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Reading comprehension, Mathematics self-efficacy perception, and Mathematics attitude as correlates of students' non-routine Mathematics problem-solving skills in Turkey

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ABSTRACT

Literature that investigates the factors affecting problem-solving evaluates the cognitive and affective components, such as reading comprehension, metacognition, Mathematics anxiety, Mathematics attitude and Mathematics self-efficacy. Recently, studies have shown that Mathematics attitude and Mathematics self-efficacy as affective factors, and reading comprehension as a cognitive factor could play a crucial role in the problem-solving of middle school students. This study investigated the influence of reading comprehension skill, Mathematics self-efficacy perception and Mathematics attitude on non-routine Mathematics problem-solving skills. It is hypothesized that non-routine problem-solving skills are related to reading comprehension skills, Mathematics self-efficacy perception and Mathematics attitudes. To achieve this aim, a reading comprehension skill test, a Mathematics self-efficacy perception scale, a Mathematics attitude scale and a non-routine problem-solving skill test were applied. The instruments were completed by 362 middle school students. A correlation analysis was used to determine the relationship of variables on non-routine problem-solving skills, and the predictive effects of the predictor variables on non-routine Mathematics problem-solving skills were examined by hierarchical regression analysis. The analysis also showed that for middle-school students' non-routine Mathematics problem-solving skills, all related factors–reading comprehension, Mathematics self-efficacy perception and Mathematics attitude were significant. Reading comprehension skills and Mathematics self-efficacy perception significantly predicted problem-solving skills, and both predictors explained a total of 22% of the total variance.

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KEYWORDS
Non-routine Mathematics problem solving; reading comprehension; Mathematics self-efficacy perception; Mathematics attitude; middle school

1. Introduction

One of the main purposes of the middle-school Mathematics curriculum is to train individuals in problem-solving skills (Department for Education, 2014; Turkish Republic Ministry of National Education, [MoNE], 2013; The National Council of Teachers of Mathematics

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[NCTM], 2000). In this sense, determining the factors effective in promoting and developing problem-solving skills is important for the students. Many research studies have argued that problem-solving skills are connected to reading or reading comprehension (Dabarera, Renandya, & Zhang, 2014; Guven & Cabakcor, 2013; Pape, 2004), Mathematics interests and Mathematics attitudes (Pimta, Tayruakham, & Nuangchalerm, 2009; Spada, Nikcevic, Moneta, & Wells, 2008), epistemological beliefs (Erdamar & Alpan, 2013; İflazoğlu-Saban & Güzel-Yüce, 2012) and intelligence level (Stankov, 2000; Veenman, Wilhelm, & Beishuizen, 2004). In this regard, it is important to determine what factors have an relationship on problem-solving skills or what variables are influential on problem-solving skills.

1.1. Theoretical framework

The dictionary of the Turkish Linguistic Society (Turkish Linguistic Society, 2015) defines a problem as the 'question or any matter to be solved by means of theorems or rules'. Lester (1980) defines the concept as a case that cannot be solved by standard methods of solution, requiring certain thinking skills. On the other hand, Posamentier and Krulik (1988) define a problem as reaching a solution by using a thinking process when an individual runs across a state for which he or she has no way out. Problem solving is a process with which an issue is overcome by using acquired information, skills and attitudes when an individual encounters a state with which he or she is not acquainted (Krulik & Rudnick, 1988). LeBlanc (1977) identifies problem solving as a process during which individuals search for solutions for the problems they come across. Problem solving is a process contributing to the development of conceptional and operational information together in the understanding of Mathematical concepts and relations (Gökkurt & Soylu, 2013). It also develops the understanding and communicating of skills by giving students an opportunity to apply profound investigation (Hiebert & Wearne, 2003). Altun (2015) divided problems into two categories, routine and non-routine. Routine problems, also known as story problems, are the types of problems that require calculations, such as profit-loss and road-time, which are common in daily life. Non-routine problems are problems that require use of Mathematical skills as 'analyzing given information, formulating a plan or strategy, determining a solution, justifying the solution' (Wathall, 2016), establishing relationships, looking for patterns and reasoning processes. These problems form the basis for the individual to establish and prove skills by enhancing their use of reasoning skills. Individuals who are able to solve non-routine problems can look at problems that are not routinely visible to all the theorems they encounter and try to produce solutions (Altun, 2008). In this context, it can be said that producing non-routine problem-solving skills is a higher-level skill. For this reason, we used non-routine problems in this study.

