



**THE EFFECT OF MATHEMATICS TEACHING THROUGH POLYA'S  
PROBLEM SOLVING STEPS UPON 4TH GRADE STUDENTS'  
SUCCESS OF SOLVING MATHEMATIC PROBLEMS<sup>i</sup>**

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**Abstract:**

In this research, the effect of mathematics teaching through Polya's problem solving steps upon problem solving success of the elementary education 4<sup>th</sup> grade students was analyzed in terms of various variables. In the study, "pre-test and post-test control-group design" was used semi-experimentally as the research method. In semi-experimental designs, there is an experimental approach in which no random distribution is used for categorizing the individuals as experimental and control groups. However, the participants' being at a fairly similar quality is regarded. The participants who participated into the study were selected among the 4<sup>th</sup> grade students studying at two state elementary schools in Adana province in 2014-2015 academic year creating one experimental group and one control group. The data collection tools were student information form and Problem Solving Success Determination Test prepared by the researcher under the control of an expert. Obtained data were transferred into the computer environment using SPSS 22 statistical software. During the data analysis, whether there was a statistical difference between post-test scores of the experimental and control groups was tested using independent groups t-test. For other comparisons, t-test and one-way variance analysis were performed. These results were concluded as

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result of the analyses. According to t-test results, problem solving success level did not differ significantly according to the age and gender of the students. Problem solving success level differed significantly according to the profession of mother and father. The problem solving success level did not differ significantly according to the socio-economic status of the family. Problem-solving success level significantly differed according to the educational status of mother; however, did not differ significantly according to the educational status of father. In terms of the analysis results on the difference in mathematical problem solving success of the students, it was concluded that success of the students increased in a problem solving process supported with activities and administered with Polya's problem solving steps accurately.

**Keywords:** activity, mathematics problems, mathematics level

## 1. Introduction

Being a part of a creative and efficient education is only possible through fulfilling the requirements of modern education. Mathematics teaching is one of these experiences. *"Our educational system has experience a transition from behavioral approach to the "constructivist" approach through new elementary education mathematics curriculum that was put into practice in 2004"* (Kal, 2013: 1).

The vision of Ministry of National Education (MNE) 2012 mathematics curriculum included the expression of *"Raising individuals who can use mathematics in their daily life, solve problems, share the solutions and thoughts, study in groups, feel self-confidence and develop positive attitudes towards mathematics is remarkable."* The same curriculum also included the expression of *"The individuals can develop problem-solving strategies, and can use these for overcoming the problems in daily life"* in general purposes of mathematics teaching. These expressions have indicated that developing attitudes towards problem solving skill and mathematics are regarded in mathematics teaching.

According to Altun (2010), although problem solving is only perceived as achieving the correct result, it is an action including a broader mental process and skills. Because individuals who acquire the skill of problem solving can use this skill on any areas of life and so life will be easier. The main task for providing students acquire such a remarkable skill in the most efficient and productive way falls to teachers.

When the mathematics course books used for mathematics teaching in our country have been analyzed, mathematics process in the course books are noticed to be associated with the problem solving process suggested by Polya (1957). Has this four-step process determined to be used while solving the problems as of elementary

education been implemented completely at school for years? If implemented, do the students acquire the skill of problem solving? Is there a relationship between students' not achieving problem solving at required level and this process? In order find answers to these questions, the effect of mathematics teaching with activities based upon Polya's problem solving process upon problem solving success of 4<sup>th</sup> grade elementary education students and the relationships between various variables were analyzed in this research.

## 2. Method

### 2.1 Research Model

In this study, "*pre-test and post-test control-group design*" was semi-experimentally used as the research method. In semi-experimental designs, there is an experimental approach in which no random distribution is used for categorizing the individuals in experimental and control groups. However, participants' having nearly the same qualities is regarded. In pre-test and post-test design model, a participant is only included in only one of the experimental or control groups (Büyüköztürk, 2001). According to Özsoy (2012), experimental models are the ones in which the data required to be observed are produced under the direct control of the researcher for determining the cause and result relationships.

In the research, pre-test and post-test control-group experimental design was used. According to this, the courses were lectured in experimental groups adhering to the problem solving steps of Polya. In control groups, the courses were lectured with traditional teaching methods.

### 2.2 Study Group

The research population included two elementary state schools in Adana province in 2014-2015 academic year. The study sample included the students studying at the 4<sup>th</sup> grade of these schools. The students who participated into the study were selected among the 4<sup>th</sup> grade students studying at two state elementary schools in Adana province in 2014-2015 academic year creating one experimental group and one control group. For selection of the schools and students, course averages and standard deviations of mathematics course for the previous term were regarded.

In the research, 41 students for the experimental group and 35 students for the control group were selected from Cumhuriyet Elementary School, and 20 students for the experimental group and 20 students for the control group were selected for the control group from Atatürk Elementary School. The reason for the number of students

to be less in Cumhuriyet Elementary School was irregular attendance of 6 students to the implementations.

