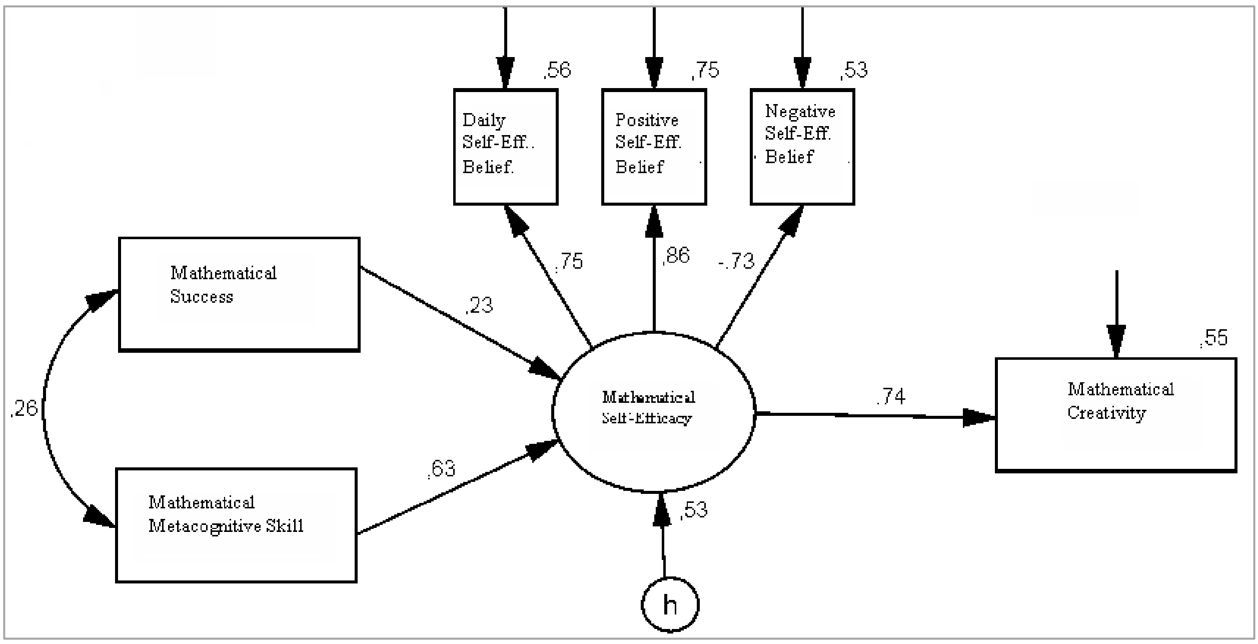
Negative self-eff.	-.354**	-.505**	-.511**	-.620**	1.000	
Math creativity	.219**	.508**	.569**	.626**	-.573**	1.000

** All correlations are meaningful at a reliability level of 0.01 (2-tailed).

The correlation values between variables ranged between .22 (between mathematical creativity and mathematical success), which is a moderate value, and .66 (between positive self-efficacy and self-efficacy regarding daily use of mathematics), which is the highest value. The correlation between the independent variables and the dependent variable "mathematical creativity" ranged from .22 to 0.63.

As stated above, the study aims to develop a model that explains the relationship among the mathematical self-efficacy, metacognitive skills and mathematical success of gifted students for mathematical creativity. Path Analysis was used to develop such model.

Focus of the research is to test the model developed by the researcher to explain the patterns of explanatory and predictor relationships among the variables, which are mathematical creativity, mathematical metacognitive skills, mathematical self-efficacy and mathematical success. It is predicted in the model that the independent variables (mathematical metacognitive skills and mathematical success) that are used to explain mathematical creativity do not directly predict mathematical creativity, but affect mathematical creativity through their influences on mathematical self-efficacy. As is understood, a model was constructed in which mathematical self-efficacy was an intervening variable. The default model of the research is presented in Figure 2.



Testing of the model began with Chi-square analysis. The Chi-square value of the model it was χ^2=20.148, and the degree of freedom (df) was 8. According to these findings, Chi square/degree of freedom value (χ^2/df) was 2.51. Because this value is less than 3, the Chi-Square test shows that the model is compatible (Büyüköztürk, 2015). After it was proven that the chi-square test was compatible, the second phase of the research followed, in which the fit index was investigated.