Various variables affect the problem-solving skills of students. They can be ranked as reading comprehension skills (Kilpatrick, 1969), interests and beliefs (Ishida, 2002), anxiety, attitude and self-efficacy (Guven & Cabakcor, 2013). When evaluated with a holistic view, the variables affecting problem-solving skills can be considered in two categories: cognitive and affective.

The cognitive variable that is considered by this study is reading comprehension. Reading comprehension is a general structure that includes finding the appropriate title, determining the main idea and auxiliary ideas of the text, finding the cause–effect relations in the

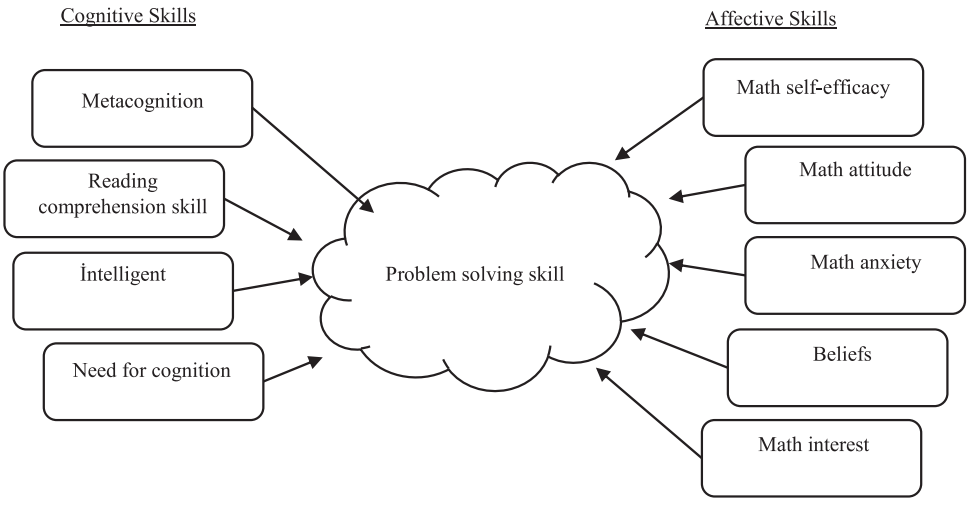

Figure 1. Cognitive and emotional variables affecting problem-solving skills.

text, and predicting the meanings of the unknown words in the text (Belet & Yaşar, 2007). It is important in the stage of understanding problems in the problem-solving process and in understanding complex problems (Lau, 2006). When individuals run across a problem, first of all, they try to understand it. It is not possible to solve the problem without understanding it (Özdemir & Sertsöz, 2006). Even the research studies conducted regarding this show that reading comprehension is important for solving problems (Vilenius Tuohimaa, Aunola, & Nurmi, 2008). In addition, Karakelle (2012) stated that metacognition, need for cognition and intelligence are also variables that affect problem-solving skills.

Affective variables influence problem-solving skills indirectly, albeit not directly. Individuals who feel themselves unable to solve problems will spend less time to solve problems and, thus, solving problems will be difficult for them. One of the significant variables that has an relationship and is discussed in this study is the Mathematical self-efficacy perception (Hoffman & Schraw, 2009). According to Bandura (1997), self-efficacy is feeling sufficient in realizing ability or skill. Mathematical self-efficacy perception is expressed as self-confidence or belief with which an individual can fulfil the duties relating to Mathematics, such as Mathematics problems and Mathematical duties that are faced in daily life (Betz & Hackett, 1983; Clutts, 2010). Another variable affecting problem solving that is mentioned in this study is Mathematics attitude. Attitude can be identified as an emotional learning regarding the subjects of school Mathematics (Haladyna, Shaughnessy, & Shaughnessy, 1983). It is well known that the attitudes of individuals regarding Mathematics can affect their Mathematical successes (Pimta et al., 2009). When belief, which is another variable, is taken into consideration, individuals may avoid solving problems that seem difficult (Temel, 2012). Cognitive and emotional variables affecting problem-solving skills are presented in Figure 1.

1.2. Review of the literature

Many studies have been conducted regarding problem solving at both the national and international level. The main focuses of the research may be collected in two categories.

The first is the research in respect to the problem-solving process (Kim, Park, Moore, & Varma, 2013; Metallidou, 2009). The second one consists of the research investigating the relationship between problem solving and certain variables (Hoffman & Spatauri, 2008; İflazoğlu-Saban & Güzel-Yüce, 2012; Saraç, Önder, & Karakelle, 2014; Uzun, 2010; Veenman et al., 2004; Walker, 2012).

