STUDENT AND TEACHER CHARACTERISTICS RELATED TO PROBLEM SOLVING SKILLS OF THE SIXTH GRADE TURKISH STUDENTS

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ABSTRACT

STUDENT AND TEACHER CHARACTERISTICS RELATED TO PROBLEM SOLVING SKILLS OF THE SIXTH GRADE TURKISH STUDENTS

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The current study, initially aimed to explore the problem solving skills of the sixth grade students within the four-process problem solving framework including the processes of *understanding the problem*, *devising a plan*, *carrying out the plan*, and *looking back and evaluating*. Secondly, it aimed to investigate the relationships between student and teacher related characteristics and problem solving skills of the students. In the study, a model was proposed based on the related literature and this proposed model was tested by using hierarchical linear modeling (HLM) technique. A total of 2562 sixth grade students from 37 public elementary schools in the eight central districts of Ankara completed a problem solving skills test developed by the researcher and a student questionnaire. At the same time, mathematics teachers of the students participated in the study completed a teacher questionnaire.

The results indicated that in general the sixth grade students displayed low performance in the overall problem solving skills test. Moreover, the students performed best in the process of *understanding problem* whereas they showed the worst performance in the process of *looking back and evaluating*.

The results of the hierarchical linear modeling technique indicated that the student characteristics significantly and positively related to the problem solving skills of the sixth grade students were *socioeconomic status, mathematics self concept, extrinsic motivation, use of control strategies*, *preference for competitive learning situation*, and *teacher support*, on the other hand student level characteristics significantly and negatively related to the problem solving skills of the sixth grade students were *mathematics anxiety*, *giving homework*, *activities related with homework*, and *different types of homework*. Furthermore, the teacher level characteristics significantly related to the problem solving skills of the sixth grade students were only *teacher gender* and *perceptions about limitations aroused from students*. The characteristic of *perceptions about limitations aroused from students* was negatively related to problem solving skills of the students on the other hand *teacher gender* was found to be related to problem solving skills of the students in favor of female teachers. It was also found that there was no teacher level characteristic influencing the relationship that was between student level characteristics and the problem solving skills of the students.

Keywords: Problem Solving Skills, Hierarchical Linear Modeling (HLM), Student Characteristics, Mathematics Teacher Characteristics.

ÖZ

ALTINCI SINIF TÜRK ÖĞRENCİLERİNİN PROBLEM ÇÖZME BECERİLERİNİ ETKİLEYEN ÖĞRENCİ VE ÖĞRETMEN ÖZELLİKLERİ

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Bu çalışmada ilk olarak, altıncı sınıf öğrencilerinin problem çözme becerilerinin, *problemi anlama*, *plan geliştirme*, *planı uygulama* ve *çözümü kontrol etme ve değerlendirme* adımlarını içeren dört-süreçli problem çözme yapısı içinde incelenmesi amaçlanmıştır. İkinci olarak ise, öğrenci ve öğretmen özellikleri ile öğrencilerin problem çözme becerileri arasındaki ilişkilerin incelenmesi hedeflenmiştir. Çalışmada ilgili literatür temel alınarak bir model öne sürülmüş ve öne sürülen bu model hiyerarşik lineer modelleme (HLM) yöntemi kullanılarak test edilmiştir. Ankara ilinin sekiz merkez ilçesinde bulunan 37 resmi ilköğretim okulunda öğrenim görmekte olan toplam 2562 altıncı sınıf öğrencisine araştırmacı tarafından geliştirilen problem çözme testi ve öğrenci anketi uygulanmıştır. Aynı zamanda, çalışmaya katılan öğrencilerin matematik öğretmenlerine de öğretmen anketi uygulanmıştır.

Sonuçlar, altıncı sınıf öğrencilerinin genel olarak problem çözme beceri testinde düşük performans sergilediklerini göstermiştir. Ayrıca, öğrencilerin *problemi anlama* sürecinde en iyi performansı sergilerken, *çözümü kontrol etme ve değerlendirme* sürecinde en kötü performansı sergiledikleri gözlenmiştir.

Hiyerarşik lineer modelleme yöntemi sonuçları, *sosyo-ekonomik statü, matematik özbenlik kavramı, dışsal motivasyon, kontrol stratejisi kullanımı, rekabetçi öğrenme ortamını tercih etme* ve *öğretmen desteği* gibi öğrenci seviyesinde ele alınan özelliklerin altıncı sınıf öğrencilerinin problem çözme becerileri ile anlamlı ve pozitif olarak, bunun yanında *matematik kaygısı, ev ödevi verme, ev ödevi ile yapılan etkinlikler* ve *farklı tipte ev ödevleri kullanımı* gibi öğrenci seviyesinde ele alınan özelliklerin ise anlamlı ve negatif olarak ilişkili olduğunu göstermiştir. Ayrıca, öğretmen seviyesinde ele alınan özelliklerden sadece *öğretmen cinsiyetinin* ve *öğrenciden kaynaklanan sınırlılıklar ile ilgili algıların* anlamlı ilişkisi olduğu gözlenmiştir. *Öğrenciden kaynaklanan sınırlılıklar ile ilgili algılar* özelliğinin öğrencilerin problem çözme becerileri ile negatif ilişkili olduğu saptanırken, *öğretmen cinsiyeti* özelliğinin ise bayan öğretmenlerin lehine olduğu gözlenmiştir. Aynı zamanda öğretmen seviyesinde ele alınan özelliklerden hiçbirinin, öğrenci seviyesinde ele alınan özelliklerle problem çözme becerileri arasındaki ilişkiyi etkilemediği bulunmuştur.

Anahtar Kelimeler: Problem Çözme Becerileri, Hiyerarşik Lineer Modelleme (HLM), Öğrenci Özellikleri, Matematik Öğretmeni Özellikleri

To My Family

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LIST OF ABBREVIATIONS

HLM:	Hierarchical linear modeling
SES:	Socioeconomic status
TYPEHOME:	Different types of homework
ACTHOME:	Activities related with homework
GIVEHOME:	Giving homework
TCSUPP:	Teacher support
PRODAILY:	Projects, daily life examples and problems
TECHNO:	Use of technology
MSCONCEPT:	Mathematics self concept
COMPE:	Preference for competitive learning situation
COOPE:	Preference for cooperative learning situation
CONTROL:	Learning strategies – Use of control strategies
ELAB:	Learning strategies – Use of elaboration strategies
ANXIETY:	Math anxiety
INTMOT:	Intrinsic motivation
EXTMOT:	Extrinsic motivation
PEREFFI:	Personal teaching efficacy
OUTCOME:	Outcome expectancy
PERSUCC:	Perceptions about being successful in mathematics
PERMATH:	Perceptions about mathematics
PHYLIM:	Perceptions about physical limitations
LIMSTU:	Perceptions abot limitations aroused from students

CHAPTER 1

INTRODUCTION

Almost all nations give emphasis on problem solving and adopt the idea of integrating problem solving in their mathematics curricula (National Council of Teachers of Mathematics [NCTM], 1989; National Research Council [NRC], 1989; Turkish Ministry of National Education [MNE], 2005; 2008). Problem solving focusing on school mathematics is the major concern of many researchers in the educational area (Charles, Lester, & O'Daffer, 1987; Grugnetti & Jaquet, 1996; Krulik & Rudnick, 1989; Rubinstein, 1980; Schoenfeld, 1992; Schwieger, 1999). It is important to teach students problem solving because it has an important role in linking mathematical knowledge to everday situations. Students encounter many problem situations in everyday life and a very few of them refers to school mathematics subjects (Krulik & Rudnick, 1989). It is known that students can make little connection between what they learn in mathematics classroom and how they use them in everyday situations. If more emphasize is given to problem solving in mathematics classroom, students would be more successful in making the related connections between the classroom world and the real world (Krulik & Rudnick, 1989; Rubinstein, 1980).

Although there is a consensus about the idea that problem solving should be the focus of the mathematics curricula among the researchers, there is no common definition of a mathematical problem. What is *problem?* and What is *problem solving?* These are not easy questions to answer. The research literature is full of different definitions representing various aspects of the term *problem*. Some researchers emphasize the mathematical content of the *problem* (e.g., Schwieger, 1999), some of them do not highlight the mathematical content specifically (Bransford & Stein, 1984; Kilpatrick, 1985; Krulik & Rudnick, 1989; Mayer, 1985; Posamentier & Krulik, 1998), and some others define *problem* from the view of information processing theory (Newell & Simon, 1972). Although different views of the term *problem* are emphasized by different researchers, the comparison of these definitions shows that they include some common features. For instance, the *problem* in its nature includes a beginning and a final situation. Moreover in the route between these two situations, individuals confront a blockage and have to perform a series of actions to reach the desired final situation. After analyzing many definitions of *problem* cited in mathematics education literature, a simple and clear definition is adopted for the current study based on the definition proposed by Schwieger (1999). In this sense, a problem is a situation or statement that requires the use of mathematical content, application, and processes to reach a conclusion. There are several important criteria that problems should have (Krulik & Rudnick, 1989; Schwieger, 1999). All of these criteria are important; however, two of them merit more attention than the others;

- The problem should be real life related, within the interest of the students, and challenging to the students.
- The problem should be presented in a concrete manner considering the mathematical level of the students.

To make the definition more concrete, a problem situation is given as an example in Table 1.1.

Table 1.1 Example of a problem situation

Canan 24 sayılık bir dergiyi sipariş etmeyi planlamaktadır. İki dergi ile ilgili aşağıdaki ilanları okuyor.

Gençlik Dergisi	**Genç Haber**
24 Sayı İlk 4 sayı ÜCRETSİZ Kalanların her biri 3 YTL	24 Sayı İlk 6 sayı ÜCRETSİZ Kalanların her biri 3.5 YTL

24 sayılık en ucuz dergi hangisidir? Ne kadar daha ucuzdur? Cevabınızı açıklamalı olarak gösteriniz.

In the example, the students are presented two different 24-issue magazine advertisements. Firstly, the students are required to carry out some mathematical operations and then make a decision with respect to which magazine is the cheaper. As it is seen, the situation is real life related; moreover, it is presented in a concrete manner in accordance with a sixth grade student's mathematical knowledge.

Similar to the various definitions of the term *problem,* in the literature, the definition of the term *problem solving* is also used for different types of activites. It is mentioned that "the term *problem solving* has been used with multiple meanings ranging from *working rote exercises* to *doing mathematics as a professional*" (Schoenfeld, 1992, p. 334). Emphasizing the major points of the definition of *problem*, in the current study the term *problem solving* is defined as a process from the beginning to the conclusion in which the student performs a series of action. However, it is stressed that in its nature the *problem solving* is a very complex procedure (Charles, Lester & O'Daffer, 1987; Lester & Kroll, 1990; Marzano et al., 1988; Posamentier & Krulik, 1998). Although, it has been strongly emphasized that *problem solving* is a complex procedure, some general approaches and guides were proposed to define the process of reaching the conclusion (Charles, Lester & O'Daffer, 1987; Grugnetti & Jaquet, 1996; Krulik & Rudnick, 1989; Lester & Kroll, 1990; Noddings, 1985; Mayer, 1985; Polya, 1957; Teare, 1980). When these models were investigated in detail, it was observed that most of the steps of different models were similar to each other and some steps of each model overlap. Considering these similarities, the steps of problem solving process models were summed up under the model of Polya (1957) by the researcher. In general, the model of Polya (1957) consists of four main steps including; *understand the problem*, *devise a plan*, *carry out the plan*, and *look back*. The steps of other proposed models were compiled under these four main processes considering what is expected from the students to perform in each process. Fundamentally, in each process of the framework different performances are expected from the students. The first process, *understanding the* *problem* refers to selecting or identifying the conditions, given data or the question in the problem; *devising a plan* refers to formulating or selecting an appropriate solution strategy; *carrying out the plan* refers to implementing the solution strategy or giving the appropriate answer; and finally, *looking back and evaluating* refers to cheking the correctness or reasonability of the solution or answer. The proposed framework and the overlapping steps of the other models are presented in Table 1.2.

The problem solving performances of Turkish students participated in the Programme for International Student Assessment (PISA) 2003 were found to be quite low. Turkish students ranked only 36 th out of 41 countries in the problem solving performance, falling behind most of the participating countries and below the international average as well (Organization for Economic Co-operation and Development [OECD], 2004a). In the PISA 2003 assessment framework, problem competency is defined as "…an individual's capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the content areas or curricular areas that might be applicable are not within a single area of mathematics, science or reading" (OECD, 2004a, p. 26). Unfortunately, 51% of the 4855 Turkish students were categorized as weak problem solvers those can only deal with straightforward problems with carefully structured tasks that require them to give responses based on facts or to make observations with few or no inferences. On the other hand, only 4% of Turkish students were categorized as reflective problem solvers who do not only analyse a situation and make decisions, but also think about the underlying relationships in a problem and relate these to the solution (OECD, 2004a). Additionally, when the released mathematics items of TIMSS 1999 (The International Study Center [ISC], 2000) and TIMSS 2007 (Foy & Olson, 2009) were investigated together with the data set for Turkey (ISC, n.d; 2009), it was observed that problems were correctly answered by approximately 35% of Turkish students. This low and undesired performance of Turkish students on problem solving pointed out that problem solving skills of Turkish students

Table 1.2 The four-process problem solving framework and overlapping steps of the other models

			Proposed models					
Framework	**Polya (1957)**	**Charles, Lester and O'Daffer (1987)**	**Lester and Kroll (1990)**	**Teare (1980)**	**Dewey (as cited in Noddings, 1985, p. 346)**	**Krulik and Rudnick (1989)**	**Noddings (1985, p. 349)**	**Noddings (1985, p. 347)**
UNDERSTANDING THE PROBLEM	1. Understand the problem	1. Understand/formulate the question in a problem	1. Understand/formulate the question in a problem	1. Define the problem and devise a goal	1. Identify a problematic situation 2. Define the problem	1. Read the problem	1. Create a representation	1. Translate words to mathematical expressions
		2. Understand the conditions and variables in the problem	2. Understand the conditions and variables in the problem			2. Explore		
		3. Select or find the data needed to solve the problem	3. Select or find the data needed to solve the problem					
DEVISING A PLAN	2. Devise a plan	4. Formulate subproblems and select appropriate solution strategies to pursue	4. Formulate subproblems and select appropriate solution strategies to pursue	2. Plan an attack by choosing a principle	3. Engage in means-ends analysis; devising a plan	3. Select a strategy		
CARRYING OUT THE PLAN	3. Carry out the plan	5. Correctly implement the solution strategy or strategies and solve subproblems	5. Correctly implement the solution strategy or strategies and solve subproblems	3. Execute the plan	4. Execute; carry out the plan	4. Solve	2. Execute a plan based on the representation	2. Execute; that is calculating
		6. Give an answer in terms of the data in the problem	6. Give an answer in terms of the data in the problem					
LOOKING BACK AND EVALUATING	4. Look back	7. Evaluate the reasonableness of the answer	7. Evaluate the reasonableness of the answer	4. Check thoroughly	5. Undergo the consequences	5. Look back	3. Undergo the consequences	3. Check the results in initial equations
			8. Maintaining adequate control over the solution effort	5. Look into the effect of assumptions, draw conclusions	6. Evaluate		4. Evaluate the results	

should be carefully investigated. In the light of these information, the important role of the problem solving skill in preparing students for the future together with the low success of students in this domain generate an impetus for the current study.