At this point, the cohesion between the recommended model and the data was evaluated. In other words, the cohesion between the covariance matrix obtained from the observed variables and matrix of the default model was investigated. Fit indices were assessed, which determine the significance of estimated parameters and how compatible the model is with the observed data. Fit indices were investigated based on an ongoing order. First, the goodness of fit index (GFI) and then the adapted good fit index (AGFI) were investigated. The GFI and AGFI values were 0.99 and 0.96, respectively. Both values were greater than 0.95, which indicated that there was a very good fit (Büyüköztürk, 2015).

Subsequently, the normed fit index (NFI) and comparative fit index (CFI) were investigated. The NFI value of the model was 0.98, and the CFI was 0.99. Because both values were greater than 0.95, it was concluded that the model was a good fit (Büyüköztürk, 2015).

After the investigation of this value, the relative fit index (RFI) was investigated. The RFI value of the model was 0.97, which is very close to 1, which showed that there was a good fit.

In addition to these values, the root mean square error of approximation (RMSEA) of the model was determined. This value was calculated as 0.05. The value was less than 0.08, which showed that there was a good fit and supported the model. When the indices of the recommended model were examined, there were no values that could increase the compatibility of the model.

The variance (R^2) rate of the model was 0.55. In other words, the model explained 55% of the variance in mathematical creativity. It also indicated that mathematical success, mathematical metacognitive skills and mathematical self-efficacy directly and indirectly affect mathematical creativity. All of the aforementioned fit indices showed values that fit well with the model which constitutes statistical evidence for considering the model compatible.

3.1 Limitations of the Study

It should be acknowledged that the detachment between mathematics success in school and success in later life or out of school as suggested Sternberg (1996), Pehkonen (1997) and Hong & Aqui (2004). Another limitation should be acknowledged as mathematical success refers students' exams scores measured by teachers in school.

4. Discussion and Conclusion

First, the relationships among students' mathematical creativity, mathematical self-efficacy, mathematical metacognitive skills and mathematical success were discussed in this chapter. A relationship was identified among students' mathematical success, mathematical self-efficacy, mathematical metacognitive skills and mathematical creativity.

When literature was examined, earlier studies explain relationships between mathematical self-efficacy and mathematical success which provides foundation of the theoretical infrastructure to the model (Coleman, 1995; Dai, 2004; Junge & Dretzke, 1995; Karnes & Wherry, 1981; Kelly & Colangelo, 1984; Malpass, O'Neil,& Hocevar, 1999; Pajares, 1996; Williams, 1998). Some research has also found a positive correlation between mathematical creativity and mathematical success (Balka, 1974; Banghart & Spraker, 1963; Jensen, 1973; Mann, 2005). The positive relationship between mathematical metacognitive skills and mathematical success/problem solving skills supports the findings of previous research (Jacobse & Harskamp, 2009; Laskey & Hetzel, 2010; Nelson, 2012; Ozsoy & Ataman, 2009). Although the number of studies that have directly investigated the relationship between mathematical self-efficacy and mathematical metacognitive skills has been limited, some research has confirmed the linear, positive relationship between metacognitive skills and self-efficacy (Downing, 2009; Pintrich, 1999; Pintrich & De Groot, 1990; Pintrich &Garcia, 1991; Wolters & Pintrich, 1998).

As a result of the analysis, it was concluded that the model developed by the researcher to explain mathematical creativity was compatible. To explain the mathematical creativity of gifted students, explanatory and predictor relationship patterns among mathematical creativity and mathematical self-efficacy, mathematical metacognitive skills and mathematical success were determined in the research model, after reviewing the literature. In the model in which mathematical creativity was the dependent variable, mathematical success and mathematical metacognitive skills were determined to be independent variables. Mathematical self-efficacy was designed as an intervening variable.

The model specified and the data collected, substantiate the relationship between self-efficacy and creativity in mathematics. We did not find research that suggested that mathematical self-efficacy directly predicted mathematical creativity. However, Sternberg et al.'s (2008) statement that self-efficacy must be increased to increase general creativity suggested that self-efficacy is a variable that predicts creativity. It could also be said that the relationship between creativity and self-efficacy would be between mathematical creativity and mathematical self-efficacy in a manner specific to the context.