There are many studies trying to discover the relationship between solving problems and certain variables. In the research conducted on problem solving and reading comprehension, it was determined that reading comprehension is critical for problem solving (Çavuşoğlu, 2010; Martin, 1963; Özçelik, 2011; Pape, 2004; Walker, 2012). On the other hand, in the studies conducted on Mathematics self-efficacy perception and problem-solving skills, it was discovered that self-efficacy is a variable predicting solving problems, and there are higher or medium levels of relationship between them (Hoffman & Schraw, 2009; Kwon, 2006; Nicolaidou & Philippou, 2003; Pajares, 1996; Pajares & Miller, 1997; Yenice, 2012). There are also research studies in this field declaring that there is a negatively oriented relationship between Mathematics self-efficacy perception and problem solving (Temel, 2012). In the research examining the relationship between problem solving and Mathematics attitude, it was declared that there is a positively oriented interaction between students' problem-solving skills and their Mathematics attitudes (Higgins, 1997; Nicolaidou & Philippou, 2003; Pimta et al., 2009). For example, Çelik (2012) investigated the variables predicting problem-solving skills. In this research, metacognitive skills, self-efficacy and self-assessment were taken as predicting variables. In the research, which used a correlational model from the quantitative research design, 101 7th-grade students were employed. Correlation analysis and regression analysis were used to analyse the research data. In the end, it was found that metacognitive awareness, self-efficacy and self-assessment predict problem solving at the rate of 66%, and the variable with the highest explanation level was metacognitive awareness. In the study conducted by Ulu (2016) on elementary school 4th-grade students, the relation between students' fluent reading, literal comprehension, inferential comprehension and problem-solving success was researched. At the end of the study, they emphasized that problem-solving success could be predicted by fluent reading, literal comprehension, and inferential comprehension skills. Boonen, de Koning, Jolles, and van der Schoot (2016) reported that students with higher reading-comprehension skills were better at solving word problems. When the results of research are considered, investigation of the relationship of variables is clearly very important for future studies regarding developing problem-solving skills; by investigating numerous variables, which one is effective and which one is non-effective can be determined. On the one hand, given the research conducted by İflazoğlu-Saban and Güzel-Yüce (2012), which is intended to compare problem solving, metacognitive skills and epistemological beliefs, it can be understood that variables apart from those must be investigated in terms of their relationship with problem solving, and they will contribute to the literature. On the other hand, determining the variables predicting problem-solving skill, which ones are related to problem solving, and to what extent they predict problem-solving skills can shed light on future works in respect to problem-solving skills. Defining the variables predicting problem solving is necessary to set them to work in positive ways when regulating the learning environment.

Taking all these facts into consideration, the belief that students will not be able to overcome the difficulties of Mathematics – in other words, the low level of Mathematics

self-efficacy – suggests that these difficulties will distract them from Mathematics courses and affect their attitudes towards Mathematics lessons. When these affective skills are weak, cognitive skills such as reading comprehension are also weak and can adversely affect the problem-solving skills of the student. In this context, it is important to examine the Mathematics self-efficacy, Mathematics attitude and reading comprehension skills as correlates of students' problem-solving skills. Discovering the results of this research is important in determining the variables affecting problem-solving skills in the literature and examining problem-solving skills. In addition, the STEM (Science, Technology, Engineering and Mathematics) report prepared by MoNE (2016a) emphasized interdisciplinary relationships. The report signals that interdisciplinary relationships will be adopted in the curriculum in future programmes. The MoNE (2016a) emphasized the importance of the studies that give priority to relationships between the disciplines, and it stated that researchers should do interdisciplinary studies. The findings of this study are expected to guide the need to design Mathematics lesson curricula related both to Turkish lessons, which are effective in that improve students' reading-comprehension skills, and art lessons, which are associated with students' attitudes improving their self-efficacy (Kaplan, Öztürk, & Ferahoğlu, 2015). Although most previous studies indicate that reading comprehension skills, Mathematics self-efficacy perception and Mathematics attitudes may predict non-routine problem solving. To our knowledge, no study has compared the relationships of non-routine Mathematics problem solving skills, reading comprehension skills, Mathematics self-efficacy perception and Mathematics attitudes well-being in a Turkish sample. TIMSS test results reported that Turkish students were at lower level according to Mathematics score; in other words, they were inadequate in solving problems (MoNE, 2016b). Therefore, examining the effect of reading comprehension, Mathematics self-efficacy and Mathematics attitude on the development of Turkish students' problem solving skills can be a guide for the development of this skill in general, and the development of Mathematics knowledge in particular.