Up to now many theorists and researchers have consistently tried to understand the determinants of achievement and to comprehend how these determinants related to achievement. Researchers have studied academic achievement using large samples and applying various statistical models to assess multiple factors of academic achievement (Baker & Stevenson, 1986). There are lots of factors related to academic achievement directly or indirectly. Students' characteristics, attitudes, and prior knowledge, teachers' characteristics and experiences, classroom practices, parent's characteristics and education level, school principals, government, curriculum and so on. They are all important and each factor completes the other ones. The review of literature shows that some of these relationships have been found to be consistently significant whereas some of them have been found to be inconsistent across the studies. In the next part of this section the mostly used factors are briefly summarized. As was spelled out by the literature, student performance in mathematics might be the result of student related characteristric such as socioeconomic status, mathematics self concept, motivation, anxiety, learning strategies, and preferences for learning situations and teacher related characteristic such as teacher experience, teacher efficacy, perceptions about mathematics teaching and learning. In addition to these characteristics, there are also classroom related characteristics such as the use of projects, technology, homework, and teacher support. In the present study a framework was proposed for investigating the problem solving skills of the sixth grade Turkish students based on the review of related literature. In this sense, Figure 1.1 summarizes the theoretical framework of the characteristics related to problem solving skills of the students.

Socioeconomic status is one of the most important student background characteristics that many studies has investigated the correlation of it between students' achievement and found high correlations (Reynolds & Conaway, 2003). Many researchers have concluded that SES affects achievement, not only in mathematics (Crane, 1996; Demir, Kılıç, & Depren, 2009; İş Güzel, 2006; O'Conner & Miranda, 2002; Okpala, Smith, Jones, & Ellis, 2000; Yang, 2003), but other disciplines as well such as science (Yang, 2003) or reading (Okpala, Smith, Jones, & Ellis, 2000).

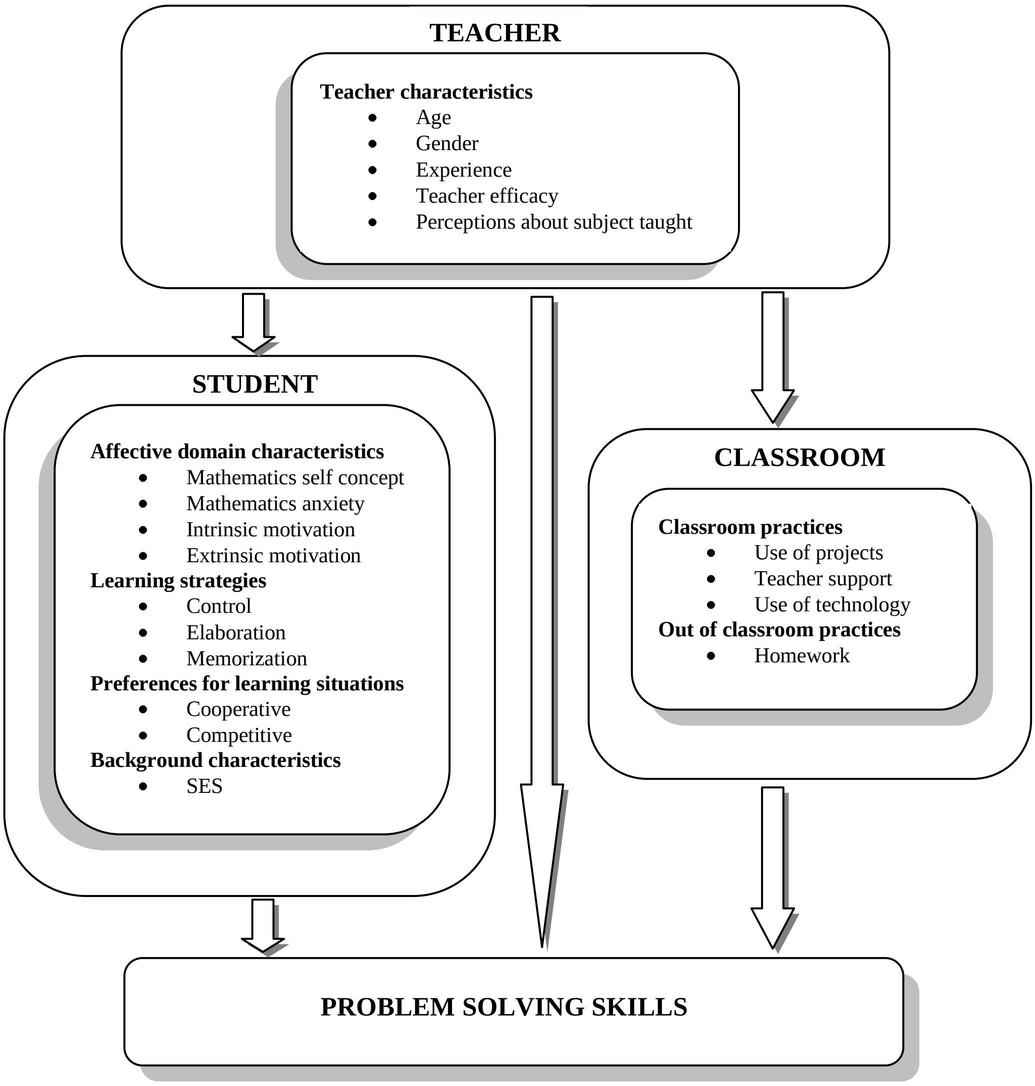

Figure 1.1 Theoretical framework for problem solving skills

In research literature, it is noted that self-concept is referred as one of the most important constructs in the learning processes (Shavelson, Hubner, & Stanton, 1976) because of its linkage to academic achievement (Byrne, 1984). Since self-concept has been referred as one of the critical constructs in learning process, many correlational and experimental studies especially investigating the relationship between self-concept and achievement have been conducted (Byrne, 1984; Dermitzaki, Leondari, & Goudas, 2009; Marsh, Hau, & Kong 2002; Wang, 2007). Whether reciprocal, average, direct, indirect, and causal or not, the results of these studies prove that there is a consistent and positive relationship between self-concept and achievement. This case is also true for mathematics self-concept and mathematics achievement.

Motivation and mathematics anxiety of the students are the mostly investigated affective domain factors. It is strongly emphasized that education systems should improve students' motivation and interest to continue their learning by this way engagement in learning and the depth of understanding are enhanced (OECD, 2004b). Improving motivation of students leads to the use of effective and deeper cognitive strategies and complete understanding of the subject taught (Pintrich & DeGroot, 1990; Wolters, Yu, & Pintrich, 1996; Zimmerman, Bandura, & Martinez-Pons, 1992). These students usually show better achievement on assigned tasks and tests (Zimmerman & Bandura, 1994). Both psychologist and educators have been interested in motivation for a long time (Ross, 2008). One of the issues related with motivation that attracted the educators is the relationship between motivation and achievement. The results of the reported studies investigating this relationship display a mixed picture (OECD, 2004b; Ross, 2008).

The construct of mathematics anxiety has gained considerable awareness by mathematics educators as an important factor in the teaching and learning of mathematics (Aiken, 1970, 1976; McLeod, 1988, 1992; Vinson, 2001). It is one of the affective domain variables, which has received more attention than any other variables included in this domain (McLeod, 1992) because of its important role in predicting mathematics achievement (Clute, 1984). Many studies reported negative relationship between mathematics anxiety and mathematics achievement (Aiken, 1970, 1976; Hembre, 1990; İş Güzel, 2006; Ma, 1999; OECD, 2004b).

Besides affective domain factors, students' preferences for learning situations and their studying habits are also frequently investigated factors. It is apparent that students learn in different ways from each other (Pritchard, 2009) and their learning behavior is affected by their preferences for learning situations (OECD, 2005). Two of mostly cited types of them are cooperative and competitive learning situations. It is reported that, competitive challenge can have both positive and negative effects on student engagement and performance (Schaper, 2008). When compared to competitive learning, cooperative learning is more effective in gaining some intended educational outcomes such as promoting intrinsic motivation and task achievement, generating higher order skills, improving attitudes toward the subject, increasing self-esteem and time on task, and lowering anxiety (Oxford, 1997).

Many researchers agree that learning strategies are important and useful for effective learning; however, a precise definition of learning strategies is lacking (McKeachie, Pintrich, & Lin, 1985). OEDC (2004b) emphasized the importance of learning strategies since students are active participants in the learning process and in managing their own learning. It is reported that if the student's aim is to retrieve the information as presented, memorization is an appropriate strategy; however, this strategy is insufficient for deep understanding (OEDC, 2004b; Purdie & Hattie, 1996). On the other hand, elaboration strategy can be used in integrating new information into student's prior knowledge and accordingly deep understanding can be achieved (OECD, 2004b). OECD (2004b) found that the relationship between the reported use of control strategies and student performance in mathematics is weak. This result is not consistent with the results of PISA 2000 where the reported use of control strategies was strongly related to reading performance of students (OECD, 2001). In another study İş Güzel (2006) reported that control strategies, elaboration strategies, and memorization strategies were significantly related to Turkish students' performance in mathematics.

Another group of factors associated with students' achievement are related to what has been conducted in the classroom. These are the use of homework and some teacher practices conducted during the instruction. Many correlational studies investigating the association of homework variables such as amount of time spent on homework, amount of time parents spent for assisting homework, amount of homework assigned, checking and grading homework, frequency of homework with achievement were conducted (Chen & Stevenson, 1989; Cooper, Lindsay, Nye, & Greathouse; 1998; Jong, Westerhof, & Creemers, 2000; Trautwein, Köller, Schmitz, & Baumert, 2002). Besides, homework related factors, the classroom practices are also important factors associated with achievement. The classroom can be defined as the nucleus where other influences on the learning of students and outcomes from their education are found. Actually, all the contributing factors to educational outcomes exist in classroom (Webster & Fisher, 2000). Different studies investigating the relationship between various types of classroom practices such as student and teacher oriented teaching styles and student achievement were conducted (Bos & Kuiper, 1999; House, 2001).

Furthermore, there are also some other factors related to teacher characteristics such as their perceptions about the subject they taught or their teaching efficacy. Teachers' beliefs do play a significant role in shaping teaching practices, but they also affect the achievement (Staub & Stern, 2002). Staub and Stern (2002) proposed that teachers' beliefs can also directly correlate with student achievement in mathematics. Specifically, teacher efficacy is defined as teachers' beliefs with regard to the ability to influence student learning and achievement of students (Guskey, 1987). Connecting teacher efficacy to teacher instruction in the classroom, it is indicated that there are correlations between teachers' beliefs and instruction (Stipek, Givvin, Salmon, & MacGyners, 2001; Thompson, 1992).

All these aforementioned characteristics have been extensively studied by using various statistical modeling techniques to assess their multiple relationships simultaneously in explaining mostly for student achievement in mathematics. Though the investigation of individual factors that affect achievement is important, modeling suggests an advantage of examination and investigation of not only each individual factor but also the relationships among those factors (Schreiber, 2002). Literature review about mathematics achievement and modeling shows that many studies proposing theoretical models have been conducted to explain mathematics achievement and its relationships between psychological, pedagogical, social, and cognitive constructs. Most of these models were tested with the data of international studies such as TIMSS or PISA (e.g. Akyüz, 2006; Bos & Kuiper, 1999; İş Güzel, 2006; Köller, Baumert, Clausen, & Hosenfeld, 1999; Lokan & Greenwood, 2000; Papanastasiou, 2000; Rodriguez, 2004; Ryoo, 2001; Sevgi, 2009; Stemler, 2001; Webster & Fisher, 2000; Yang, 2003). Some of these models used structural equation modeling (e.g. Bos & Kuiper, 1999; Lokan & Greenwood (2000) Marsh, 1986; Meece, Wigfield, & Eccles, 1990) whereas some of them used multilevel and hierarchical linear modeling to examine student, teacher, and school level characteristics in order to investigate predominantly the mathematics achievement (e.g. Abu-Hilal, 2000; Akyüz, 2006; D'Agostino, 2000; İş Güzel, 2006; Lee & Bryk, 1989; Park, 2003; Rodriguez, 2004; Schiller, Khmelkov, & Wang, 2002; Sevgi 2009; Stemler, 2001; Van den Broeck, Van Damme & Opdenakker, 2005; Webster & Fisher, 2000).

In the current study the first aim is to display the problem solving skills of the sixth grade students within the four-process problem solving framework. Secondly, the next aim is to test the model presented in Figure 1.1 to investigate the relationships among the student and teacher characteristics and problem solving skills of the students by using hierarchical linear modeling. Though in the related literature there is no model developed specifically for explaining problem solving skills of the students, the research studies considered are those developed for explaining mathematics achievement of the students. Student characteristics used in the analyses are socioeconomic status, mathematics self concept, mathematics anxiety, intrinsic and extrinsic motivation for learning mathematics, mathematics learning strategies, preferences for mathematics. Moreover, the classroom characteristics are handled at the student level, since information regarding these factors obtained from the students. These classroom related characteristics are classroom practices such as the use of projects and technology, teacher support; and out of classroom practices such as the use of homework. On the other hand, the teacher characteristics are gender, age, teaching experience, perceptions about mathematics, and teacher efficacy. The identified factors are those previous studies frequently investigated and found important relationships with mathematics achievement of the students. Since the topic of problem solving is included in school mathematics most of the selected factors are the factors those associated with mathematics.

