The Effect Of Prospective Teachers' Problem Solving Beliefs On Self-Efficacy Beliefs About Mathematical Literacy

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ABSTRACT

This study examines prospective teachers' beliefs in their own abilities and effectiveness to impart mathematical literacy to their students, their beliefs about mathematical problem solving, and the relationship between these two belief systems. A total of 567 prospective teachers, majoring in mathematics, science and elementary teacher education programs volunteered to participate in the study. The Self-Efficacy Beliefs Scale about Mathematical Literacy and the Beliefs about Mathematical Problem solving instruments were administered to prospective teachers. Results of the study revealed that there was a significant relationship between the beliefs about mathematical problem solving and self-efficacy. Findings of this study indicated that prospective teachers' beliefs about mathematical literacy were an important predictor on the beliefs about mathematical problem solving.

Keywords: Beliefs about Mathematical Problem Solving; Mathematical Literacy; Self-Efficacy Beliefs about Mathematical Literacy; Prospective Teachers

INTRODUCTION

Cognitive abilities and affective variables are inseparable parts of learning and share a close relationship within the learning process. Affective variables—such as beliefs—play an important role in learning and teaching mathematics (McLeod, 1992), and help students develop positive attitudes towards mathematics and mathematics teaching and learning (Kayaaslan, 2006). Key factors like teaching methods, teachers' evaluation of the subject, teachers' objectives, and their assessment of how well they relay information to students all play a part in mathematics education (Baydar & Bulut 2002). Thus it is important that teachers develop students' beliefs about mathematics. The recommendation of NCTM (1989) illustrate this, and much research (Kloosterman, 1991; Kloosterman & Cougan, 1994; Schoenfeld, 1989; Thompson, 1984) corroborate that students' beliefs about mathematics education have a direct effect on their learning abilities and their overall experience and success with mathematics education. For example, if students believe that all mathematics problems can be solved within five minutes, it may impact the time they allocate for problems in the future (Schoenfeld, 1992). Since beliefs have such influence on the cognitive and affective abilities of students, teachers should provide opportunities for students to gain positive beliefs by making a suitable educational environment available.

Problem solving activities enable students to gain mathematics skills (Swing & Peterson, 1988), as they build on their body of knowledge and learn to create new strategies to solve problems (Olkun & Toluk, 2003). We can understand an individuals' skill for solving mathematical problems by examining their self-efficacy beliefs about problem solving (Kloosterman & Stage, 1992; Mason, 2003); those who have high-level beliefs are more successful at problem solving than those with a lower level of belief (Blumenfeld, Soloway & Marx, 1991; Pajares & Miller, 1997). Kayan & Çakıroğlu (2008) and Lloyd & Wilson (1998) noted that prospective teachers' beliefs regarding mathematical problem solving is a vital factor for the success of the learning environment and for the success of the student. Therefore, it is most important to determine prospective teachers' beliefs regarding mathematical problem solving.

A high level of mathematical literacy is integral to understanding the role of mathematics in the world, carrying out mathematics-related applications in daily life, and developing numerical, spatial, and critical thinking skills (Özgen & Bindak, 2008). Several studies (Frankenstein, 1998; Goldman & Hasselbring, 1997; Kramarski & Mizrachi, 2006; Niss, 1996; Pugalee, 1999; Timothy & Quickenton, 2005; Whitin, Mills & O'Keefe, 1990; Wilburne & Napoli, 2008), have illustrated various educational methods and techniques to help students develop mathematical literacy (Frankenstein, 1998; Goldman & Hasselbring, 1997; Kramarski & Mizrachi, 2006; Niss, 1996; Pugalee, 1999; Timothy & Quickenton, 2005; Whitin, Mills & O'Keefe, 1990; Wilburne & Napoli, 2008). Teachers obviously play an important role in this development and must utilize many different educational methods and techniques to reach their students. If students are to develop a more complete mathematical literacy, they need opportunities to acquire and learn aspects of mathematics discourse communities different from the school discourse (Rittenhouse, 1998).