This study tried to respond to the questions regarding middle-school students' reading comprehension, Mathematics self-efficacy perception, and Mathematics attitudes, as well as to what extent they predict non-routine Mathematics problem-solving skills. In this context, this study tried to answer the following questions:

(1) Is there any relationship between reading-comprehension skills, Mathematics self-efficacy perception, Mathematics attitudes and non-routine Mathematics problem-solving skills of Turkish middle-school students?
(2) What are the variables predicting the non-routine Mathematics problem-solving skills of Turkish middle-school students?

2. Method

2.1. Research design

The present study was conducted with the correlational research method. This method is one of quantitative research design. The correlational research method determines the co-existence or degree of relation between two or more variables. The described relationships are later comprehensively analysed, and an opportunity to predict between predictor and

criterion variables is examined. It does not establish a cause–effect relationship (Fraenkel, Wallen, & Hyun, 2012; McMillan & Schumacher, 2014; Tekbıyık, 2014). The current study aimed to determine the variables related with non-routine problem solving skills and to examine the predictive level of these variables in non-routine problem solving skills. When relationship between variables are examined, it is recommended to use correlational research design. In the study, correlational research was used to predict the role of middle school students' reading comprehension, Mathematics self-efficacy perception and Mathematics attitude in non-routine Mathematics problem-solving skills.

2.2. Participants

The participants were 362 middle school students. Seventy-four of the students (20.5%) were grade 5 (aged 11 years), 79 of them (21.8%) were grade 6 (aged 12 years), 93 of them (25.7%) were grade 7 (aged 13 years) and 116 of them (32.0%) were grade 8 (aged 14 years). Students were selected by the convenience sampling method. Convenience sampling can provide a high participation rate with less cost (Fraenkel et al., 2012; McMillan & Schumacher, 2014). In this study, the participants participated voluntarily, and they were informed regarding the study and ensured that their personal information would not be shared with anybody. The ethnic groupings were Turkish. One hundred and twenty-one of the students (33.4%) were from low-income families, 212 of the students (58.6%) were from families with average income, and 29 of the students were from families with high income (8.0%). One hundred and sixty-three of students (45%) were female, and 199 of students (55%) were male.

2.3. Measures

To examine the relationship of certain variables on problem-solving skills, we relied on the measures of a problem-solving skill test, reading-comprehension skill test, Mathematics self-efficacy perception scale and Mathematics attitude scale. The reliability estimate for each instrument was calculated using a sample group of 72 students. Field (2009) identified a Cronbach's coefficient of .70 or higher as indicating adequate internal consistency reliability. All instruments used in the study met this minimum requirement.

2.3.1. Non-routine Mathematics problem-solving skill test and rubric

The literature shows that Turkish scales exist that can be used to measure students' problem-solving skills (Sadık, 2006; Turhan & Güven, 2014). These scales were developed for routine Mathematics problems. We purposely searched for a non-routine problem-solving skills test for the present study. However, no assessment developed for this purpose has been found in the relevant literature in Turkish. Problem solving is defined as a process standard affecting the whole curriculum rather than being a subject area in Mathematics curriculum (MoNE, 2013; NCTM, 2000). Therefore, the problems prepared according to grade levels in different curricula may vary. In other words, there may be intercultural differences in problem solving. As a matter of fact, TIMSS results revealed differences between problem solving levels among countries (MoNE, 2016b). Thus, we did not use the translate non-routine problem solving test prepared for another culture. We developed a non-routine problem-solving skills test for this study.

To prepare a non-routine problem-solving skills test, we created a measurement tool consisting of 10 items. Because problem solving is a process skill, open-ended items are preferred to evaluate the cognitive skills that emerge in the process. When writing the items, we have made use of the literature (Altun, 2008; Schoen, 2006; Yıldızlar, 2012). Two of the items of measurement are in the form of insight, two are finding unknowns, two are quantitative comparisons, two are systematic reasoning, and two are pattern-generalization problems.