1.1 Research questions

Within the four-process problem solving framework and the previously developed models, there are three main research questions motivating the current study;

1. What are the problem solving skills of the sixth grade students considering the four-process problem solving framework?
2. Which mathematics teacher characteristics have significantly related to the problem solving skills of the sixth grade students?
3. What proportion of variance in problem solving skills of the sixth grade students is explained by mathematics teacher characteristics?

Additionally, there are four research questions to be answered related to the hierarchical linear modeling;

4. Are there differences in the sixth grade students' problem solving skills among mathematics teachers?
5. Which mathematics teacher characteristics are associated with differences in the sixth grade students' problem solving skills?
6. Which student characteristics are associated with the differences in the sixth grade students' problem solving skills?
7. Which mathematics teacher characteristics influence the relationship that is between student characteristics and the sixth grade students' problem solving skills?

1.2 Definition of the important terms

For clarity and consistency, a definition of the terms delineated below will provide an overview of how the terms were used by the researcher within the context of the study.

Problem: A problem is a situation or statement that requires the use of mathematical content, application, and processes to reach a conclusion. The two important criteria that a problem should have;

- The problem should be real life related, within the interest of the students, and challenging to the students.
- The problem should be presented in a concrete manner considering the mathematical level of the students.

Problem solving: Problem solving is a process from the beginning to the conclusion in which the student performs a series of action.

Four-process problem solving framework: It is a framework constructed by the researcher based on problem solving steps proposed by Polya (1957). The processes are *understanding the problem*, *devising a plan*, *carrying out the plan*, and *looking back and evaluating*.

Socioeconomic status: The term socioeconomic status (SES) refers to family's overall rank in the social and economic hierarchy (Mayer & Jencks, 1989). In the current study the descriptors of the SES construct are parents' highest education levels, the number of books at home, the number of siblings, and home possessions such as dishwasher and computer.

Mathematics self-concept: Mathematics self-concept is a construct referring to the perception of a student in his/her own competence about mathematics abilities (Dermitzaki, Leondari, & Goudas, 2009).

Mathematics motivation: Mathematics motivation is defined as the driving forces of learning mathematics (OECD, 2004b). In the current study two types of motivation are used. These are intrinsic and extrinsic motivations. Intrinsic motivation is a type of motivation associated with activities that are inherently enjoyable, interesting, or challenging (Deci & Ryan, 1985). On the other hand, extrinsic motivation refers implementing the learning activity for the sake of material or other rewards (Husman, & Lens, 1999).

Mathematics anxiety: Mathematics anxiety is defined as “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide array of ordinary life and academic situation” (Richardson & Suinn, 1972, p. 551).

Mathematics learning strategies: Mathematics learning strategies are defined as behaviors and thoughts that a learner engages in during learning mathematics and that are intended to influence the learner’s encoding process (Weinstein & Mayer, 1986). The strategies used in the current study are control, memorization, and elaboration strategies. Control strategies refer to strategies through which students can plan, monitor and regulate their learning such as checking what they have learned and working out what they still need to learn. Memorization strategies refer learning key terms and repeated learning of material. Elaboration strategies refer to making connections to related areas or thinking about alternative solutions (OEDC, 2004b).

Preferences for mathematics learning situations: Students learn in different ways from each other (Pritchard, 2009) and their learning behavior is affected by their preferences for learning situations (OECD, 2005). This term refers to students' preferences in learning mathematics such as cooperative and competitive learning situations. The descriptors of preferences for cooperative learning situations are reports of students such as learning most when working with others or enjoying working with others. On the other hand, preferences for competitive learning situations are reports of students such as trying to do better than the others or liking to be the best in the classroom.

Mathematics homework: The descriptors of the term mathematics homework are the frequency, amount, type, and the use of mathematics homework assigned to the student by their mathematics teachers.

Mathematics classroom practices: Mathematics classroom practices refer some practices such as the use of board, calculator, computer, overhead projector, individual working, group working, giving real-life examples conducted in the classroom during mathematics instruction. In addition to such practices, some supportive practices of mathematics teacher such as helping student when they need help, repeating what he or she told until they understand or giving them opportunity to explain their ideas are also considered.

Teaching experience: Teaching experience refers to the number of years the teacher spends in the teaching profession.

Teachers' perceptions about mathematics: This general term covers three different parts as to what the mathematics teachers think about mathematics and mathematics teaching. These are teachers' perceptions about the necessary skills for students to be good at mathematics, various factors limit classroom instruction for mathematics, and the nature of mathematics and mathematics teaching. Teachers' perceptions about necessary skills for students to be good at mathematics are measured by asking them to what extent some practices such as remembering formulas and operations or thinking creatively are important. Teachers' perceptions regarding various factors limit classroom instruction for mathematics are measured by asking them to what extent some issues such as unsuccessful students in mathematics, crowded classrooms, or inadequacy of mathematical materials limit mathematics instruction. Finally, teachers' perceptions about the nature of mathematics and mathematics teaching are measured by asking them to what extent they agree some ideas such as mathematics is an abstract subject or when teaching mathematics topics more than one representation should be used.

Teacher efficacy beliefs: This term refers a two-dimension construct; general teaching efficacy and personal teaching efficacy. General teaching efficacy represented a teacher's sense or belief that any teacher's ability to bring about change is limited by external factors such as home environment, family background, and parental influence. Personal teaching efficacy represented a teacher's sense or belief that she or he has the skills and abilities to bring about student learning (Dembo & Gibson, 1984).

1.3 Significance of the study

Turkey has undergone some reform movements to improve the content and the quality of mathematics curricula. Certainly, problem solving is considered as one of the most important issues in the new Turkish mathematics curriculum. Besides this, the performances of the Turkish students have been quite low as measured in international studies. The low performance of Turkish students makes it clear that problem solving should be studied from various perspectives so that it can be possible to improve their performances on problem solving.

First of all, the present study aims to display the performances of the sixth grade students within the four-process problem solving framework. The second aim is to develop the model explaining the factors related to problem solving skills of the sixth grade students by using two-level HLM. It is assumed that the final model would be helpful to understand how the student and the mathematics teacher characteristics associated with the complex nature of problem solving skills of the students. The results of the study might provide a general and comprehensive picture of problem solving skills of the students together with possibly related factors such as students' affective domain characteristics, learning preferences, classroom practices in their mathematics classrooms, use of homework, teachers' characteristics and perceptions related with mathematics, mathematics instruction, and their teacher efficacy beliefs. Learning about factors positively or negatively related to problem solving skills of the students might be helpful for mathematics teachers to assist their students effectively in improving their problem solving performances. For instance they might try to foster contributing student characteristics or emphasize the contributing classroom practices in the mathematics classrooms whereas they might try to suppress the inhibiting factors. Moreover, the results of the model might open the ways for the researchers in the mathematics education to reinvestigate the significant factors in further research studies for more in-depth conclusions. Since many models have been developed for explaining students' achievement especially in mathematics, the current study has an importance for being the first in the attempt in handling the problem solving skills of the students in the modeling studies. Eventually, it is assumed that educators in mathematics will benefit from the knowledge of inhibiting and contributing factors related to the problem solving skills of the students.

Another advantage of the current study is the use of HLM technique. This statistical technique has been extensively used by the researchers in the educational area to analyze the data formed in nested structure. The advantage of this technique is to overcome the shortcomings of traditional regression analysis methods providing more powerful and precise results. Finally, it is believed that the current study would shed light regarding how the student and teacher characteristics should be handled in order to increase the problem solving skills of the sixth grade Turkish students.

CHAPTER 2

LITERATURE REVIEW

The first purpose of this chapter is to provide a base for the problem solving framework used in the present study. The various definitions of *problem* and *problem solving* are presented together with various models proposed for problem solving processes. The second purpose is to review the student and teacher characteristics associated with students' achievement especially in mathematics. This review is used to construct a theoretical model to investigate relationships between student and teacher characteristics and problem solving skills of the students.

2.1 What is problem?

The review of voluminous literature about problem and problem solving displays that there are many different definitions of both problem and problem solving including different aspects of the both terms. Schwieger (1999) pointed out the ongoing difficulty with the terminology associated with problem solving and defined the problem as "a situation or statement which calls for the use of mathematical content, application, and processes to resolve a blockage or reach a conclusion" (p. 113) by stressing the use of mathematics. Different from Schwieger (1999), Posamentier and Krulik (1998) defined problem as "a situation that confronts a person, that requires resolution, and for which the path to the solution is not immediately known" (p. 1) without referring the use of mathematics. Kilpatrick (1985) defined problem as "a situation in which a goal is to be attained and a direct route to the goal is blocked" (p. 2). He added that for a problem to be mathematical, mathematical concepts and principles should be used in seeking the answer. From this point of view he characterizes problem as an activity of a motivated subject. Kilpatrick (1985) also stresses the instable aspect of problem that is a problem for you today may not be one for me today or for you tomorrow. Similar to this idea, Krulik and Rudnick (1989) stress that once a problem is solved by the student; the situation will no longer be considered as a problem for him or her. This characteristic of the problem has been accepted by researchers in mathematics education for a long time (Kilpatrick, 1985).

Krulik and Rudnick (1989) state that until recently the difficulty in the problem solving has been the nonagreement about the definition of the problem. However, they note that many of the mathematics educators accept the following definition of the problem. "A problem is a situation, quantitative or otherwise, that confronts an individual or group of individuals, that requires resolution, and for which the individual sees no apparent path to the solution" (Krulik & Rudnick, 1989, p. 3). Moreover, they distinguish problem from question or exercises emphasizing that problem requires *analysis* and *synthesis* of previously learned knowledge to resolve. At the same time they investigate the nature of problem from the students' point of view. In order to be considered as a problem by a student, a problem must satisfy three criteria; *acceptance*, *blockage*, and *exploration*. The *acceptance* refers to that the student should accept the problem for some various reasons such as, motivation, desire and so on. *Blockage* refers to that the student's first attempts to solve the problem are ineffective. Finally the last criterion *exploration* refers to that the acceptance of the student forces him or her to explore new strategies to reach the solution (Krulik & Rudnick, 1989).

Emphasizing the beginning and the final situation in problem, Bransford and Stein (1984) stated that "a problem exists whenever the present situation is different from a desired situation" (p. 3). Similarly, Mayer (1985) indicated that "a problem occurs when you are confronted with a given situation – let's call that the given state – and you want another situation – let's call that the goal state – but there is no obvious way of accomplishing your goal" (p. 123). In his definition, Mayer emphasized that there is no direct route from the given state to the goal state. Referring the components of a problem, Wickelgren (1974) states that a problem composed of three information; *givens*, *operations*, and *goals*. In this definition, *givens* refer to the set of expressions present in the problem, *operations*, refer to the actions to be performed on the givens, and *goals*, refer to the terminal expression one wishes to reach. Newell and Simon (1972) defined problem from the view of information processing theory as "a person is confronted with a *problem* when he wants something and does not know immediately what series of actions he can perform to get it" (p. 72).

Marzano et al. (1988) pointed out that problems are classified into two broad categories, well-defined and ill-structured and students should receive systematic practice in both types. Frederiksen (1984) pointed out that instruction in problem solving generally emphasizes well-structured problems – "the kind of problem which is clearly presented with all the information needed at hand and with an appropriate algorithm available that generates a correct answer, such as long division, areas of triangles, Ohm's law and linear equations" (p. 303).

Noddings (1985) stressed that since school word problems are highly structured and predefined, they do not constitute a "problem" situation for students. On the other hand she emphasizes that the use of school word problems has an efficient role in teaching "problem solving", illustrating mathematical concepts and their application, deepening and broadening students' understanding of concepts and ability to manipulating symbols. In line with Noddings (1985), Krulik and Rudnick (1989) stress that many of the problems given in mathematics textbooks can not be considered as problems because generally the model developed and presented by teacher in classroom. In this manner the students only apply the presented model to solve the problem and by this way they practice an algorithm or a technique. Thus, such so-called problems those called "routine problems" by some of researchers do not require higher-order thought by the students (Krulik & Rudnick, 1989). Similar to Krulik and Rudnick, Polya (1966) stated that "the routine problem has practically no chance to contribute to the mental development of the student" (p. 126).

In the light of these different definitions of the problem some researchers listed some characteristics of a good problem and some important criteria that problems should have. Krulik and Rudnick (1989) summarized characteristics of a good problem;

1. The solution to the problem involves the understanding of distinct mathematical concepts or the use of mathematical skills.
2. The solution of the problem leads to a generalization.
3. The problem is open-ended in that it affords an opportunity for extension.
4. The problem lends itself to a variety of solutions.
5. The problem should be interesting and challenging to the students (Krulik & Rudnick, 1989, p. 9).

Schwieger (1999) proposed some several important criteria that problems should have;

1. The problem should be practical and real life related (not contrived and within the interest range of the children).
2. The problem should be set at the mathematical level of the children.
3. The problem should include a variety of topics and subject areas.
4. The problem should vary in the types of skills and strategies likely to be required for solution.
5. The problem should be presented in varying formats
6. The problem should be stated in words or symbols children are familiar with or can research (p. 118).

It was noted that, not every good problem need have all of these characteristics and in many cases these characteristics will overlap (Krulik & Rudnick, 1989).

2.2 What is problem solving?

Although there is an increasing common consensus for teaching problem solving in school mathematics, a consensus on the definition of *problem solving* has not been reached in the literature by the researchers in the field (Mayer, 1985; Posamentier & Krulik, 1998; Schoenfeld, 1992). Schoenfeld (1992) mentioned that "in literature the term *problem solving* has been used with multiple meaning ranging from *working rote exercises* to *doing mathematics as a professional*" (p. 334).

By using very general terms Schwieger (1999) defined problem solving as "the process of using tools, knowledge, problem solving skills, and strategies to find or develop the solution to a problem" (p. 113). Similarly, Lester (1985) stated that "problem solving takes place when there is uncertainty involved" (p. 46). Consistent with his definition of problem Mayer (1985) defined problem solving as "the process of moving from the given state to the goal state of a problem" (p. 124). In a more detailed view, Grugnetti and Jaquet (1996) defined problem solving as an activity, in which the student encounters an obstacle that includes a conflict between student's initial ineffective knowledge and the new knowledge, and this conflict make him or her progress. It is emphasized that the major principle is that, the student constructs his or her own knowledge during this activity.