### 2.3 Data Collection Tools

Student Information Form and Problem Solving Success Determining Test prepared by the researcher under the control of an expert were the measurement tools used in the research as data collection tools. The Problem Solving Success determining Test was primarily performed to 107 5<sup>th</sup> grade students who were not included into the research, and 0.815 reliability coefficient was obtained at the end of the analysis. This obtained value proved that Problem Solving Success Determining Test was adequate for being used in the research.

Obtained data were transferred into the computer environment benefiting from SPSS 16 statistical software. During the data analysis process, whether there was a statistical difference between the post-test scores of the experimental and control groups was tested with independent group t-test. For other comparisons, t-test and one-way variance analysis were performed.

### 3. Findings

**Table 1:** Distribution of Experimental and Control Group Students According to Gender in Cumhuriyet Elementary School

Groups	Female	Male	Total
Experimental Group	16	25	41
Control Group	15	20	35
Total	31	45	76

As could be seen in Table 1, there were 16 female and 25 male students in the experimental group, and 15 female and 20 male students in the control group in Cumhuriyet Elementary Education School.

**Table 2:** Distribution of Experimental and Control Group Students According to Gender in Atatürk Elementary School

Groups	Female	Male	Total
Experimental Group	11	9	20
Control Group	9	11	20
Total	20	20	40

As could be seen in Table 2, there were 11 female and 9 male students in the experimental group, and 9 female and 11 male students in the control group in Atatrk Elementary Education School.

**Table 3:** T-Test Results for the Difference between Pre-Test Scores Related to Whether Problem Solving Success Differs According to the Gender or Not

CİNSİYET	N	X	s.s	SD	t	P
Female	51	45,7451	23,03722			
Male	65	40,6154	18,4032	114	,185	-

According to Table 3, problem solving success level did not differ significantly according to gender [ $t(114)=.185$ ;  $p>.05$ ]. Namely, gender was not a distinctive factor for learning and gender.

**Table 4:** Variance Analysis Results Related to Whether Problem Solving Success Differs According to the Age of Students or Not

Source of the Variance	SD	Sum of Squares	Mean of Squares	F	P
Between Groups	2	7.3	3.65		
In-group	113	47525.459	420.579		
TOTAL	115	47532.759		.009	---

According to Table 4, Problem Solving Success test did not significantly differ according to the age of the students ( $p>.05$ ). As result of these statistical processes, age was noticed to be a factor that did not affect success.

**Table 5:** Variance Analysis Results Related to Whether Problem Solving Success Differs According to the Profession of Mother or Not

Source of the Variance	SD	Sum of Squares	Mean of Squares	F	P
Between Groups	4	5144.905	1286.226		
In-group	111	42387.854	381.873		
TOTAL	115	47532.759		3.368	.012

According to Table 5, Problem Solving Success Test scores differed significantly at the level of 0.12 according to the profession of mother ( $p<.05$ ).

**Table 6:** Variance Analysis Results Related to Whether Problem Solving Success Differs According to the Educational Status of Mother or Not

Source of the Variance	SD	Sum of Squares	Mean of Squares	F	P
Between Groups	5	5985.788	1197.158		
In-group	110	41546.971	377.700		
TOTAL	115	47532.759		3.170	.010

According to Table 6, Problem Solving Success Test scores differed significantly at the level of .010 according to the educational status of mother ( $p < .05$ ).

**Table 7:** Variance Analysis Results Related to Whether Problem Solving Success Differs According to the Profession of Father or Not

Source of the Variance	SD	Sum of Squares	Mean of Squares	F	P
Between Groups	4	7898.789	1974.697		
In-group	111	39633.970	357.063		
TOTAL	115	47532.759		5.530	.000

According to Table 7, Problem Solving Success Test scores differed significantly at the level of .000 according to the profession of father.

**Table 8:** Variance Analysis Results Related to Whether Problem Solving Success Differs According to the Educational Status of Father or Not

Source of the Variance	SD	Sum of Squares	Mean of Squares	F	P
Between Groups	5	4190.677	838.135		
In-group	110	43342.082	394.019		
TOTAL	115	47532.759		2.127	--

According to Table 8, Problem Solving Success Test scores did not differ significantly according to the educational status of father ( $p > .05$ ).

**Table 9:** Variance Analysis Results Related to Whether Problem Solving Success Differs According to the Economic Status of Family or Not

Source of the Variance	SD	Sum of Squares	Mean of Squares	F	P
Between Groups	3	1712.588	570.863		
In-group	112	45820.171	409.109		
TOTAL	115	47532.759		1.395	--

According to Table 9, Problem Solving Success Test scores did not differ significantly according to the socio-economic status of the family ( $p > .05$ ).