The first two items are the questions for finding unknowns. In this kind of item, for example, we show the relationship between the age of the teacher and the student and add the age of the two. We want the student to find the teacher's age. Questions 3 and 4 are problems in the insight style. Insight problems are where the individual may come up with an idea after working on a question (Goldstein, 2013). In this type of problem, for example, it is required to perform an addition operation that is composed of letters (including meaningful words) and assign the numbers in this process to a correct result (by assigning the same number to the same letter and assigning different numbers to different letters). Questions 5 and 6 are questions that require quantitative comparison. In this kind of item, for example, students are given information about the location of a ticket line and the positions of two people in the ticket line. In this problem, one person in the ticket line was in a place as counted from the beginning and one person was in a place as counted from the end. Students are asked to determine how many people, at minimum, are in the ticket line. Questions 7 and 8 are questions that require systematic reasoning. For example, certain measurements were given regarding a cup, and different measurements are required to be obtained with the help of these cups. The last two questions are problems in the form of pattern generalization. In these problems, students should use linear patterns and shape patterns together. For example, in a question asked to students, a few steps of the pattern are given, and then, students are asked to determine any interleaved shape.

We prepared a table of specifications to examine the suitability of the prepared questions for the desired gains. We show items in one section of the table and the gains in the second section. The table consists of two sections: problems and suitability of solution strategy. The table of specifications was presented to 11 experts, seven with PhD degrees in Mathematics education and four with master's degrees in Mathematics education, for their expert opinion. They evaluated the appropriateness and relevance of each problem on the test. Based upon comments from these experts, four problems whose content validity ratio was less than .59 were removed from the test. The content validity ratio of the remaining six problems is .72. Lawshe (1975) have reported that a content validity ratio more than .591 demonstrates that the instrument has significant content validity.

Each problem was prepared written on a separate card and given to four students, a student from each grade level, for language review. The reading level of problems was adapted according to readers. Gronlund (1977)'s index of item difficulty and item discrimination are important to open-ended questions because the index of item difficulty provides information about the difficulty of a question. The values of the index of difficulty are higher than .20 and lower than .80 (Bayrakçeken, 2007). The index of the item discriminant is one that distinguishes between correct and incorrect answers (Gronlund, 1977). For the values of the index of discriminant, more than.30 are acceptable (Bayrakçeken, 2007). The mean of the index of item difficulty of the six-problem test was .22, and this value indicates that problems were difficult. The reason for this situation was that problems were obscured by

Table 1. Non-routine problem solving skills test.

No.	Problems including convenient solving strategies for middle-school students.
1	19 more than 3 times my teacher's age is 100. How old is my teacher?
2	ELİF + SÜT = İÇTİ — In the addition given to the side, ELİF is a four digit, SÜT is a three digit, and İÇTİ is a four-digit number. Every different letter represents a different number. You can find a number of different additions that can give a correct result. Can you find and write down one of them?
3	In a ticket line, Başaran is in the 7th place from the beginning, Soner is in the 5th place from the end. As there are 2 people between Başaran and Soner, how many people are there, at minimum, in this ticket line?
4	Aunt Ayşe made 4 lt. of pekmez. She has a cup of 4 lt., a cup of 3 lt. and a cup of 1 lt. She wants to share pekmez between her two sons equally, 2 lt. for each. As she doesn't have the chance to quantify, how can you help her separate pekmez equally by using only the three cups she has?
5	A teacher is giving walnuts to his students. If he gives 2 walnuts per student, 10 walnuts will be left. If he gives 3 walnuts per student, there will not be any walnuts for 5 students. How many students are there in the class?
6	 There is a regular pattern given to the side. In this pattern, which geometrical shape is there in the 21st line?

their difficulty and non-routine nature. The mean of the index of item discriminant was .32, and this value shows that the discriminating power of the problems was at a sufficient level. We show the non-routine problem-solving skills test in Table 1.

We prepared a rubric to evaluate students' non-routine problem-solving skills because its results are not only important for assessing problem-solving skills but also the problem-solving process itself. The rubric is a key that uses points to evaluate a process. Although individual judgment can become confused with the evaluation of open-ended problems, this issue is surmountable using a rubric (Akkuş & Duatepe-Paksu, 2006). Thus, we prepared the rubric. In this context, we created seven categories (point 0–6), taking inspiration in preparing these categories from Akkuş and Duatepe-Paksu (2006). This categorization was organized as follows: if a student left the answer blank or just wrote any answer, he/she was given 0 points. If a student wrote only a request or if the information given in the question was processed by random values, he/she was given 1 point. If a student used only some of the expected reasoning but could not continue, used numbers randomly or made wrong calculations, he/she was given 2 points. If a student used the expected reasoning and reached the correct result but made the wrong operations, drew some expected relationships but could not arrive at a result, or the problem was brought up to a certain level with random values, he/she was given 3 points. If a student used the expected reasoning but did not reach the result, or reached the expected correct result but did not understand the root of the question correctly, he/she was given 4 points. If a student brought the solution to its final stage but did not make the final step, or progressed with correct reasoning to the conclusion but did not draw it, he/she was given 5 points. If a student solved the problem correctly (complete), demonstrated the necessary reasoning, performed correctly, and showed correctness with the necessary explanations, he/she was given 6 points.