Some researchers stressed the nature and complexity of problem solving (Charles, Lester & O'Daffer, 1987; Lester & Kroll, 1990; Marzano et al., 1988; Posamentier & Krulik, 1998). For instance, Charles, Lester and O'Daffer (1987) referred problem solving as a complex form of intellectual activity. Similarly, Lester and Kroll (1990) indicated that problem solving is an activity which is very complex by its nature. This activity involves not only simple recall of facts and application learned procedures, but also coordination of previous experiences, knowledge, and intuition. Therefore, the ability of problem solving develops gradually over a long period of time (Charles, Lester, & O'Daffer, 1987).

Marzano et al. (1988) consider *problem solving* as one of the thinking processes. They stated that thinking process is the set of mental operations involving the use of several thinking skills and it is often rich, multifaceted, and complex. They also added that problem solving involves the production or application of knowledge (Marzano et al., 1988). Posamentier and Krulik (1998) emphasize reasoning that involves a broad range of thinking in problem solving.

In some of the definitions of problem solving the active role of the students has been emphasized. Grugnetti and Jaquet (1996) pointed out that, on contrary to traditional instruction in which the student is passive receiver of the transmitted knowledge, problem solving places the student in an active role constructing his or her own knowledge. Then, they define problem solving as a new activity which is meaningful to the students. According to Grugnetti and Jaquet (1996) this activity should be close to students' current knowledge to be assimilated and also should be different in order to make them transform their methods of thinking. The idea that problem situation requires reexamination of student's current body of knowledge to construct a more efficient body of knowledge reflects the constructivist approach of the problem solving (Grugnetti & Jaquet, 1996). According to Krulik and Rudnick (1989) problem solving is "a process in which an individual uses previously acquired knowledge, skills, and understanding to satisfy the demands of an unfamiliar situation" (p. 5). They emphasize that this process requires students to synthesize what they learned and to apply it to the new and different situations.

Marzano et al. (1988) proposed that educators generally refer to problem solving as specific types of tasks presented to students in different courses such as mathematics, science or social sciences and they called attention that the cognitive psychologists and educators approach problem solving from different perspectives. For instance, Anderson (1983) defined any goal-directed behavior as problem solving. Wickelgren (1974) described problem solving as using set of operations to reach a specific "goal state" However these differences may be used in favor of improving problem solving skills of students (Reif, 1980). Reif (1980) indicated that both cognitive scientists and educators are interested in gaps in the area of problem solving; however, these two types of people differ with respect to their concerns. The aim of cognitive scientists is to formulate explicit theoretical models applied with computer implementation rather than human subjects. In contrast to cognitive scientists, educators directly concerned with real life teaching application with human students (Reif, 1980). He suggests that bridging these gaps coming from views of two types of researchers and collaboration between them may enhance human problem-solving capabilities and improve educational effectiveness.

2.3 Importance of problem solving

The change or progress in mathematics curricula differs with respect to different nations and these differences may depend on political, economical, and social considerations of the nations. However, the emphasis given to problem solving and the idea for integrating problem solving in the mathematics curricula are common issues for all nations. For instance, both National Council of Teachers of Mathematics (1989) and National Research Council (1989) give strong emphasis to problem solving. Turkish Ministry of National Education (MNE) improved the content and the quality of the mathematics instruction. The problem solving was considered as the one of the major focuses of the new mathematics curriculum (Ministry of National Education, 2005; 2008).

Charles, Lester, and O'Daffer (1987) emphasize that problem solving should be the focus of school mathematics and this idea is taken up seriously by all people in the educational area. The reason for the necessity of problem solving in mathematics education is the role of it in linking mathematical knowledge to everyday situations. In their everyday lives students encounter with many problem situations and very few those problem situations refer to school mathematics subjects (Krulik & Rudnick, 1989). Krulik and Rudnick (1989) state that "problem solving is the link between facts and algorithms and the real-life problem situations we all face" (p. 6). However, it is known that students can make little connection between what they learn in mathematics classroom and encounter in their real lives. If a more emphasize is given to problem solving in mathematics classroom, students would be more successful in making the related connections between the classroom world and real world (Krulik & Rudnick, 1989). Similarly, Rubinstein (1980) noted that it is no more important to teach students stored knowledge and fixed values since there is a rapid social and technological change in the era. Depending on this idea, Rubinstein (1980) emphasized that problem solving approach can help students transfer the knowledge that is taught in school to related situations in real life by developing the ability to cope with the problems. His recommendation about this issue is not to teach problem solving as a discipline but rather as a framework in an interdisciplinary manner. In a more specific manner to teaching problem solving, Noddings (1985) stressed that the objective of school problem solving should not be to reach the solution of the problem but should make students gain powerful problem solving processes by the use of cognitive reorganization.

Schwieger (1999) pointed out that the traditional approach assumes that if the students well learn the mathematical content and processes, they would also transfer this knowledge into ability to solve real life problems; however, this is not the case. Mathematics educators realize the importance of preparing students to solve problems when they recognize that many students graduated from high schools have difficulties in overcoming real life problems related with mathematics (Schwieger, 1999). Additionally, he noted that teaching of problem solving is formed at the same time of teaching of other mathematical concepts and processes. That is, problem solving is highly interconnected with other mathematics.

The importance given to problem solving in mathematics curricula is not taken into consideration only for elementary school level, it is reported that both secondary and higher education level should also include problem solving practices (Grugnetti & Jaquet, 1996; Kozmetsky, 1980). For instance, Kozmetsky

(1980) emphasized that one of most important objectives of the higher education is to connect the knowledge and the reality of problem-solving practices to prepare students for active and effective participation in modern society. Since no person can acquire a set of problem-solving kits and find a suitable match for any given situation, the students should be helped to develop their own problem-solving constructs to adapt their abilities for complex situations in their professions.

Grugnetti and Jaquet (1996) noticed that in recent years professional associations, committees, and individuals related with mathematics education has emphasized the importance of problem solving in mathematics curricula. On the other hand, it is pointed out that the progress of research in mathematics education has been quite slow and there is many questions waiting to be resolved related with problem solving and its all components including learning and teaching (Grugnetti & Jaquet, 1996). Some researchers discussed these issues from various perspectives. According to Posamentier and Krulik (1998) there are two obstacles in integrating problem solving successfully into school curriculum. The first one is the weaknesses in training teachers received in problem solving. The second obstacle is the lack of attention paid to the ways in which problem solving skills can be incorporated into school curriculum. Posamentier and Krulik (1998) recommended that teachers should know the meaning of problem solving, the reason for using problem solving, and the presentation of problem solving to the students. The three ways that problem solving can be taught of are;

1. Problem solving is a subject for study in and of itself.
2. Problem solving is an approach to a particular problem.
3. Problem solving is a way of teaching (Posamentier & Krulik, 1998, p. 3).

Larkin (1980) mentioned that there are three major difficulties encountered in problem solving in classroom practices. The first difficulty is that even best teachers with considerable experience have limited success in teaching problems solving to students especially in the areas of mathematics and physics. The second one is that educational research has not used methods that are useful in offering productive informative in effective problem solving processes. There are some studies however neither of them provides good insights into the processes of effective problem solving, how these processes are acquired, or what types of difficulties incompetent problem solvers encountered. The final difficulty is that although there are some instructions that are useful for students to solve problems, there is no considerable information about how these instructions work (Larkin, 1980). In a similar vein, Grugnetti and Jaquet (1996) stressed the importance of teacher training in adapting problem solving into mathematics curricula.

From the assessment point of view, Charles, Lester, and O'Daffer (1987) noted some obstacles in the implementation of problem solving in school mathematics successively. The first is the prevalent use of answer-focused paper-and-pencil tests as the most common assessment technique. Secondly, process oriented view of problem-solving evaluation is rarely used by very few teachers.

Referring to the classroom practices in problem solving, Grugnetti and Jaquet (1996) noted that using problem situations in classrooms presents some difficulties. For instance, using problem solving requires much time in terms of preparation for teacher, identifying about students' prior knowledge, managing classroom, operating the problem situation, and evaluating students' performances. Bransford and Stein (1984) emphasized that problem solving can be learned; however it is not taught at schools. Instead, in schools the students are taught "what to think" rather than "how to think." Similar to Bransford and Stein, Lester (1985) criticizes mathematics instruction for training students to be rigid in their thinking instead of being flexible and adaptable, teaching them how to perform procedures instead of when and under what conditions to perform them, and showing them what to do instead of why to do it. Bransford and Stein (1984) mentioned that although the teachers may use problem solving processes unconsciously, they are not aware of these processes and thus they do not teach these processes explicitly to the students. They added that in formal educational settings how concepts and procedures can be used in problem solving is ignored. Students often encounter concepts but they do not have any idea of the types of problems they are asked to solve.

Another reason proposed for dissatisfying instruction performance on problem solving is proposed by Greeno (1980). He proposed that there is lack of sufficiently developed theory about processes such as planning and representation that are involved in good problem solving. Similarly, Schoenfeld (1992) noted that there is a general acceptance about educating students as competent problem solvers in mathematics education literature. However, he pointed out the difficulties of educating students as competent problem solvers. These difficulties are the existence of various definitions of the term “problem solving”, unclear role of “problem solving” in the mathematics curricula and as a result inexplicitness of ways how it can be integrated into the subjects of mathematics in the curricula (Schoenfeld, 1992).

2.4 Problem solving processes

In the problem solving process the problem solver should carry on a series of tasks and maintain some thought processes that are closely linked together to form what is called a *set of heuristics* (Krulik & Rudnick, 1989). Heuristics provide a general approach and guide problem solvers in understanding the problem, developing appropriate solution strategy and obtaining the answer for the given problem (Krulik & Rudnick, 1989). Krulik and Rudnick (1989) noted that applying heuristics is a difficult skill and teaching this skill takes a long time. There are many ways of executing a problem situation; as a result of this in education literature many models of problem solving processes are proposed. In fact, most of the proposed models have common phases or steps. This idea is supported by Krulik and Rudnick (1989). They stated that “there is no single set of heuristics for problem solving, although several people have put forth workable models” (p. 23). They also added that “over the years several sets of heuristics have been developed to assist students in problem solving, in the main, they are quite similar" (p. 24).

Krulik and Rudnick (1989) proposed a set of heuristics. They pointed out that this heuristics plan represents a continuum of thought that is its parts are not discrete. The set of heuristics proposed by Krulik and Rudnick (1989) and tasks or question related to each part are given in the following;

1. *Read the problem*: Note key words, describe the problem setting, visualize the action, restate the problem in your own words, questions to be answered are "what is being asked for?" or "what information is given?"
2. *Explore*: Organize the information, draw a diagram or construct a model, make a chart or a table, questions to be answered are "is there enough information?" or "is there too much information?"
3. *Select a strategy*: Pattern recognition, working backwards, guess and test, simulation and experimentation, reduction/solve a simpler problem, organized listing/exhaustive listing, logical deduction, divide and conquer.
4. *Solve*: Carry out your strategy, use computational skills, use geometric skills, use algebraic skills, and use elementary logic.
5. *Look back*: Check your answer, find another way, extend, and generalize (p. 24).

Charles, Lester and O'Daffer (1987) pointed out that problem solving is a very complex activity involving many different capabilities such as recalling facts, using a variety of problem solving procedures, evaluate one's own thinking and progress while solving problem. Based on review of literature Charles, Lester and O'Daffer (1987) identify problem solving process in seven important thinking skills;

1. *Understand / formulate the question in a problem*: This basic task refers making sense of what is asked in the problem, understanding the meaning

of specific words, and recognizing how question relates to other statements in the problem.

2. *Understand the conditions and variables in the problem*: In this process the problem solver makes sense about how the condition and variables relate to each other and grasps meaning of the information given in the problem. Shortly, he or she internalizes the problem.
3. *Select or find the data needed to solve the problem*: This process is closely related to the previous process. After the problem solver understands the conditions and the variables, he or she must be able to identify necessary data, eliminate unnecessary data, collect and use data from different sources such as graphs, maps or tables.
4. *Formulate subproblems and select appropriate solution strategies to pursue*: This process refers to the planning of the solution strategy. The problem solver must identify the subproblems and subgoals to be solved if the problem includes any. Then he or she decides which solution strategy or strategies might be tried. The important point is that the problem solver should know how to and when to use the identified strategy.
5. *Correctly implement the solution strategy or strategies and solve subproblems*: In this phase, the problem solver implements the identified strategy or strategies. This process may involve many cognitive skills such as performing computations, using logical reasoning, solving equations, and activities such as making a list or table, drawing a graph, and so on.
6. *Give an answer in terms of the data in the problem*: The problem solver should able to give the answer considering the characteristics of the variables and what is asked in the problem. For instance, he or she uses the correct unit or expressing the answer in a complete sentence.
7. *Evaluate the reasonableness of the answer*: The problem solver should be able to assess whether the answer is reasonable or not. To assess the reasonableness of the answer the problem solver may check the answer

considering the conditions and variables given in the problem or may use estimation techniques.

Similar to Charles, Lester and O'Daffer (1987), Lester and Kroll (1990) propose the same cognitive processes. In addition to these similar processes they add an eighth process referring to maintaining adequate control over the solution effort. This is also an important point of view that Charles, Lester and O'Daffer (1987) have already mentioned and stressed.

Grugnetti and Jaquet (1996) specified a framework of problem situation used with the topics taught at primary and lower secondary classes. The phases proposed by Grugnetti and Jaquet (1996) are given below;

- the appropriation phase, in which the student reformulates the problem in his/her own language;
- the research phase, in which the student develops new models and tools;
- the formulation phase, which allows the student to clarify and validate the new knowledge;
- the institutionalization phase in which the teacher specifies the knowledge to be retained;
- the structuring phase, which allows the student time to assimilate the new knowledge (p. 621).