**Table 10:** T-Test Results Related to the Difference between Cumhuriyet Elementary School Experimental and Control Groups' Pre-Test Success Scores

Groups	n	x	s.s	SD	T	p
Control Group	35	42,0732	22,13525			
Experimental Group	41	50,0000	20,09353	40	1,910	,063

According to the pre-test results, there was no difference between success of the experimental group and control group [ $t(40)=1.910$ ;  $p>.05$ ].

**Table 11:** T-Test Results Related to the Difference between Cumhuriyet Elementary School Experimental and Control Groups' Post-Test Success Scores

Groups	n	x	s.s	SD	T	p
Control Group	35	36.4634	23.32498			
Experimental Group	41	69.5122	22.60544	40	6.713	,000

There was a significant difference between post-test success test scores of the experimental and control groups [ $t(40)=6.713$ ;  $p<.05$ ]. The significant difference at the level of .00 between post-tests of the experimental and control groups indicated that mathematics teaching with the activities based upon Polya's problem solving method affected success positively.

**Table 12:** T-Test Results Related to the Difference between Atatrk Elementary School Experimental and Control Groups' Pre-Test Success Scores

Groups	n	x	s.s	SD	T	p
Control Group	20	42,7500	20,74120			
Experimental Group	20	40,5000	19,18744	19	,361	,722

According to the pre-test results, there was no significant difference between success of the experimental group and control group [ $t(19)=,361$ ;  $p>.05$ ].

**Table 13:** T-Test Results Related to the Difference between Atatrk Elementary School Experimental and Control Groups' Post-Test Success Scores

Groups	n	x	s.s	SD	T	p
Control Group	20	36.8421	26.46856			
Experimental Group	20	65.5000	21.91157	18	4.481	.000

There was a significant difference between post-test success scores of the experimental and control groups [ $t(18)=4.481$ ;  $p<.05$ ]. The significant difference between post-test

scores of the experimental and control groups indicated that mathematics teaching with the activities based upon Polya's problem solving method affected success positively.

#### 4. Conclusion

According to research results, no significant difference was found between gender and problem solving success because  $t(317) = .137$ ;  $p > .05$ . This result was compatible with the results obtained in various studies (Arsal, 2009; Saracalođlu, Serin and Bozkurt, 2001; Kılıç and Karadeniz, 2004; Alver, 2005) investigating the effects of gender upon success. In some researches, results related to the fact that gender created a significant difference upon success were obtained (Özkal and Çetingöz, 2006; Gürsakal, 2012; Bahar, 2006).

At the end of the analyses, it was concluded that Problem Solving Success Test scores did not differ significantly according to the age of the students ( $p > .05$ ). Upon revealing this result, students' being at ages closer to each other was possible to be mentioned as efficient.

According to obtained results, Problem Solving Success Test scores differed significantly according to the educational status of mother ( $p < .05$ ); however, the scores did not differ significantly according to the educational status of father. In the study carried out by Ural and Çınar (2014), it was noticed that as the educational status of mother and father, especially the mother, increased, the mathematics grades of the students increased, as well. In the study of Öksüzler and Sürekçi (2010), it was determined that one of the most important factors that affected the possibility for the students to be successful in OKS exam was the educational status of the families.

Problem Solving Success Test scores did not differ significantly according to the socio-economic status of the families ( $p > .05$ ). Whereas the children of the families with low socio-economic status had the highest average with  $\bar{X} = 55.0000$ , children of the families with medium socio-economic status level had the lowest average with  $\bar{X} = 35.5000$ .

According to the analysis results, Problem Solving Success Determining Test scores differed significantly according to the profession of mother and father. The group with the highest average among the answers given for the profession of mother was the one with officer mothers with the average of  $\bar{X} = 64.0000$ ; and the group with the highest average among the answers given for the profession of father was the one with officer fathers with the average of  $\bar{X} = 57.5000$ . As could be understood here, children of the parents who were conscious on education had higher academic success.

Another result that was obtained in the research was that success of the students increased during a problem solving process supported with activities and Polya's



problem solving method that was implemented accurately. According to Okur, Tatar and İşleyen (2006), problem solving approach was included in all curriculums, and became the main target in mathematics teaching at the end of George Polya's studies. As could be concluded here, acquiring the problem solving skills should be determined as the target during the process of mathematics teaching.

## 5. Recommendations

In accordance with obtained results, the suggestions below were offered for teachers, students and researchers:

Problem solving process could be fulfilled through the out-of-class activities, if needed.

Teaching with games could be used in mathematics as could be used in any courses on condition to being appropriate to age and level.

Because mathematics is a spiral discipline, regular review of the students can provide contributions upon their success.

Studies revealing the mathematics and problem solving perceptions of the students can be carried out interviewing students as face-to-face in a way that is totally qualitative.

In this research, Polya's problem solving method was discussed within the scope of mathematics course. However, researches discussing the use of this method and these steps in other courses could be carried out and the process could be integrated in other courses when considered that problem solving skills is associated with other courses, as well.

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