Teachers should be able to think critically and creatively, should possess mathematical reasoning skills, and should be confident in their knowledge base and abilities to relate mathematical concepts to their students. Self-efficacy beliefs - in this case, the beliefs of students regarding their abilities to implement the knowledge provided to them in order to achieve an objective - are key If *students' beliefs about their own self-efficacy* are strong, they are more receptive to teaching and more willing to learn (Bandura, 1986; Schunk, 1989 and 1992; Cited in Alcı & Altun, 2007). Thus prospective teachers must be aware of and try to cultivate their students' self-efficacy about mathematical literacy (Özgen & Bindak, 2008).

The ability to analyze mathematics problems involves understanding mathematical statements and expressions, both of which require a high level of mathematical literacy (Gellert, Jablonka & Keitel, 2001; Pugalee, 1999). Doyle (2005) explained that students who have poor literacy skills inevitably have poor problem solving skills when problems require reading and interpreting texts, because they cannot glean sufficient meaning from the text. Further, Miller and Koesling (2009) explained that literacy plays a role in teaching students to solve complex word problems, read mathematics text, and come to a better understanding of mathematics instruction. Dagmar explained the mathematical reading and reasoning process comprises *reading for understanding, identifying a problem solving process, solving the problem and check for reasonableness* (Cited in Miller and Koesling, 2009). Due to these reasons, mathematical literacy and problem solving skills have been linked together in some studies (Cook & Rieder, 2005; Lucangeli, Tressoldi & Cendron, 1998; Miller & Koesling, 2009; Passolunghi, Cornoldi & de Liberto, 1999; Sulentic-Dowell, Beal & Capraro, 2006). Despite this link, the relationship between the two has been explored in only in few studies (Doyle, 2005; Sulentic-Dowell, Beal & Capraro, 2006). Therefore, the purpose of our study is to examine prospective teachers' self-efficacy beliefs about mathematical literacy and their beliefs about mathematical problem solving, and to determine the relationship between these two systems. This study aims to answer the following questions:

1. What are the prospective teacher's beliefs about mathematical problem solving?
2. What are the prospective teacher's self-efficacy beliefs about mathematical literacy?
3. Is there a significant relationship between prospective teacher's beliefs about mathematical problem solving and their self-efficacy beliefs about mathematical literacy?
4. Are the prospective teacher's self-efficacy beliefs about mathematical literacy a significant predictor of their beliefs about mathematical problem solving?

METHODOLOGY

Research Model

We utilized the general screening model of descriptive research methods to elucidate the relationship between self-efficacy beliefs about mathematical literacy and the beliefs about mathematical problem solving of prospective teachers in various education fields.

Participants

A total of 567 prospective teachers studying in the Education Faculty of Abant İzzet Baysal University in Turkey during the fall semester of the 2011 participated in our research project. In this study, participants involved 195 prospective mathematics teachers, 185 prospective science teachers and 185 prospective elementary teachers. The samples involved 422 female and 145 male prospective teachers.

Table 1. Distribution of Prospective Teachers According to Teaching Fields and Gender

Gender	Teaching Fields							
	Mathematics		Science		Elementary		Total	
	f	%	f	%	f	%	f	%
Female	146	25.7	148	26.1	128	22.6	422	74.4
Male	49	8.6	39	6.9	57	10.1	145	25.6
Total	195	34.3	187	33.0	185	32.7	567	100.0

Data Collection Instrument

Data were collected using two instruments, the *Self-Efficacy Beliefs Scale about Mathematical Literacy* (Özgen & Bindak, 2008) and the *Beliefs about Mathematical Problem Solving Instrument* (Hacıömeroğlu, 2011).

The *Beliefs about Mathematical Problem Solving Instrument*, which was developed by Kloosterman and Stage, 1992, was adapted into Turkish by Hacıömeroğlu (2011), and the Turkish version was administered to prospective teachers. It contains a five point likert scale type rating, constituting 24 articles under 5 factors. These factors include Mathematical Skill, Place of Mathematics, Understanding of the Problem, Importance of Mathematics, and Problem Solving Skill. The scale contained 7 negative and 17 positive items, permitting a score of 120 at the highest and 24 at the lowest. We drew our conclusions by dividing the total points by number of items. Higher point totals indicate that the problem solving beliefs of prospective teachers are developed.