Most frequently used and referred theories of problems solving trace their roots to Dewey's (as cited in Noddings, 1985, p. 346) basic plan. The steps of this plan are given below;

1. Undergoing of feeling a lack – identifying a problematic situation.
2. Defining the problem.
3. Engaging in means-ends analysis; devising a plan.
4. Executing; carrying out the plan.

5. Undergoing or living through the consequences.
6. Evaluating: looking back to assess whether the result satisfies the initial conditions; looking ahead to generalization of both methods and results.

In problem solving literature mostly cited name is George Polya. Similar to Dewey (as cited in Noddings, 1985), Polya (1957) concentrates his attention on problem solving processes and proposes a four-stage model. The steps and related questions to be answered in the each step are given in the following;

1. *Understanding the problem*: "What is the unknown?", "What are the data?", "What is the condition?", "Is it possible to satisfy the condition?", "Is the condition sufficient to determine the unknown?", or "Is it insufficient?"
2. *Devising a plan*: "Have you seen it before?", "Have you seen the same problem in a slightly different form?", "Do you know a related problem?", "Do you know a theorem that could be useful?"
3. *Carrying out the plan*: "Can you see clearly that the step is correct?"
4. *Looking back*: "Can you check the result?", or "Can you check the argument?" (p. xvi).

Emphasis on "being observable" Noddings (1985) noted that Polya's four-stage model may be reduced to three stages since the step "understanding the problem" cannot be directly observable. Then the new model is;

1. Translating words to mathematical expressions.
2. Executing; that is calculating.
3. Checking results in initial equations. (p. 347).

Basing on information-processing models, Mayer (1985) states that cognitive psychologists emphasize only two major steps in problem solving processes;

1. Representation (understanding the problem).
2. Solution (searching for a means to solve the problem (p. 124).

Noddings (1985) proposes a four-stage model by modifying the two-stage information processing model of Mayer (1985) by retaining the undergoing and evaluating stages;

1. Creation of a representation.
2. Executing a plan based on the representation.
3. Undergoing the consequences.
4. Evaluating the results. (p. 349).

Referring to school problems, Noddings (1985) emhazised that the problems solved in mathematics classrooms are very artificial. He noted that the students should live their own problem solving processes and they should internalize these processes by themselves.

Teare (1980) summarizes the problem solving stages on a given engineering problem;

1. Define the problem and devise a goal.
2. Plan an attack by choosing a principle, planning how it will be used, and making simplifying assumptions.
3. Execute the plan.
4. Check thoroughly.
5. Look into the effect of assumptions, draw conclusions, and, what is very important, see what has been learned that may be useful in other problems (p. 170).

Teare (1980) notes that, these given stages are the same steps given by Polya for solving problems although they were developed independently by various researchers.

Heller and Hungate (1985) stress that knowledge for understanding and representing problems has vital importance in reaching the correct and reasonable solution of the problem. The problem solver understands the given problem and creates a representation of the problem. This representation plays a mediating role between the problem situation and its solution. Addtionally, Heller and Hungate (1985) differentiate the nature of knowledge required for solving problems in complex subject-matter domains. These knowledge types are strategic knowledge, knowledge of basic concepts and principles, and repertoires of familiar patterns and known procedures.

Greeno (1980) draws attention to two developments in the analysis of problem solving. One of these developments is the concept of planning in problem solving and the other is the analysis of processes of representing problem situations. Although the planning process displays differences in different individuals depending on the knowledge that the solver has about the situation, the process of decomposing a problem into manageable subgoals is a significant view in the planning process. The process of representation of problem involves forming a cognitive structure of important relationships among problem elements.

Basing on the results of the studies related with problem solving, Teare (1980) concludes that there is still no methodology of general problem solving that can be taught and used. On the other hand, Krulik and Rudnick (1989) pointed out that number of steps or the actions those should be conducted for each step is not important. According to them, the important thing is that students should learn their own heuristic model, develop an organized set of questions to ask themselves in the related steps and use their model when encounter a problem.

As previously mentioned, a simple and clear definition adopted for the present study. In this sense, a problem is a situation or statement that requires the use of mathematical content, application, and processes to reach a conclusion. The two of the criteria considered to evaluate whether the given situation is a problem or not are as follows;

- The problem should be real life related, within the interest of the students, and challenging to the students.
- The problem should be presented in a concrete manner considering the mathematical level of the students.

After giving detailed information about the problem and problem solving, importance of the problem solving, and the problem solving processes, from this point forward, the constructs taking place in the theoretical model of the study will be explained in detail.

2.5 Socioeconomic status

The term socioeconomic status (SES) is used by sociologists to refer individuals or family's overall rank in the social and economic hierarchy (Mayer & Jencks, 1989). Up to now very similar descriptors have been used for measuring SES. Parents' occupations, educations, incomes, number of books and computers in the homes, and newspapers read regularly are commonly used SES indicators (Kohr, Coldiron, Skiffington, Masters, & Blust, 1988). Similarly, Mayer and Jencks (1989) pointed out that in most of the research studies SES is measured by a combination of parents' education and occupational prestige, and family income.

As it is seen in Figure 1.1, socioeconomic status is one of the most important student background characteristics that the correlation of it between students' achievement has been repeatedly investigated. Most studies reported that it demonstrated to have a high correlation with students' achievement (Reynolds & Conaway, 2003). Many researchers have concluded that SES affects achievement, not only in mathematics (Crane, 1996; Demir, Kılıç, & Depren, 2009; İş Güzel, 2006; O'Conner & Miranda, 2002; Okpala, Smith, Jones, & Ellis, 2000; Yang, 2003), but other disciplines as well such as science (Yang, 2003) or reading (Okpala, Smith, Jones, & Ellis, 2000).

Crane (1996) analyzed the effect of SES on students' mathematics skills. The data used in the study are from subsamples of the National Longitudinal Survey of Youth (NLSY). The results of the analysis supported the hypothesis that SES had significant effect on the mathematics test scores of 5- to 9-year-old children.

Demir, Kılıç, and Depren (2009) investigated the contribution of some factors together with student background to the explanation of the variance in Turkish students' mathematics performance by using PISA 2003 data. The variable of student background refers to highest educational level of parents, the highest occupational level of parents, home educational resources, and cultural possessions. The results of the multiple regression analysis displayed that all of the factors including student background accounted for approximately 34 % of the variance in mathematics performance and all of them had statistically significant effects on the performance.

Another study investigating relationship between highest parental occupational status, highest educational level of parents, socioeconomic and cultural status, computer facilities at home, cultural possessions of the family, home educational resources and mathematical literacy is conducted by İş Güzel (2006). She investigated the impact of human and physical resource allocations and their interaction on students' mathematical literacy skills across Turkey, member and candidate countries of European Union by using data of PISA 2003. She used hierarchical linear modeling techniques for student and school level characteristics. Based on the findings of the analyses, she reported that among these variables the index of home educational resources referring students' reports on the availability of items such as dictionary, quiet place to study, desk for study, calculator, and books to help with school work was found to be significantly and positively related to mathematical literacy performance for Turkish students. İş

Güzel (2006) reported that this finding is consistent with the previous studies. Differently from the relationship found for Turkish students, highest parental occupational status, highest educational level of parents, computer facilities at home, and home educational resources were found to be significantly related to mathematical literacy performance of students in the member countries of European Union. Among these factors highest parental occupational status, computer facilities at home, and home educational resources were positively related whereas the factor highest educational level of parents was negatively related to mathematical literacy performance. She suggested a further investigation for this unexpected negative relationship. Finally, the factors highest parental occupational status, computer facilities at home, and home educational resources were significantly and positively related to mathematical literacy performance of students in the candidate countries of European Union (İş Güzel, 2006).

O'Conner and Miranda (2002) investigated the linkages among a set of factors together with socioeconomic status and mathematics achievement of 1522 seniors participated in National Education Longitudinal Study of 1988 (NELS: 88). They reported that one of the key findings was the negligible influence of SES on mathematics achievement.

Okpala, Smith, Jones, and Ellis (2000) examined the effects of some school, teacher, and family demographic characteristics on the changes in reading and mathematics achievement scores of 4256 fourth grade public school students. The Pearson Product-Moment Correlation analysis displayed that there existed a link between selected school and teacher characteristics, student demographics, and student achievement. Specifically, the percentage of students on free or reduced lunch was negatively correlated with mathematics and reading achievement, whereas, the percentage of parents with post high school education was positively correlated with mathematics and reading achievement.

Yang (2003) examined the relationship between SES and mathematics and science performances of 13-year old students participated TIMSS from 17 countries. SES found to have a significant interaction with both mathematics and science achievement at the individual and at the school level as well. In the study a set of home possession items was used as SES indicators from TIMSS student questionnaire.

All of the mentioned studies above are the results of the comprehensive studies with large sample sizes including students from different cultures. Therefore, the results can be used to claim that SES has a high correlation with student achievement. Not all of the studies in literature examined the relationship with SES and student achievement. There are also studies investigating the relationship between SES and students' experiences and engagements during classroom instruction (Anyon, 1981; Lubienski, 2000). For instance, Anyon (1981) reported that students of lower SES received rote instruction whereas higher SES students were actively involved in problem solving.

Lubienski (2000) focused on the class differences in students' experiences in one problem-centered mathematics classroom. She examined the differences in lower SES and higher SES students' experiences in one-problem centered mathematics classroom. In her exploratory study she used interviews, various surveys, student work, teaching-journal entries, and daily audio recordings to document students' experiences. The detailed analysis displayed that students coming from families with higher SES tended to display confidence and solved problems considering the mathematical ideas, whereas students coming from families with lower SES preferred more external direction and sometimes they missed some mathematical ideas while solving problems.

2.6 Mathematics self-concept

The review of research literature related to self-concept has showed that the terms "self concept of ability," "self-competence," and "self-perception" have all been used to refer children's self-schemata concerning their academic abilities (Rytkönen, Aunola, & Nurmi, 2007). Together with the use of these terms interchangeably, also there is variability among the definitions of self-concept given in literature by various researchers. However, Shavelson, Hubner and Stanton (1976) noted that many of the definitions overlap in various ways and therefore it is possible to construct a definition of self-concept by integrating common features of the definitions. They developed a definition of self-concept from existing definitions. In broad terms, their definition was that "self-concept is a person's perception of himself" they also added that "these perceptions are formed through his experience with his environment" (p. 411). Similarly, Dermitzaki, Leondari, and Goudas (2009) defined self-concept as a construct referring one's perceived competence in a domain.

By the examination of self-concept as a construct, some properties of self-concept were discovered (Bong & Clark, 1999; Shavelson, Hubner, & Stanton, 1976). The hierarchical model of Shavelson, Hubner and Stanton (1976) divided general self-concept into two; academic self-concepts and nonacademic self concepts. The most cited self-concept in education is academic self-concept and it is defined as individual's perception of self with respect to achievement in school (Reyes, 1984). This hierarchical structure of self-concept made it easy for researchers to investigate this construct (Shavelson, Hubner, & Stanton, 1976). Referring the complex nature of self-concept, Bong and Clark (1999) noted that self-concept is a complex construct including both cognitive and affective responses about the self and is mainly influenced by social comparison.

In line with the definition of general self-concept, mathematics self-concept has been defined by various researchers. According to Reyes (1984), mathematics self-concept refers "how sure a person is of being able to learn new topics, perform well in mathematics class, and do well on mathematics tests" (Reyes, 1984, p. 560). Similarly, Dermitzaki, Leondari, and Goudas (2009) defined mathematics self-concept as the beliefs in one's competence about mathematics abilities.

Since self-concept, either as an outcome or as a predictor variable is referred as one of the most important constructs in the learning processes

(Shavelson, Hubner, & Stanton (1976), it is involved in Figure 1.1. The reason for this importance comes from the consistent positive relationship with academic achievement (Byrne, 1984). Byrne (1984) noted that since there is a linkage of self-concept to academic achievement, it is an important construct in education. She also stressed that changes in self-concept can lead to changes in academic achievement. Shavelson, Hubner and Stanton (1976) emphasized that whether used as an outcome or as a mediator variable in explaining achievement outcomes, it is highly important variable in educational research area.

Because of its importance in learning process, many correlational and experimental studies especially investigating the relationship between self-concept and achievement have been conducted (Byrne, 1984; Dermitzaki, Leondari, & Goudas, 2009). Dermitzaki, Leondari and Goudas (2009) reported that extant literature supports both direct and indirect relationships between the academic self-concept and academic achievement. It was noted that most of the studies investigating the relationship between self-concept and academic achievement were correlational studies (Bong & Clark 1999; Byrne, 1984). Byrne (1984) also added that these correlational studies could be categorized into two groups; determining association between self-concept and achievement and establishing causal direction between these two constructs. Byrne (1984) reviewed both correlational and experimental studies and reported that there is an average, positive, and persistent relationship between self-concept and academic achievement for various populations. Focusing on the results of the studies she reviewed, Byrne (1984) reported that students hold certain attitudes about themselves and their abilities, these attitudes have a strong effect on their academic achievement in school. Vice versa, achievement in school has an influence on attitudes students develop about themselves and their abilities. Although the results of the studies revealed positive relationships, Byrne (1984) noted that the causal predominance between self-concept and academic achievement still had not been fully confirmed. To validate the causality between self-concept and achievement, Marsh, Byrne and Yeung (1999) reanalyzed the data obtained by Byrne in 1986 and reported that their final models revealed some important results. Their analyses revealed mixed results. One of their model provided evidence for the effects of prior self-concept on subsequent achievement whereas another model displayed that there were no effects of prior self-concept on subsequent achievement or prior achievement on subsequent self-concepts (Marsh, Byrne, & Yeung, 1999).

Some criticisms have come into stage with respect to the nature of the relationship between self-concept and achievement (Wigfield & Karpathian, 1991) and different instruments used to measure self-concept (Shavelson, Hubner, & Stanton, 1976). Wigfield and Karpathian (1991) pointed out that it was questioned that how students' self-concepts relate their school achievement and there was a running debate in educational area about the direction and causality of this relation. Some researchers claimed that achievement determines self-concept, whereas others argued that increases in self-concept can improve achievement. According to Wigfield and Karpathian (1991), it is fruitless to deal about the general question asking the direction and causality of the relationship between the self-concept and achievement. They suggested that this relation is complex and is affected by many factors. Another criticism comes from Shavelson, Hubner and Stanton (1976). They noted that since there was no equivalence among the self-concept measurements used in different studies, it was impossible to generalize the results of the studies.