2.3.2. Reading-comprehension skill test

Examining the literature detected a number of reading-comprehension skill tests in Turkish form for middle-school students. Criteria for selecting the test consisted of a lower number of items, inclusion of different texts, and appropriateness for students' level of understanding. Therefore, we used the reading comprehension skill test developed by Acat

(1996). The questions in the test are given in the form of short texts and questions regarding the text, for example, 'As far as Atatürk's personal honor, Turkish cheerleaders were too fond of it. It was not arrogant: I remind you that you spoke on friendly terms with your masters and servants. However, he was proud'. Students were given the text and asked questions such as 'What is really discussed in the above paragraph? What is Ataturk's fondness? What is the meaning of 'extreme devotion' in the paragraph?' The multiple-choice test consists of 20 items. The maximum score is 20, and the minimum score is 0. First, we prepared a test that included 30 items, and then 10items that decreased the reliability coefficient were removed from the test, reducing the test to 20 items. Reliability analysis yielded KR-20 coefficients of .83. The counting mean of the item difficulty was .57, and the mean of the item discriminant was .81. The reliability coefficient was calculated as .86.

2.3.3. Mathematics self-efficacy perception scale

The Mathematics self-efficacy perception scale in Turkish form, which was developed by Umay (2001), was used in order to determine university students' levels of Mathematics self-efficacy perception. This scale has been used with middle-school students some studies (Doruk, Kaplan, & Öztürk, 2014; Guven & Cabakcor, 2013; Şengül, 2011). Some examples from the items in the test are 'I am self-sufficient in solving problems in Mathematics', 'I know how to behave when I encounter a new situation in Mathematics', 'Any problem in life can bring a solution with Mathematical approach'. This scale uses a five-point Likert scale with responses such as 'never', 'rarely', 'sometimes', 'usually', and 'always', and consists of 14 items, of which 8 are positive and 6 are negative. The possible scores of this scale ranged from 14 to 70. The scale consists of three dimensions: sense of self perception related to Mathematics, difference in behaviour related to Mathematics subjects and ability to apply Mathematics to life skills. The calculated mean of the item validity of scale was .64, and the reliability coefficient was .88. The scale was given to seventy-two students for reliability analysis for this study. The reliability coefficient was calculated to be.72.

2.3.4. Mathematics attitude scale

A Mathematics attitude scale in Turkish form was developed by Aladağ (2005). This scale was used to measure middle-school students' Mathematics attitude. Some examples from the items in the test are 'I enjoy being in a Mathematics class', 'It is easy for me to understand Mathematics', and 'I like to study Mathematics in my free time'. This five-point Likert scale included 24 items on a scale ranging from '1-completely disagree' to '5-completely agree'. In the first phase, the dimensions of scale were examined via exploratory factor analysis, and we found a single factor structure. Items with a factor load value of less than .30 were removed from the scale, which reduced the scale to 18 items: 9 positive and 9 negative. The second phase included expert opinion to determine content validity. The reliability coefficient of the scale was found to be.82. The scale was given to seventy-two students for reliability analysis for this study. The reliability coefficient was calculated to be .84. The range of total scores of the Mathematics attitude scale is between 18 and 90 in this study.

2.4. Data analysis and procedure

Descriptive and inferential statistics were utilized in the data analysis of the study. Descriptive statistics were used to summarize data. These statistics must be explicated as the

result of quantitative research (McMillan & Schumacher, 2014). Inferential statistics were conducted to examine the relationship between their non-routine Mathematics problem-solving skills, reading-comprehension skills, Mathematics self-efficacy perception and Mathematics attitude.

The data were analysed with SPSS 18 (PASW Statistics) statistical software. We tested whether a distribution was normal before data analysis. We detected that all variables were distributed normally. Thus, we used a Pearson's correlation coefficient for correlation analysis for data with normal distribution. The predictive roles of the predictor variables in non-routine Mathematics problem-solving skills were examined by hierarchical regression analysis because we first detected relational variables and their relationship levels in the study and then included this sequence in the analysis.