The factor loads of 24 items included in the scale vary between 0.39 and 0.86. Cronbach Alpha reliability coefficients are 0.73 for the whole of the scale, calculated as 0.77, 0.67, 0.76, 0.54 and as 0.84 respectively for the factors that constitute the scale. The item total test correlation values regarding the items included within the scale vary between 0.21 and 0.51. Cronbach Alpha internal reliability coefficients related to each of the factors have been calculated as 0.877, 0.775, 0.704, 0.500 and as 0.802 respectively, and the internal reliability coefficient related to the whole of the scale is 0.768. The test-retest reliability coefficient is 0.704 (p=0.001) (Hacıömeroğlu, 2011).

The *Self-Efficacy Beliefs Scale about Mathematical Literacy* was developed by Özgen and Bindak in 2008. It consists of a five point likert scale containing 25 items. The highest point that could be obtained from this scale, where it has been prepared as to contain 4 negative and 21 positive items, is 125 and the lowest point is 25. The highest point that could be obtained from the scale is referred to prospective teachers' self-efficacy belief about mathematical literacy is developed. In addition to this, a conclusion can be reached about the literacy levels of individuals by dividing the total points obtained from the scale to the number of items.

The factor loads of 25 items that are included in the scale are arranged between .52 and .78. Internal consistency reliability coefficients have been to be .95 for the whole of the inventory and it has been calculated as .88 and .93 for sub-components. The item-total correlation values of the items that are included in the scale varied between .48 and .75. Internal consistency reliability coefficients of the scale have been calculated as .942 and the test split-half reliability coefficient as .924 through the Spearman-Brown correction (Özgen & Bindak, 2008).

Data Collection and Analysis

Prospective teachers who volunteered to participate in this study completed the *Self-Efficacy Beliefs Scale about Mathematical Literacy* and the *Beliefs about Mathematical Problem Solving Instrument* within 30 minutes. The data were analysed using the SPSS 14.0 program.

The group interval coefficient value was calculated by dividing the difference between the greatest and smallest progression values by the determined number of groups in the study (Kan, 2009), providing an average reference interval of (5-1)/5=0.80. We used descriptive statistics to determine the beliefs about mathematical problem solving and mathematical literacy of the prospective teachers. The correlation and regression analysis were used to investigate the relationship between the two beliefs. Büyüköztürk (2010: 32), posited that a Pearson correlation coefficient between 0.30-0.00 shows a low-level relationship; a coefficient between 0.70-0.30 shows a medium level relationship; and a score between 1.00-0.70 shows high level relationship.

FINDINGS

Descriptive statistical results about the average points, where prospective teachers have obtained from their responses for the items included within the *Beliefs about Mathematical Problem Solving Instrument,* have been included in Table 2.

Table 2. Descriptive Analysis Results of Average Points of the Beliefs about Problem Solving of Mathematics, Science and Elementary Prospective Teachers

Teaching Fields	N	Minimum	Maximum	$\overline{X}$	S
Mathematics	195	2.54	3.88	3.27	.229
Science	187	2.63	3.83	3.23	.246
Elementary	185	2.54	4.00	3.21	.268
Total	567	2.54	4.00	3.24	.259

According to the descriptive statistical results, the average points of mathematics, science and elementary prospective teachers about their *beliefs about mathematical problem solving* were between 2.61 and 3.40; in other words, the views of the prospective teachers about problem solving corresponded to the *uncertain* choice. The descriptive statistical results obtained from prospective teachers' answers to the *Beliefs about Mathematical Problem Solving Instrument* are displayed in the tables below (See Tables 3, 4 and 5).