Apart from the results of review studies and the criticisms about studies dealing with self-concept, it is believed that reviewing the recent individual studies would give information about the relationships between self-concepts and some other constructs frequently used in educational area. Some studies were conducted investigating reciprocal relationship between academic self-concept and academic achievement (Marsh, Hau, & Kong 2002) and some especially focused on mathematics self- concept and mathematics achievement (Wang, 2007). Marsh, Hau, and Kong (2002) emphasized the importance of reciprocal effects model of self-concept and achievement. They defined this model as “academic self-concept and academic achievement are reciprocally related and mutually reinforcing: improved academic self-concept will lead to greater achievement, and greater achievement will lead to improved academic self-concept” (p. 729). Wang (2007) investigated whether the reciprocal relationship found between self-concept and academic achievement in Western countries can also be confirmed for the students in Hong Kong. Wang (2007) used the empirical data of TIMSS 1995, 1999, and 2003 in exploratory and confirmatory inquiries. The results of this investigation displayed that there is a weak and reciprocal relationship between mathematics achievement and mathematics self-concept of students from Hong Kong.

Some studies did only focus on the relationship between mathematics self-concepts and mathematics achievement especially by using comprehensive international studies (Chiu & Klassen; 2009; Eklöf, 2007; Wilkins, 2004). Chiu and Klassen (2009) examined mathematics self-concept on mathematics achievement of 88.590 15-year-old students participated in the Program for International Student Assessment (PISA). The results of multilevel analyses displayed that students with higher mathematics self-concept had higher mathematics scores. Additionally, they reported that students’ mathematics self-concept was more strongly linked to mathematics achievement in countries those were wealthier, more egalitarian, more tolerant of uncertainty, or more flexible regarding gender roles. Similarly, Eklöf (2007) examined the relationship between mathematics achievement and two variables those; mathematics self-concept and students’ valuing of mathematics by using TIMSS 2003 data of 4256 Swedish eighth graders. The results displayed that mathematics self-concept was positively related to mathematics achievement whereas students’ valuing of mathematics was unrelated to mathematics achievement. In line with the results of the previously cited studies, Wilkins (2004) found that there was a positive relationship between mathematics achievement and mathematics self-concept by using TIMSS data. Dermitzaki, Leondari and Goudas (2009) reported that mathematics self-concept captures beliefs in one’s competence about mathematics abilities and is positively related to mathematics achievement.

The mathematics achievement is one of the most important outcomes in the learning process; however, it is not the only variable that was investigated together with mathematics self-concept. There are also other variables such as various strategic behaviors (Dermitzaki, Leondari, & Goudas, 2009), motivation to learn mathematics (Githua & Mwangi, 2003), parents’ causal attributions (Rytkönen, Aunola, & Nurmi, 2007), family structure, general self-concept, effort, and performance (O’Conner & Miranda, 2002). Also the gender differences were investigated in terms of the relationship between mathematics self-concept and mathematics achievement (Wang, 2006).

Dermitzaki, Leondari and Goudas (2009) investigated the network of relations between the first and second grade students’ strategic behavior during problem solving, their performance on them and their academic self concept in mathematics. They constructed a structural equation modeling and showed that the various strategic behaviors and their underlying factors were related to task performance and to self-concept in mathematics. Githua and Mwangi (2003) examined how students’ mathematics self-concept is related to their motivation to learn mathematics. The study was conducted with a sample of 649 students from 32 secondary schools. The results indicated that there is a significant relationship between students’ mathematic self-concept and their motivation to learn mathematics and also mathematics self-concept explained 63% of the variance in motivation to learn mathematics. Rytkönen, Aunola, and Nurmi (2007) examined the relationship between parents’ causal attributions and the accuracy of their children’s self-concepts of maths ability. In their study the data were obtained from 207 first and second grade students and their 182 mothers and 167 fathers. The results showed that the more mothers and fathers thought that their children succeeded at school because of their abilities, the more accurate the children’s self-concept of maths ability became, whereas, the more the mothers and fathers attributed their children’s success to effort, the less accurate and more optimistic the children's self- concept of ability became. O'Conner and Miranda (2002) investigated the relationships among family structure, general self-concept, effort, performance, and mathematics achievement of American students by using data of National Education Longitudinal Study of 1988 (NELS: 88) and regression analyses. O'Conner and Miranda (2002) reported that inconsistently with the research literature self-concept, and the students' perceptions of performance and effort had no influence on mathematics achievement. Wang (2006) investigated the gender difference in the relationship between mathematics achievement and self-concept of students from Hong Kong by using TIMSS and TIMSS-R data. The result of this investigation displayed a weak reciprocal relationship among the eighth-grade students for girls and boys.

Whether reciprocal, average direct, indirect, and causal or not, it can be claimed that there is a consistent and positive relationship between mathematics self-concept and mathematics achievement. Based on this proved relationships we can expect a positive relationship between problem solving performance and mathematics self-concept.

2.7 Motivation

As it is seen in Figure 1.1, motivation is one of the mostly investigated affective domain variables related to students' achievement. Both psychologist and educators have been interested in motivation for a long time (Ross, 2008). In general, motivation can be defined as the driving forces of learning (OECD, 2004b). It is stressed that education systems should improve students' motivation and interest to continue their learning, by this way engagement in learning and the depth of understanding are enhanced (OECD, 2004b).

One of the issues related with motivation that attracted the educators is the relationship between motivation and achievement. However, it is reported that this relationship is very complex (Pintrich, 2003). Although it is complex, in general when a student is motivated to do an academic task, he or she spends more effort and persistence, tries to use effective cognitive strategies and finally, has a better performance on the task (Pintrich, 2003). The evidence suggests that increased motivation in students can lead to improved overall academic achievement. Improving motivation of students leads to the use of effective and deeper cognitive strategies and complete understanding of the subject taught (Pintrich & DeGroot, 1990; Wolters, Yu, & Pintrich, 1996; Zimmerman, Bandura, & Martinez-Pons, 1992). These students usually show better achievement on assigned tasks and tests (Zimmerman & Bandura, 1994).

Then it is crucial to improve motivation in students; however, encouraging student interest and motivation is a very complex task because students may have various goals and reasons for studying. Based on this complexity, a student's total motivation is often a combination of intrinsic and extrinsic motivation (Husman, & Lens, 1999). Deci and Ryan (1985) defined intrinsic motivation as a type of motivation associated with activities that are inherently enjoyable, interesting, or challenging. Similarly, Husman and Lens (1999) stated that intrinsic motivation refers to that the goal is to learn or achieve in school in itself. On the other hand, extrinsic motivation refers implementing the learning activity for the sake of material or other rewards (Husman, & Lens, 1999). Also called as instrumental or external motivation, this construct is defined as students' beliefs about success in mathematics would help them in their future work and study in PISA 2003 (OECD, 2004b).

In PISA 2003 the aspect of motivation to learn mathematics categorized as students' interest in, and enjoyment of, mathematics, and instrumental motivation in mathematics (OECD, 2004b). As it was noted in OECD (2004b), the first category is related to internal characteristics of the learner whereas the second is related to external rewards. In this sense, students' interest in, and enjoyment of, mathematics is also labeled as intrinsic motivation and instrumental motivation is also labeled as external motivation. Also, these two variables are empirically related two each other (OECD, 2004b).

By using the results of PISA 2003 dataset the relationships between students' intrinsic and instrumental motivation and their mathematics performance were investigated within each country. Although the strength of the relationship between intrinsic motivation and mathematics performance varies for each country, it cannot be claimed that students with greater intrinsic motivation tend to have better performances in mathematics. On the other hand, the relationship between instrumental motivation and mathematics performance students is much weaker than with intrinsic motivation (OECD, 2004b).

Also other studies investigating the relationship between motivation and achievement were conducted by using PISA dataset for different cultures and countries (İş Güzel, 2006; Ross, 2008). For instance, İş Güzel (2006) investigated the relationship between intrinsic and instrumental motivation and mathematical literacy. She investigated the impact of human and physical resource allocations and their interaction on the students' mathematical literacy skills across Turkey, member and candidate countries of European Union by using data of PISA 2003. She used hierarchical linear modeling techniques for the student and school level characteristics. Basing on the findings of the analyses, she reported that both intrinsic and instrumental motivations in mathematics were not significantly related to Turkish students' performance in mathematics. The case was a little bit different for the member and the candidate countries of European Union. The variable intrinsic motivation was significantly related to mathematical literacy whereas the instrumental motivation was not significantly related to mathematical literacy. However, this relationship was negative unexpectedly. She explained that intrinsic motivation in mathematics and performance might be mutually reinforcing and might also be affected by other variables (İş Güzel, 2006).

Ross (2008) investigated the relationships between the motivation and academic achievement for two different cultures. In the study Western culture referred to Canada, the United States, and the United Kingdom whereas Asian culture referred to Hong Kong-Chine, Japan, and Korea. Hierarchical linear modeling (HLM) was used to analyze the data obtained from PISA 2003. The final models displayed that intrinsic motivation was significantly associated with academic achievement in the countries in Asia culture, whereas the results were inconsistent for the countries in Western culture. Inversely, instrumental motivation was significantly associated with the academic achievement in the countries in Western culture, whereas the results were inconsistent for the countries in Asia culture. Based on the results it was noted that the relationships between motivation and academic achievement reflected some cultural differences.

In an another study, Schiefele and Csikszentmihalyi (1995) examined the relationships among interest, achievement motivation, mathematical ability, the quality of experience when doing mathematics, and mathematics achievement of 108 freshmen and sophomores. The interest variable used in the used refers to a subject-matter-specific motivational factor; on the other hand achievement motivation represents a more general motivational orientation that drives student to perform well. The results of the study suggested that interest could account for a significant portion of achievement variance. They also reported that interest and achievement influence each other reciprocally. Additionally, the results also displayed that subject-matter-specific motivational measures are more predictive of achievement of a particular subject than general motivation.

2.8 Mathematics anxiety

The construct of mathematics anxiety has gained considerable awareness by mathematics educators as an important factor in the teaching and learning of mathematics (Aiken, 1970, 1976; McLeod, 1988, 1992; Vinson, 2001). Since it is one of the affective domain variables, which has received more attention than any other variables included in this domain (McLeod, 1992), it is included in Figure 1.1.

Many definitions of mathematics anxiety were given in literature (Bandalos, Yates, & Thorndike-Christ, 1995; Idris, 2006; Richardson & Suinn, 1972; Vinson, 2001). Generally, mathematics anxiety is assumed more than a dislike toward mathematics (Vinson, 2001). It is rather is a combination of low self-confidence, a fear of failure and a negative attitude towards learning math (Bandalos, Yates, & Thorndike-Christ, 1995). A more specific and frequently mentioned definition is proposed by Richardson and Suinn (1972). They defined mathematics anxiety as “feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide array of ordinary life and academic situation” (p. 551). Similarly, Idris (2006) defined mathematics anxiety as “a psychological state engendered when a student experiences or expects to lose self-esteem in confronting a mathematical task” (p. 70).

Since mathematics anxiety arises and pursues within a complex learning process, it is not a simple phenomenon to be studied (Bessant, 1995). However, it has an important role in predicting mathematics achievement (Clute, 1984). Many studies reported negative relationship between the mathematics anxiety and mathematics achievement (Aiken, 1970, 1976; Hembre, 1990; İş Güzel, 2006; Ma, 1999; OECD, 2004). Newstead (1998) noted that the relationship found between anxiety and achievement might be indirect and is necessarily ambiguous with respect to the direction of causality. Whether indirect or not, it is often assumed that mathematics anxiety hinders students to learn even the simplest mathematical task (Idris, 2006) and high levels of anxiety impair performance of the students (Newstead, 1998).

Since many studies conducted investigating the relationship between mathematics anxiety and mathematics achievement, many review studies were conducted to summarize the results of these studies briefly. For instance, Aiken (1970) conducted a comprehensive review of a research on attitudes toward mathematics covering the decade of the 1960’s. After 5 years later Aiken (1976) updated his review because of the interesting new directions applied in researches. The research studies were investigated from various perspectives across different grade levels. One of the results reported in the reviews was that mathematics anxiety had been found to be related to mathematics achievement. Also it was reported that, from elementary school to college level high achievement in mathematics was related to low anxiety in mathematics (Aiken, 1970, 1976). Similarly, Hembre (1990) conducted a meta-analysis for examining the construct of mathematics anxiety regarding its nature, effects, and relationships. In the study, a total of 151 studies were investigated. It was reported that mathematics anxiety is related to low mathematics achievement and at the same time mathematics anxiety is negatively associated with positive attitudes toward mathematics. In his meta analysis, Ma (1999) examined 26 studies including articles and dissertations to investigate the magnitude of the relationship between anxiety toward mathematics and achievement in mathematics. He found that the common population correlation for the relationship between anxiety toward mathematics and achievement in mathematics was significant and the magnitude was -0.27. Additionally, Ma (1999) reported that also this relationship is same for females and males, different grade-levels, ethnic groups, instruments used for measuring anxiety, and years of publication.

In addition to review studies and meta analyses, the results of comprehensive cross cultural studies confirmed this negative relationship. For instance, anxiety in mathematics is one of the affective domain factors investigated in PISA 2003. The results of this study displayed that anxiety in mathematics is negatively related to students' mathematics performance (OECD, 2004). Another study investigating relationship between anxiety in mathematics and mathematical literacy is conducted by İş Güzel (2006). She investigated the impact of human and physical resource allocations and their interaction on students' mathematical literacy skills across Turkey, member and candidate countries of European Union by using data of PISA 2003. She used hierarchical linear modeling techniques for student and school level characteristics. As it was expected, the analyses showed that mathematics anxiety was significantly and negatively related to students' performance in mathematics for Turkey, member and candidate countries of European Union (İş Güzel, 2006).

2.9 Preference for learning situations

Besides affective domain variables, as it is displayed in Figure 1.1, students' preferences for learning situations are frequently investigated factors. It is apparent that students learn in different ways from each other (Pritchard, 2009) and their learning behavior is affected by their preferences for learning situations (OECD, 2005). Two of mostly cited types of them are cooperative and competitive learning situations.