To understand the relationship of mathematical success with mathematical creativity, two different research findings and different theoretical studies in the literature were reviewed. We found that there was no consensus regarding this issue in the literature. Although mathematical success was a predictor of creativity in one of the two models developed for mathematical creativity, it was not a predictor in the other (Livne & Milgram, 2006). Mathematical success as one of the prerequisites of mathematical creativity can be seen in Usiskin's (2000) research, in which he classifies mathematical skill in a hierarchical manner. Considering the relationship of mathematical success with mathematical self-efficacy in this research, mathematical success would not directly predict mathematical creativity, but it would affect mathematical creativity through its influence on mathematical self-efficacy. The idea that mathematical self-efficacy could be predicted by mathematical success is grounded in Bandura's (1997) explanation that the most important and effective source of self-efficacy is direct experiences in social learning theory. Although there is no explanation suggesting that mathematical self-efficacy could be directly predicted by mathematical success in Bandura's research under discussion, Bandura (1997) stated that achievements could strongly build self-efficacy beliefs, whereas failures could weaken self-efficacy. The research was performed with gifted students, which offers evidence to support this deduction. Research conducted with gifted students has shown that there is a positive relationship between mathematical self-efficacy and mathematical success (Coleman, 1995; Dai, 2004; Junge & Dretzke, 1995; Karnes & Wherry, 1981; Kelly & Colangelo, 1984; Malpass et al., 1999; Pejares, 1996; Williams, 1998).

Usher (2009) reviewed sources of self-efficacy in his qualitative research on the self-efficacy perceptions of 8 gifted students in the 6^{th}-8^{th} grades. He concluded that variables that are closely related to metacognitive skills, such as trial-and-error methods, teaching strategies and self-evaluation, are important sources of mathematical self-efficacy. Based on this research, it is believed that mathematical metacognitive skills can predict mathematical self-efficacy. In the research model, mathematical metacognitive skills were regarded as a variable that predicts mathematical self-efficacy and affects mathematical creativity through its influence on mathematical self-efficacy, similar to mathematical success. The research model was found to be compatible, offering new evidence for the existence of such a relationship.

This research aimed to reveal the explanatory and predictive relationships among gifted students' mathematical creativity, mathematical self-efficacy, mathematical success and mathematical metacognitive skills. The results of the model offered significant evidence regarding the effectiveness of the variables of mathematical self-efficacy, mathematical success and mathematical metacognitive skills in terms of mathematical creativity. Therefore, the research findings also revealed the need to consider the aforementioned variables in model research that will be conducted on mathematical creativity. Consequently, the research results demonstrated that it is important to improve the mathematical self-efficacy, mathematical success and mathematical metacognitive skills of gifted students to improve their mathematical creativity.

The recommendations that are provided in light of the findings of this research were gathered into two groups with regard to school implementations and new research that will be undertaken. After obtaining the research findings and reviewing the literature, the following recommendations are presented.

1. Instructional design could include activities that aim to improve the mathematical self-efficacy and mathematical metacognitive skills of students. Including such activities -that model manifests- this inclusion may arise creativity in mathematics.
2. In-service education training could be provided to teachers to improve the mathematical self-efficacy, mathematical metacognitive skills and mathematical creativity of students.

Limited numbers of studies aim to understand the nature of gifted students' mathematical creativity and its relationship with different variables. Thus, it is necessary to conduct research in more settings to determine how these features could be utilized in the education of gifted students.

1. In class settings where activities are performed to improve mathematical self-efficacy and mathematical metacognitive skills, way these variables improve and how their influence over on mathematical creativity changes could be investigated.
2. This research was conducted with middle school (5^{th}, 6^{th}, 7^{th} and 8^{th} grades) students. Future research could be conducted in different grades to explain similar or different patterns.
3. Within the scope of this research, mathematical self-efficacy, mathematical metacognitive skills and mathematical creativity variables were addressed. Future research could address other variables that could be related to mathematical creativity, such as general intelligence, general creativity, socio-economic status, continuity in class, mathematical worries, mathematical attitudes, mathematical perceptions, self-perceptions, learning styles,

lateralization, creativity levels perceived by the students and evaluations of students by teachers, and their influence on mathematical creativity.

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