Table 3. Descriptive Analysis Results of Average Points Related to Sub-Dimensions of the Beliefs about Mathematical Problem Solving of Mathematics Prospective Teachers

Sub-dimensions	N	Minimum	Maximum	$\overline{X}$	S
Mathematical Skill	195	2.17	3.50	2.99	.219
Place of mathematics	195	1.83	4.17	2.67	.418
Understanding of the Problem	195	1.20	5.00	3.91	.692
Importance of mathematics	195	1.67	5.00	4.02	.701
Problem Solving Skill	195	1.75	4.75	3.22	.575

Table 4. Descriptive Analysis Results of Average Points Related to Sub-Dimensions of the Beliefs about Mathematical Problem Solving of Science Prospective Teachers

Sub-dimensions	N	Minimum	Maximum	$\overline{X}$	S
Mathematical Skill	187	2.17	3.67	3.00	.208
Place of mathematics	187	1.50	4.00	2.78	.432
Understanding of the Problem	187	1.00	5.00	3.86	.708
Importance of mathematics	187	1.00	5.00	3.74	.795
Problem Solving Skill	187	1.25	4.50	3.07	.555

Table 5. Descriptive Analysis Results of Average Points Related to Sub-Dimensions of the Beliefs about Mathematical Problem Solving of Elementary Prospective Teachers

Sub-dimensions	N	Minimum	Maximum	$\overline{X}$	S
Mathematical Skill	185	2.17	4.00	3.02	.263
Place of mathematics	185	1.33	4.67	2.77	.482
Understanding of the Problem	185	1.60	5.00	3.73	.712
Importance of mathematics	185	1.00	5.00	3.69	.870
Problem Solving Skill	185	1.00	5.00	3.17	.639

The descriptive statistical results are similar for mathematics, science, and elementary prospective teachers. The views of the prospective teachers about the *Understanding of the Problem* and about the *Importance of mathematics* factors correspond to the *I agree* choice. The views of the prospective teachers about the *Mathematical Skill, Place of mathematics* and about *Problem Solving Skill* factors correspond to the *uncertain* choice.

Descriptive statistical results for prospective teachers' responses regarding the *Self-Efficacy Beliefs Scale about Mathematical Literacy are* included in Table 6.

Table 6. Descriptive Analysis Results of Average Points of the Self-Efficacy Beliefs about Literacy

Teaching Fields	N	Minimum	Maximum	$\overline{X}$	S
Mathematics	195	2.08	5.00	3.60	.445
Science	187	1.81	5.00	3.60	.470
Elementary	185	1.81	5.00	3.41	.538
Total	567	1.81	5.00	3.54	.493

According to analysis of the average of prospective teachers' responses for the items included within the *Self-Efficacy Beliefs Scale about Mathematical Literacy,* their views about mathematical correspond to the *I agree* choice. Results of the correlation analysis, which show whether there is a relationship between *Self-efficacy Beliefs about Mathematical Literacy* and *Beliefs about Mathematical Problem Solving* of mathematics, science and elementary prospective teachers through the *Self-Efficacy Beliefs Scale about Mathematical Literacy* and the *Beliefs about Mathematical Problem Solving Instrument,* are included in Table 7.

Table 7. The Correlation Analysis Results Related to the Self-Efficacy Beliefs about Mathematical Literacy and the Beliefs about Mathematical Problem Solving

	N	Pearson Correlation	p
Self-efficacy beliefs about literacy Beliefs about problem solving	567	0.438	.000*

* Correlation is significant at the 0.01 level (p<.01)

Our analysis shows that there is an intermediate and positive level relationship (r=0.438, p<.01) between *Self-Efficacy Beliefs about Mathematical Literacy* and *Beliefs about Mathematical Problem Solving* of prospective teachers. Correlation analysis results are included below.

Table 8. The Correlation Analysis Results Related to the Factors of the Instruments

	N	Pearson Correlation	p
Mathematical Skill Self-Efficacy Beliefs about Literacy	567	0.041	.334
Place of mathematics Self-Efficacy Beliefs about Literacy	567	-0.128	.002**
Understanding of the Problem Self-Efficacy Beliefs about Literacy	567	0.507	.000**
Importance of mathematics Self-Efficacy Beliefs about Literacy	567	0.377	.000**
Problem Solving Skill Self-Efficacy Beliefs about Literacy	567	0.084	.045*

* Correlation is significant at the 0.05 level (p<0.05)
** Correlation is significant at the 0.01 level (p<0.01)