Cooperative learning is one of the approaches widely used in the teaching of mathematics, science, social studies, languages, and many other subjects (Oxford, 1997). "Cooperative learning enhances cognitive and social skills via a set of known techniques. In cooperative learning individual is accountable to the group and vice versa; teacher facilitates, but group is primary" (Oxford, 1997, p. 444). The results of the numerous research studies display that cooperative learning enhances students' academic achievement and social relations among the students (Cohen, 1994; Johnson & Johnson, 1999; Slavin, 1995; 1991). Moreover, based on the results of the reviewed studies, Slavin (1995) reported that cooperative learning can have consistent and important effects on the learning of all students.

According to Grasha (1996), students who prefer cooperative learning situations feel that they can learn by sharing ideas and talents. Such students cooperate with the teacher and like to work with their classmates. They enjoy small group discussions and group projects. They also like to work on group projects, help their classmates, and share their ideas with their classmates (Grasha, 1996).

In contrast to cooperative learning, competitive learning exists when students focus on performing faster and more accurately than their classmates (Johnson & Johnson, 1999). According to Grasha (1996), students who prefer a competitive learning style are more likely to perform better than others in the class. Competitive students like to be in the center of attention, receive recognition for their success in class, and become the group leader in classroom discussions. They also prefer teacher-centered procedures and activities where they can do better than others (Grasha, 1996). When the number of research studies investigating the effects of cooperative and competitive learning, it is seen that the number of studies related to cooperative learning is more than ones related to competitive learning. Even if the number of studies is just a bit, it is reported that, competitive challenge can have both positive and negative effects on student engagement and performance (Schaper, 2008). When compared to competitive learning, cooperative learning is more effective in gaining some intended educational outcomes such as promoting intrinsic motivation and task achievement, generating higher order skills, improving attitudes toward the subject, increasing self-esteem and time on task, and lowering anxiety (Oxford, 1997).

Both learning situations have some advantages and disadvantages on their own. Grasha (1996) summarized several advantages and disadvantages both for collaborative and competitive learning. The advantages of competitive learning are motivating students to keep up and setting goals for learning, on the other hand, this type of learning may not be useful for less competitive students, and also it may make difficult to learn collaborative skills. The advantage of collaborative learning style is developing skills for working in groups and teams, on the other hand, it is hard to handle with competitive students and this type of learning depends too much on other students.

2.10 Learning strategies

Since many researchers agree that learning strategies are important and useful for effective learning, learning strategies are included in the present study as it seen in Figure 1.1. Nevertheless, it is reported that a precise definition of learning strategies is lacking (McKeachie, Pintrich, & Lin, 1985). A highly referred definition for learning strategies was proposed by Weinstein and Mayer

(1986). They defined learning strategies as "behaviors and thoughts that a learner engages in during learning and that are intended to influence the learner's encoding process" (p. 315). Based on their definition of learning strategy they claimed that any learning strategy may affect learner's affective or motivational situation or the way how the learner selects, acquires, organizes, or integrates new knowledge. They specifically stressed the importance of teaching students learning strategies since the use of learning strategies can affect the encoding process and accordingly it affects the learning outcome and performance. A parallel definition was also given by Weinstein, Husman, and Dierking (2005). They noted that "learning strategies include any thoughts, behaviors, beliefs, or emotions that facilitate the acquisition, understanding, or later transfer of new knowledge and skills" (p. 727).

Weinstein and Mayer (1986) proposed eight major categories of learning strategies. These categories are, rehearsal strategies for basic and complex learning tasks, elaboration strategies for basic and complex learning tasks, organizational strategies for basic and complex learning tasks, comprehension monitoring strategies, and affective and motivational strategies. Rehearsal strategies refer tasks such as repeating the concepts, copying or underlining the material presented. Elaboration strategies include tasks such as forming a mental image or sentence relating the items in each pair for a paired-associate list of words, paraphrasing, summarizing, or describing how new information relates to existing knowledge. Organizational strategies cover tasks such as grouping or ordering to-be-learned items, outlining a passage or creating a hierarchy. Comprehension monitoring strategies include tasks such as checking for comprehension failures whereas affective strategies refer being alert and relaxed (Weinstein & Mayer, 1986).

OEDC (2004) emphasized the importance of learning strategies since students are active participants in the learning process and in managing their own learning. In PISA 2003, the second three-yearly survey of student knowledge and skills, three constructs were described and used in student questionnaire. These constructs are control, memorization, and elaboration strategies OEDC (2004). Control strategies used in PISA 2003 refer strategies through which students can plan, monitor and regulate their learning such as checking what they have learned and working out what they still need to learn. Similar to rehearsal strategies proposed in the categorization of Weinstein and Mayer (1986), memorization strategies used in PISA 2003 refer learning key terms and repeated learning of material (OEDC, 2004). It is reported that if the student's aim is to retrieve the information as presented, memorization is an appropriate strategy; however this strategy is insufficient for deep understanding (OEDC, 2004). Similarly Purdie and Hattie (1996) pointed out that the use of memorization strategies leads only low-level learning outcomes. Parallel to definition of Weinstein and Mayer (1986), elaboration strategies used in PISA 2003 refer making connections to related areas or thinking about alternative solutions. This strategy can be used in integrating new information into student's prior knowledge and accordingly deep understanding can be achieved (OECD, 2004).

In literature learning strategies are also labeled as self-controlled, self-instructed, self-reinforced, or more frequently self-regulated learning strategies (Zimmerman & Martinez-Pons, 1986). Zimmerman and Martinez-Pons (1986, 1988, 1990) identified 14 self-regulated learning strategies. These strategies are self-evaluation, organization and transformation, goal setting and planning, information seeking, record keeping and self-monitoring, environmental structuring, giving self-consequences, rehearsing and memorizing, seeking social assistance, and reviewing.

Although the definition and categorization of learning strategies, or the way to teach students learning strategies are frequently mentioned topics, there are not many studies investigating the relationship between particular learning strategies and academic performance. For instance one of the studies proving evidence for the relationship between learning strategies and achievement was the study of OECD (2004). OECD (2004) found that the relationship between the reported use of control strategies and student performance in mathematics is weak. This result is not consistent with the results of PISA 2000 where the use of reported use of control strategies was strongly related to reading performance of students (OECD, 2001).

Another study investigating relationship between learning strategies and mathematical literacy is conducted by İş Güzel (2006). She investigated the impact of human and physical resource allocations and their interaction on students' mathematical literacy skills across Turkey, member and candidate countries of European Union by using data of PISA 2003. She used hierarchical linear modeling techniques for student and school level characteristics. Based on the findings of the analyses, she reported that control strategies, elaboration strategies, and memorization strategies were significantly related to Turkish students' performance in mathematics. There was a positive relationship between control strategy and mathematical literacy whereas there was a negative relationship between elaboration strategies and mathematical literacy. She noted the latter relationship as a problematic case since she expected a positive correlation. She suggested that unreliable responses of Turkish students may be one of the reasons for this unexpected relationship. Finally, memorization strategies were found to be negatively related to Turkish students' mathematical literacy. She pointed out that this result was expected since the skills obtained through memorization strategies cannot be sufficient for obtaining high performance on mathematical literacy. The relationships constructed between elaboration and memorization strategies and mathematical literacy for the member countries of European Union were the same as the relationships found for Turkish students. Additionally, for candidate countries of European Union, only memorization strategies were found to be significantly related to mathematical literacy and also consistent with previous findings this relationship was negative (İş Güzel, 2006).

Thiessen and Blasius (2008) investigated the relationships between students' reported mathematics learning strategies and their mathematics performances by using PISA 2003 data set. The results displayed that control strategies was found to be important for the mathematics performance. In other words, they noted that cognitive maps of high achievers are more complex than those of low achievers.

Demir, Kılıç, and Depren (2009) investigated the contribution of some factors together with learning strategies factor to the explanation of the variance in Turkish students' mathematics performance by using PISA 2003 data. The results of the multiple regression analysis displayed that all of the factors including learning strategies accounted for approximately 34% of the variance in mathematics performance and all of them had statistically significant effects on the performance. Although they did not examine the effects of learning strategies separately, such as memorization, control, or elaboration strategies, they reported that learning strategies has a positive and statistically significant effect on mathematics achievement.

Zimmerman and Martinez-Pons (1986) emphasized that the use of self-regulated learning strategies is associated with students' achievement. Specifically, they found that high achievers relied more heavily on the strategy of seeking social assistance. Students who prefer this category ask a friend, teacher or adults when they have a problem. Although Zimmerman and Martinez-Pons (1986) believed that self-evaluation was on of the important self-regulated learning strategies, they found that self-evaluation failed to associate to student achievement. This category refers student-initiated evaluations of the progress such as checking over work to make sure that they did the task right. Therefore they suggested improving the descriptions of this category of self-regulated learning strategy.

2.11 Homework

The importance, value, and necessity of homework have always been parts of the educational debate. Based on educational expectations, through different period of time the emphasis given to homework has changed. From a historical perspective, Wildman (1968) evaluated the value and importance of homework. She reported that in the first part of 20 th century, homework was thought to play an important role in learning on the other hand in the 1940's there was a trend for less homework. Then this case was also changed again. Wildman also pointed out that the controversial issue of the homework is the type and the amount of homework that should be given. Finally she recommended giving less homework to children and taking the pressure off children. In the 1980s the value and importance of homework come to prominence again (Cooper, 1989).

Many correlational studies investigating the effect of homework variables such as amount of time spent on homework, amount of time parents spent assisting with homework, amount of homework assigned, checking and grading homework, frequency of homework on achievement were conducted (Chen & Stevenson, 1989; Cooper, Lindsay, Nye, & Greathouse; 1998; Jong, Westerhof, & Creemers, 2000; Trautwein, Köller, Schmitz, & Baumert, 2002).

Chen and Stevenson (1989) conducted a cross-cultural study investigating the cultural differences in the relations between amount of time spent on homework by Chinese, Japanese, and American children, amount of time parents spent assisting their children with homework, and children's achievement in mathematics and reading at elementary grade level. In the study the findings were mixed. They found that only four of the correlations between homework time and achievement were significant out of 14 correlations. The two were positive and the others were negative. Although there were positive, negative and also nonsignificant results, they proposed that if students could see homework as interesting and useful, homework could enhance their academic achievement. On the contrary, if the quality of the homework was poor with including just drill and practice, increasing the amount of homework might have negative effect on academic achievement.

Cooper, Lindsay, Nye, and Greathouse (1998) found weak relations between amount of homework assigned and the student achievement in mathematics and English. On the other hand, there were positive relations between the amount of homework students completed and achievement especially at grades between 6 and 12. Jong, Westerhof, and Creemers (2000) investigated some homework characteristic in Dutch schools and analyzed the relationships among these characteristics and mathematics achievement for students 12 old years at four levels; school, teacher, parents, and student. The results of the analysis showed that the amount of homework was the only homework variable related to mathematics achievement. On the other hand frequency of homework and homework time were not related to achievement. Also, checking and grading behavior of teachers were not found to affect the mathematics achievement of the students.

Differently from the previously mentioned studies, Trautwein, Köller, Schmitz, and Baumert (2002) analyzed the role of homework in improving mathematics achievement by using data of 1976 German 7th grade students and controlling the intelligence, socioeconomic status, motivation, and type of secondary school. They reported that the frequency of homework had a positive effect on mathematics achievement while lengthy homework and monitoring of homework completion had no effect.

The review of correlational studies revealed that the relationships found between different homework variables and achievement are inconsisted. Then it is hard to claim that there is a definitive relationship between some sort of homework variables and achievement. These inconsistencies might arise from grade level, the subject asked in the achievement measure, the instruments measuring the homework variables.

Correlational studies are not the only type of studies investigating the effects of homework on achievement. There are also many studies investigating empirical studies to provide evidence for definite results pertinent to the relationship between homework and achievement (Cooper, 1989; Coulter, 1979; Goldstein, 1960; Paschal, Weinstein, & Walberg, 1984; Walberg, Paschal, & Weinstein, 1985).

One of the oldest studies was conducted by Goldstein (1960). Goldstein made a review of related researches published during the 30 years before 1958 to examine the value of homework. His review produced some several valuable results. He reported that the results of most studies suggested that regularly assigned homework favored higher academic achievement. He also encountered some studies indicating the probability that homework might be more important at some grade levels than at other, in some subjects than in others, or for some pupils than for others. This experience of Goldstein (1960) might be the cause for inconsistent findings found in correlational studies.

Coulter (1979) overviewed research studies related to homework and identified some important conceptual and methodological problems found in these studies. He reported that during classroom follow-up, the amount of teacher feedback on homework, the correspondence of tested material and the content of the homework and relating of homework to other class work positively affect academic achievement. Based on his review, he suggested researchers firstly observing, identifying and then describing the variables related to homework from classroom and home environment point of view. Moreover he pointed out that the homework variables should be investigated in terms of teacher and student behaviors in detail.

Paschal, Weinstein and Walberg (1984) investigated the results of empirical studies of homework and of various homework strategies on the academic achievement and attitude of elementary and secondary students. They included the 15 empirical research studies conducted in the period 1966-1981. They reported that the results of most studies favored the homework, and additionally the homework graded or included comments of teachers had more influence on achievement. In another study, Walberg, Paschal, and Weinstein (1985) did a synthesis of 15 empirical studies reported between 1964 and 1981. Based on their investigation they reported that homework had positive effects on learning of elementary and secondary level students. Another finding was that regularly given homework had more effect than homework given irregularly.

By conducting a very comprehensive study, Cooper (1989) made a review and investigated nearly 120 studies of homework's effects. Based on the results of this review he claimed that both positive and negative effects of homework were broad and unexpected. One of the positive effects of homework that Cooper (1989) reported was that homework had an immediate impact on retention and understanding of the material covers. One the other hand, one of the negative effects reported was the probability for losing interest in academic material and resulting physical and emotional fatigue in students. He also found that homework was very effective at increasing achievement in high school students; however, it had very little effect at increasing the achievement of elementary level students.

In research literature also some modeling studies those investigating several variables concurrently (Cooper, Jackson, Nye, & Lindsay, 2001; Keith, 1982). Keith (1982) investigated the relationships between homework time and high school grades of high school students using path analytic approach. The result of the analysis revealed that amount of time spent on homework had a positive effect on a student's grades in high school even after controlling for race, family background, and ability. Cooper, Jackson, Nye, and Lindsay (2001) proposed and tested a model of homework's influence on the classroom performance of elementary school students. Their modeling revealed some important results. The result related with the achievement was that classroom grades of the elementary grade students were predicted by how much homework the students completed even after the use of homework in grading was controlled.