At the beginning of this study, approval was procured from the Turkish Republic Ministry of National Education to conduct research. First, a non-routine Mathematics problem-solving skill test and Mathematics self-efficacy perception scale were given during a scheduled class time, and second, a reading comprehension test and the Mathematics attitude scale were given during a scheduled class time; both were completed in the regular classroom.

3. Results

The results comprise two sections. The first section indicates the relationship between other variables and Mathematical problem-solving performance. The second section shows the predictive role of prediction variables in non-routine Mathematics problem-solving skills.

3.1. The relationship between predictor variables and non-routine math problem-solving skills

The results of correlation coefficients and descriptive statistics are presented in Table 2.

Examining Table 2, there was a positive and significant relationship between each variable and non-routine Mathematics problem-solving skills. Reading-comprehension skill correlated positively and moderately significantly with non-routine Mathematics problem-solving skills of middle-school students ($p < .001$). It is also indicated that there is a high significant and positive relationship between Mathematics self-efficacy perception and students' non-routine Mathematics problem-solving skills ($p < .001$). In addition, Mathematics attitude was significantly correlated with students' non-routine Mathematics problem-solving skills ($p < .05$). Additionally, the results of the current study show

Table 2. Correlations between variables.

	Bivariate Correlation				Descriptive statistics			
Variables	1	2	3	4	M	SD	Skewness	Kurtosis
Non-routine problem solving	1	.45**	.24**	.18**	19.03	9.32	−.016	−.548
Reading comprehension	–	1	.22**	.15*	16.80	2.87	−.925	.107
Math self-efficacy perception	–	–	1	.65**	52.56	12.11	−.437	−.291
Math attitude	–	–	–	1	63.71	13.52	−.414	−.184

*$p < .05$, **$p < .001$.

Table 3. Results of hierarchical regression analysis.

		Step 2		Step 3	
Variables	Step 1B	B	95%CI	B	95%CI
Constant	−5.24*	−9.48**	[−15.23, −3.74]	−10.08**	[−16.19, −3.96]
Reading comprehension	1.45**	1.34**	[1.03, 1.64]	1.34**	[1.03, 1.64]
Math self-efficacy perception		.12**	[0.04, 0.19]	0.10*	[0.00, 0.19]
Math attitude				.02	[−0.06, 0.11]
R^2	.20	.22		.22	
F	88.69**	50.27**		33.56**	
ΔR^2		.21		.21	
ΔF		9.70**		.32	

*$p < .05$, **$p < .001$.

that there were significant and positive correlations between Mathematics attitude and Mathematics self-efficacy perception.

3.2. The factors influencing non-routine math problem-solving skills

The hierarchical regression analysis results regarding the prediction of non-routine Mathematics problem-solving skills are presented in Table 3.

As seen in Table 3, the hierarchical regression analysis was conducted in three steps. First, only reading comprehension was included. In this step, reading-comprehension skill explained 20% of the total variance, a significant amount ($p < .001$). Secondly, reading comprehension and Mathematics self-efficacy perception were included. These two variables explained 21% of the total variance. This step was found to be significant ($p < .001$). Lastly, reading comprehension, Mathematics self-efficacy perception and Mathematics attitude were included. These variables explained 21% of the total variance, but the step was not significant ($p > .05$).

4. Conclusion and discussion

The basic aim of this study was to detect the factors affecting middle school students' non-routine Mathematics problem-solving skills. The possibility of reading comprehension and Mathematics self-efficacy perception to predict non-routine Mathematics problem-solving skills was also examined. According to the results, there was a positive and significant relationship between the middle-school students' reading-comprehension skill, Mathematics self-efficacy perception, Mathematics attitude and their Mathematics problem-solving skills. Polya (1985) notes that understanding the problem is the first and most important step of the problem-solving process. When considering that there is a near-high relationship between understanding problem-solving and a reading comprehension skill (Yılmaz, 2008), it is natural that reading comprehension skill and non-routine Mathematics problem-solving skills are also related. Numerous studies have shown that students' reading-comprehension skills are positively and significantly related to their problem-solving skills (Boonen et al., 2016; Çavuşoğlu, 2010; Kılıç, 2009; Kilpatrick, 1969; Pape, 2004; Ulu, 2016; Uzun, 2010; Walker, 2012). In the context of reading comprehension, it can be said that non-routine Mathematical problem solving is more related to reading comprehension when compared to routine Mathematical problem solving. This is because of the fact that non-routine problems are considered more complex and difficult to

understand than routine problems, and they include more solutions (Mogari & Chirove, 2017). Previous studies and this current study have shown that reading comprehension is an important criterion for students' problem solving skills. However, results of international exams (Progress in International Reading Literacy Study [PIRLS], Programme for International Student Assessment [PISA]) show that Turkish students' level of reading skills are low (MoNE, 2015; Mullis, Martin, Gonzalez, & Kennedy, 2003). As a result of these tests, MoNE attached more importance to reading comprehension skills. Along with this importance, questions with reading comprehension skills will be used in the national examinations from 2019. When these changes were taken into consideration, the findings of this study – the presence of a significant effect of reading comprehension skill on non-routine problem solving skill of Turkish students – emphasized the importance of the change made on reading comprehension.