According to the correlation analysis results, there is an intermediate-level positive relationship between factors of *Understanding of the Problem* and *Importance of mathematics* about the mathematical problem solving beliefs together with *Self-Efficacy Beliefs about Mathematical Literacy* (r_3=0.507 and r_4=0.377, p<0.01). Also, there is a low-level negative relationship between factors of *Place of mathematics* and *Self-Efficacy Beliefs about Mathematical Literacy* (r_2= -0.128, p<0.01) and a low-level positive relationship between factors of *Problem Solving Skill* and *Self-Efficacy about Mathematical Literacy Beliefs* about problem solving (r=0.045, p<0.05). However, we did not find a significant relationship between *Mathematical Skill* and *Literacy* of prospective teachers

about problem solving. We performed multiple regression analysis in order to find out whether there was a significant predictor of beliefs about mathematical problem solving and their self-efficacy about mathematical literacy beliefs of factors, which constituted these beliefs. Information about the results are included in the following tables (Table 9 and 10).

Table 9. Result of the Regression Analysis about Prediction of Problem Solving Beliefs of Prospective Teachers According to Their Self-Efficacy about Mathematical Literacy Beliefs

Predictor Factor	Beliefs About Mathematical Problem Solving				
	B	Std.Error	Beta	t	p
Self-Efficacy Beliefs about Literacy	0.219	0.019	0.434	11.317	.000
Teaching Fields	-0.008	0.012	-0.027	-0.694	.488
R=0.439 R^2=0.193 F(2,564)=67.333 p= .000					

Prospective teachers' beliefs about *Mathematical Problem Solving* produce a significant relationship at a high level together with their self-efficacy about mathematical literacy beliefs and the teaching field they are educated in (F(2,564)= 67.333, (p<.01). The self-efficacy about literacy and teaching field variables predict together 19.3% of the total variation about their *Problem Solving Beliefs*. According to standardized regression coefficient (Beta), relative order of importance of these predicting variables about *Problem Solving Beliefs* are; self-efficacy about mathematical literacy beliefs and the teaching field. When the results of the t-test about the significance of the regression coefficients are examined, it can be seen that only the self-efficacy about mathematical literacy beliefs is an important predictor on the *Problem Solving Beliefs*. The teaching field variable does not have an important effect.

Table 10. Result of the Regression Analysis about Prediction of the Factors about the Problem Solving Beliefs of Prospective Teachers according to Their Self-Efficacy about Mathematical Literacy Beliefs

Predictor Factors	B	Std.Err	Beta	t	Total R^2	Total F
Mathematical Skill					0.004	1.079
Self-Efficacy Beliefs about Literacy	0.023	0.020	0.048	1.133		
Teaching Fields	0.013	0.012	0.047	1.106		
Place of mathematics					0.022	6.271*
Self-Efficacy Beliefs about literacy	-0.104	0.038	-0.115	-2.734		
Teaching Fields	0.041	0.023	0.075	1.776		
Understanding of the Problem					0.258	98.065*
Self-Efficacy Beliefs about literacy	0.721	0.053	0.503	13.691		
Teaching Fields	-0.022	0.032	-0.025	-0.682		
Importance of mathematics					0.155	51.611*
Self-Efficacy Beliefs about literacy	0.584	0.064	0.359	9.143		
Teaching Fields	-0.111	0.038	-0.113	-2.883		
Problem Solving Skill					0.008	2.217
Self-Efficacy Beliefs about literacy	0.096	0.051	0.080	1.878		
Teaching Fields	-0.019	0.031	-0.027	-0.633		