Another factor positively and significantly affecting middle-school students' problem-solving skill was their Mathematics self-efficacy perception. This finding is consistent with the findings of earlier studies on the relationship between Mathematics self-efficacy perception and Mathematics problem-solving skills (Çelik, 2012; Nicolaidou & Philippou, 2003; Pajares, 1996; Pajares & Miller, 1997; Pimta et al., 2009; Yenice, 2012). Studies in the literature observed that as students' Mathematics self-efficacy perception increased, their problem-solving achievement also increased significantly (Hoffman & Spatauri, 2008; Kwon, 2006). Hoffman and Schraw (2009) point out that self-efficacy is directly related to intelligence, and the relationship between the self-efficacy and problem-solving achievement serves as a mediator variable connecting intelligence. In contrast, Temel (2012) found that there was a negative relationship between Mathematics self-efficacy perception and Mathematics problem-solving skills. It may be expected that middle-school students' Mathematics self-efficacy perception is affected significantly and in a positive sense by their problem-solving skills. Because a high level of self-efficacy creates interest and trust in students' facility towards Mathematics, the use of self-regulatory strategies and problem-solving allows better achievement than others who do not use these tactics (Nicolaidou & Philippou, 2003).

The results also revealed a significant and positive relationship between middle-school students' Mathematics attitudes and their non-routine Mathematics problem-solving skills. Higgins (1997) reported that when students' Mathematics attitude was enhanced, their problem-solving achievement was also enhanced significantly. Pimta et al. (2009) used path analysis to show that the Mathematics attitude directly and indirectly affects problem-solving skills. This result is consistent with prior research (Nicolaidou & Philippou, 2003).

When we examined predictor variables on problem-solving skills, Mathematics problem-solving skills were highly related to reading-comprehension skills and Mathematics self-efficacy perception. Özçelik (2011) demonstrated that reading comprehension explains 40% of the variance in the problem-solving performance. Numerous studies show that self-efficacy predicted problem-solving performance (Çelik, 2012; Hoffman & Spatauri, 2008; Nicolaidou & Philippou, 2003). In this context, it can be stated that reading comprehension and self-efficacy predicted problem solving. This result confirms earlier findings.

The results of the study indicated that the factors of problem solving for middle-school students were significantly related to reading comprehension, Mathematics self-efficacy

perception and Mathematics attitude. These results were consistent with the findings in the correlational analysis. In addition, reading-comprehension skills and Mathematics self-efficacy perception predict non-routine Mathematics problem-solving skills. Hierarchical regression was added to model the sequence of variables in accordance with the theoretical framework. In this context, although Mathematics self-efficacy perception was related to both Mathematics attitude and non-routine problem-solving skills, Mathematics attitude does not predict non-routine problem-solving skills. This is not a contradiction. The findings of the present study resolved the gap that İflazoğlu-Saban and Güzel-Yüce (2012) mentioned as uncovering the undefined factors' effect on problem solving. In this study, it is noted that middle-school students' reading-comprehension skills and Mathematics self-efficacy perception factors contribute to increase their problem-solving skills.

5. Limitations

Several limitations of the present study should be addressed. The first of these is sampling. Participants are middle-school students in Bayburt and Gümüşhane. The second limitation is that the results of this study are limited to our interest in gathering data. The study used a correlational method. Correlational research is a pioneer for empirical study, which can contribute to the assessment of effective factors in Mathematics problem solving. However, future researchers can examine the relationship between different variables, including the subscales by means of structural equation models.

6. Implications

Despite the present study has several limitations mentioned above, the present study makes some important contributions to the existing literature on Mathematics education through examining constructs like non-routine Mathematics problem solving, Mathematics self-efficacy and Mathematics attitude. Mathematics educators should consider the role of reading comprehension and emotional variables to increase non-routine problem-solving skills. Therefore, Mathematics curriculum programmes which aim to increase non-routine problem solving skills could use emotional variables and reading comprehension skills as effective method.

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