The *Place of mathematics*, *Understanding of the Problem* and *Importance of mathematics* factors about mathematical problem solving of prospective teachers produce significant relationships at high levels together with their self-efficacy beliefs about mathematical literacy and teaching field they are educated in (F_{PL}(2,564)= 6.271, F_U(2,564)= 98.065, F_I(2,564)= 51.611; p<.01). The self-efficacy about literacy and teaching field variables explain together 2.2% of the beliefs of prospective teachers about the *Place of mathematics*, 25.8% of the total variation about the prospective teachers' beliefs about the *Understanding of the Problem* and 15.5% of the total variation about the *Importance of mathematics.* According to standardized regression coefficient (Beta), relative order of importance of these predicting variables about the *Understanding of the Problem* and *Importance of mathematics* are; self-efficacy about mathematical literacy belief and the teaching field. Differently, relative order of importance of these predicting variables about the *Place of mathematics* are; teaching field and self-efficacy about mathematical literacy beliefs. When the results of the t-test about the meaningfulness of the regression coefficients are examined, it can be understood that only the self-efficacy about mathematical literacy belief is an important predictor on the *Place of mathematics, Importance of mathematics* and *Understanding of the Problem*. The teaching field variable does not have an important effect on the *Place of mathematics* and *Understanding of the Problem* while it has an important effect on the *Importance of mathematics* factor.

The *Mathematical Skill* and *Problem Solving Skill* factors, which is two of the factors about beliefs of prospective teachers about mathematical problem solving, does not produce significant relationships together with their self-efficacy about mathematical literacy beliefs and the teaching field they are educated in ($F_M(2,564)= 1.079$, $F_{PR}(2,564)= 2.217$; $p>.01$).

CONCLUSIONS

The prospective teachers' responses to both instruments show the need for development of their beliefs about mathematical problem solving and self-efficacy beliefs about mathematical literacy. Their responses about *Understanding of the Problem* and the *Importance of mathematics* seem to be more positive in comparison to their beliefs that were measured by other dimensions of the instrument. Also, the positive relationship between S*elf-Efficacy about Mathematical Literacy* and *Beliefs about Mathematical Problem Solving, Understanding of the Problem* and the *Importance of mathematics* illustrate that their self-efficacy about mathematical literacy beliefs have an impact on their beliefs about mathematical problem solving. Similar results were found by Doyle (2005) and Sulentic-Dowell, Beal and Capraro (2006). In particular, the mathematical literacy has an effect on factors of *Understanding of the Problem* and on *Importance of Mathematics.*

As a result of the correlation analysis, we found a positive and intermediate level relationship between the prospective teachers'*Self-Efficacy Beliefs about Mathematical Literacy* and *Beliefs about Mathematical Problem Solving*. From regression analysis, we determined that the self-efficacy beliefs of prospective teachers about mathematical literacy are an important predictor for their *Beliefs about Mathematical Problem Solving.* The self-efficacy beliefs of prospective teachers about mathematical literacy and the variables of teaching fields are together significant predictors for prospective teachers beliefs about *Understanding of Mathematics Problem*, *Importance of mathematics* and *Place of mathematics*. Teachers' self-efficacy beliefs, together with the variables of teaching field, explain/predict 25.8% of their beliefs about *understanding of mathematics,* 15.5% of their beliefs about the *Importance of mathematics,* and 2.2% of their beliefs about *Place of mathematics*. Thus their self-efficacy beliefs play a rather important role on the *Beliefs about Mathematical Problem Solving, Understanding of the Problem,* and the *Importance of \Mathematics.* In the same way, Yılmaz and Delice (2007) illustrate that the beliefs of teachers regarding the *Understanding of the Problem* and about the *Importance of mathematics* are more developed than other sub-dimensions of problem solving.

Prospective teachers' beliefs about mathematical problem solving are important for their professional development, and could impact the learning environments of their students and their effective teaching of mathematical problem solving process. Their beliefs about mathematical problem solving are important for professional development, and can impact the arrangement of study environments with their students and their effective teaching of mathematics and problem solving. These beliefs can contribute to teachers being more open to new ideas, and being better able to adapt easily to changes and overcome problems (Cai, 2003a and 2003b; Kayan & Çakıroğlu, 2008; Lloyd & Wilson, 1998). Successful problem solving in mathematics or science requires high levels of mathematical literacy (Gellert, Jablonka & Keitel, 2001; Pugalee, 1999), and the results of our study indicate that prospective teachers could be better mathematical problem solvers with the development of their mathematical literacy levels. In addition, integrating literature within courses could develop literacy skills and promote mathematical problem solving. For this purpose, It may be useful for prospective elementary teachers to use children's literature as a basis in method courses in teacher education programs so that they may wish to include literature-based experiences in their future classrooms.

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