The review of research literature displays that although the number of research studies pertinent to homework and its effectiveness is extensive, the results of these studies are inconsistent. The obtained findings pointed out some controversy over whether or not homework and its variables exert positive effect on achievement. Muhlenbruck, Cooper, Nye, and Lindsay (2000) noted that for the last few decades, the strengths and weaknesses of assigned homework had been discussed and there had been no agreement whether homework played an effective role at improving achievement.

Given inconsistent findings these conducted research studies were under attack by some of the researchers. For instance, Trautwein and Köller (2003) draw attention to the inconsistencies found in the homework research literature and ambiguity about the nature and the strength of the relationship between homework and achievement. They pointed out that the existing research studies revealed weak evidences for claiming that larger amounts of homework improve academic achievement. They also added that the relationship between time spent on homework and achievement is ambiguous. Their suggestion for obtaining clear and understandable results about this relationship was that the homework and achievement should be clearly defined. Another suggestion was using multilevel modeling. Muhlenbruck, Cooper, Nye, and Lindsay (2000) reported that much of this inconsistency was arising from conceptual and methodological deficiencies of the empirical studies conducted in this area. Similarly, it was reported that although there were plenty of statements of opinions and reports of studies pertinent of homework, there were a few well-designed studies providing reliable evidences for their claims related to homework (Coulter, 1979; Goldstein, 1960).

In Turkey, homework constitutes a major part of the educational process (Berberoğlu, 2008). Thus in the present study the use of homework was taken as one of the independent variables under out of classroom practices to explain students' problem solving skills as it is seen in Figure 1.1.

2.12 Classroom practices

The classroom can be defined as the nucleus where other influences on the learning of students and outcomes from their education are found. These influences can be relationships with peers; peer groups in general, teachers and textbooks. Actually, all the contributing factors to educational outcomes exist in classroom (Webster & Fisher, 2000).

Since the instruction begins formally in the classrooms and the instructional activities used in the classrooms are the most important ones in predicting the student achievement, classroom practices were included in the present study as it is seen in Figure 1.1. In the classrooms teachers show their experiences by using different and effective methods, motivate students, prepare suitable conditions for the teaching and the learning, and try to transmit all his or her knowledge to students (NCTM, 2000).

One report, "Mathematics Achievement and Classroom Instructional Activities: National Assessment of Educational Progress (NAEP). 1985-86," (as cited in Lewis, 1991) drew relationships based on the data from the last NAEP assessment of mathematics with K-12 students, between instructional activities and math achievement, pointing out that:

1. Daily exposure to traditional instruction, such as working math problems alone, doing math homework, or working from a textbook, is associated with higher achievement.
2. Such exposure is more helpful to learning how to compute and math terms than it is to problem solving or forming concepts.
3. Computer use enhances math courses, particularly for eleventh-graders.

Duruhan, Akdağ, and Güven (1990) indicated that most students expected that mathematics teachers should encourage student participation and consider the differences in success level of students during student participation. Additionally, Pehlivan (1995) listed some teacher behaviors those contribute to display their roles in structuring the instructional activities, performing these activities, and obtaining fruitful outcomes. She mentioned about the studies that focused on the factors affecting instruction such as, student participation, feedback-correction, giving clue and the teachers' competencies in using these factors. It was reported that students especially those who display low performance benefit from practices of teachers who are interested in the progress of their students (OECD, 2001). This may be result of the idea that all students are expected to reach the reasonable and accessible performance standards and teachers are willing to help student to meet the standards (OECD, 2001). In PISA 2000, students were asked the frequency of the practices such as teachers show an interest in every student's learning, give students an opportunity to express opinions, help students with their work, and continue to teach until students understand to investigate the relationship between the supportive teaching practices and performance of the students (OECD, 2001). The results of these analyses were found be quite mixed. As it was reported in report of OECD (2001), in most countries with high levels of teacher support the association with performance tends to be weakly positive. On the other hand, in the countries in which lower levels of supportive teaching practices are reported, both positive and negative associations were reported. It was noted that the complex pattern of this association may be the consequence of many different factors and further research is needed to explore these factors (OECD, 2001). The results obtained from OISA 2003 were consistent with those of found in PISA 2000. In the report of OECD (2004a) it was reported that the relationship between the teacher support and students achievement is mixed and generally weak. The general result found by Hill and Rowe (1998) was that the relationship between student-teacher relations and the student mathematics achievement is positive. They concluded that teacher can and do make a difference and teacher interactions with their students affect their students' performances.

Bos and Kuiper (1999) reported that although the factors class climate and instructional formats (co-operative learning) were supposed to have direct influence on mathematics achievement, they did not show significant path coefficient in the most of the models of European countries. Also, Bos and Kuiper (1999) defined the variable teaching style as reflecting more student oriented and more teacher oriented teaching. The results showed that the dominating teaching style (student or teacher) has no influence in most of the European countries. Furthermore, students' attitude towards mathematics is linked to class climate significantly in six systems.

The results of the study conducted by House (2001) identified a number of instructional activities that were significantly related to the mathematics achievement of students in Japan. When teaching new mathematics topics, for instance, students whose teachers more frequently explained rules and definitions tended to show higher mathematics achievement test scores. Similarly, students who reported that their teachers more frequently solved an example related to the new topic also showed higher mathematics test scores. Considering instructional activities used in typical mathematics lessons, students who more often used things from everyday life to solve mathematics problems showed higher test scores. However, more frequent the use of collaborate learning activities such as working together in pairs or small groups when learning new topics and working together in pairs or small groups in mathematics lessons, was associated with lower mathematics test scores (OECD, 2001).

2.13 Teacher perceptions

The mathematicians have not agreed upon a common definition about the nature of mathematics (Dossey, 1992). In literature, various categorization or views about the nature of mathematics have been proposed (Collier, 1972; Ernst, 1989; Peck & Connell, 1991). For instance, Peck and Connell (1991) found that preservice teachers shared six commonly held beliefs about mathematics: mathematics is computation, mathematics problems should be quickly solvable in a few steps, the goal of mathematics is obtaining the correct answer, observing patterns is sufficient evidence for accepting a rule, the role of the student is to passively receive knowledge, and problem solving consist of recalling and applying specific rule to specific kinds of problems. Some of which overlap with the views reported by Peck and Connell (1991), Ernst (1989) proposed three views about nature of mathematics. The first one is the dynamic, problem-driven view seeing mathematics as a continually expanding field of human inquiry. The second view sees mathematics as a static but unified body of knowledge. Finally, according to the third view, mathematics is a useful but unrelated collection of facts, rules, and skills.

Collier (1972) mentioned about two views about nature of mathematics; formal and informal. The formal view sees mathematics as an organized body of knowledge composed of rules or formulas and this view supports the idea that the benefit of mathematics is developing the ability to follow directions. Inversely, the informal view sees mathematics as a subject containing many of the finest and most elegant creations of the human kind and this view supports the idea that the benefit of mathematics is to develop the ability to think creatively (Collier, 1972). Thompson (1992) stated that many teachers possess the belief that mathematics is a static body of knowledge and it includes a set of rules and procedures that are applied to procedure one right answer. In this sense, it can be claimed that making mathematics is composed of performing procedures and manipulating symbols without understanding what they represent (Thompson, 1992). In contrast, some teachers possess the belief that mathematics is a discipline that is continually undergoing change and revision. In the latter view, mathematics is a tool for thought and creative problem solving (Thompson, 1992).

Together with the shift from a formal view of mathematics to a less formal view, Collier (1972) reported that an emphasis had been given to the beliefs of mathematics teachers about mathematics. This emphasis directed researchers to investigate teachers' perceptions about mathematics, mathematics teaching and learning as well as their relationships with teaching practices (Clark & Peterson, 1986; Dossey, 1992; Fang, 1996; Raymond, 1997; Thompson, 1984, 1992). The results of review studies display that teachers' beliefs and values about teaching and learning affect their teaching practices (Clark & Peterson, 1986; Thompson, 1992). Also, it was reported that teachers' beliefs are not always consistent with their teaching practices (Fang, 1996; Raymond, 1997). For explaining this inconsistency, Brown and Borko (1992) proposed that, beginning elementary school teachers often enter the teaching profession with nontraditional beliefs about how they should teach; however when they encounter with the actual classroom constraints, they tend to implement more traditional classroom practices.

Teachers' beliefs did play a significant role in shaping teaching practices, but they also affect the achievement (Staub & Stern, 2002). For instance Peck and Connell (1991) proposed that views defining mathematics as computing, recalling and applying specific rules hinder students in reaching higher-order skills in mathematics. Similarly, Collier (1972) proposed that high achievers have slightly informal view of mathematics and high achievers have a more informal view than low achievers.

As it is proposed that teachers' beliefs are related to student achievement, teachers' perceptions about the subject they teach are included in Figure 1.1. Staub and Stern (2002) proposed that teachers' beliefs can also directly correlate with student achievement in mathematics. This correlation was investigated in Akyüz's (2006) study. Akyüz (2006) investigated the effects of mathematics teacher and classroom characteristics on students' mathematics achievement across Turkey, member and candidate countries of European Union by using TIMSS 1999 data sets. She used Hierarchical Linear Modeling (HLM) to build explanatory models after the variable home educational resources of students were controlled. In her descriptive analyses she reported that a greater proportion of mathematics teachers in Turkey than that of member and candidate countries of European Union believed that mathematics was primarily an abstract subject. In addition to this conception Turkish mathematics teachers believed that mathematics is the formal representation of world. Based on these results Akyüz (2006) proposed that it could be claimed that most of the Turkish mathematics teachers thought mathematics should be taught as a set of algorithms and rules and basic computational skills were important in teaching primary school mathematics.

Akyüz (2006) considered two different conceptions of mathematics teachers in her study. The first one was discipline –oriented point of view whereas the second one was process –oriented point of view about mathematics. Akyüz (2006) reported that one who has the former view believes that mathematics is an abstract subject; on the other hand one who has the latter view believes that mathematics is a subject that is a formal way of representing the world. The results of the HLM analyses displayed that process-oriented point of view had a positive significant effect on mathematics achievement of students in Belgium, but a negative significant effect in Czech Republic. Additionally, the case was different for Turkey, that no significant effect of conceptions on mathematics achievement. Based on this finding Akyüz (2006) suggested that this result might be the inconstant responses of Turkish mathematics teachers.

2.14 Teacher efficacy

Generally, in literature, the construct describing the level of teacher confidence in teaching have been called by using different terms such as teacher efficacy, teacher's sense of efficacy, and teacher's self-efficacy. Specifically, teacher self-efficacy is defined as teachers' belief that they possess the ability to influence student learning and achievement of students (Guskey, 1987). Many studies were conducted related with the nature and the dimensions of teacher efficacy (Dembo & Gibson, 1984; Guskey & Passaro, 1994). For instance, Dembo and Gibson (1984) factor analyzed the responses of 208 elementary school teachers on 30-item Teacher Efficacy Scale. The results displayed that within this construct there were two dimensions; general teaching efficacy and personal teaching efficacy. General teaching efficacy represents a teacher's sense or belief that any teacher's ability to bring about change is limited by external factors such as home environment, family background, and parental influence. On the other hand personal teaching efficacy represens a teacher's sense or belief that she or he has the skills and abilities to bring about student learning.

Using the instruments constructed for measuring teacher efficacy and its dimensions many studies were conducted related with teacher efficacy. The main point about teacher efficacy is that the way people perceive themselves can affect their behavior. Pajares (1992) stated that teacher beliefs "are the best indicators of the decisions individuals make throughout their lives" (p. 307). Connecting teacher efficacy to teacher instruction in the classroom, it was indicated that there were correlations between teachers' beliefs and instruction (Stipek, Givvin, Salmon, & MacGyners, 2001; Thompson, 1992). Tschannen-Moran, Hoy and Hoy (1998) found that teachers with high teacher self-efficacy produced students with an increased interest in school and students that retained the perception that learning is important. Similarly, teachers who possess strong feelings of responsibility related to student achievement produced higher gains in student performance and achievement (Dembo & Gibson, 1985). It is reasonable to claim that when teachers believe in their ability in understanding the needs of their students, they design and deliver instruction in consistent with students' needs. Inevitably, this make students construct new knowledge and understand. This claim was verified by the research studies. Teachers' sense of efficacy is found to be related to students' achievement gains (Dembo & Gibson, 1985). Similarly, it was reported that, a strong link exists between teacher self-efficacy and improved student achievement (Dembo & Gibson, 1985; Tschannen-Moran & Hoy, 2001).

Studies investigating the relationship between the teacher efficacy and student achievement noted that teacher self-efficacy is an indicator of student achievement. Since it is believed that improving science and mathematics teaching efficacy will improve instruction and student achievement in elementary classrooms, it is strongly recommended that teacher education programs and professional development activities should stress teachers' self-efficacy (Huinker, & Madison, 1997; McLaughlin & Berman, 1977). Therefore, as it is seen in Figure 1.1, teacher efficacy is included in the current study to investigate its relationship between problem solving skills of the students.

2.15 Modeling studies

The identification and examination of the factors that explain achievement have long been investigated by the researchers. Though the investigation of individual factors that affect achievement is important, modeling suggests an advantage of examination and investigation of not only each individual factor but also the relationships among those factors (Schreiber, 2002). In 1989 Shavelson, McDonnell, and Oakes and in 1987 McDonnell, Oakes, and Carey (as cited in Schreiber, 2002) argued that a model is required because a single indicator is not able to provide information about a "phenomenon as complex education." Literature review about mathematics achievement and modeling shows that many studies proposing theoretical models have been carried out to explain mathematics achievement and its relationships between psychological, pedagogical, social, and cognitive constructs. Most of these models were tested with the data of international studies such as TIMSS or PISA (e.g. Akyüz, 2006; Bos & Kuiper, 1999; İş Güzel, 2006; Köller, Baumert, Clausen, & Hosenfeld, 1999; Lokan & Greenwood, 2000; Papanastasiou, 2000; Rodriguez, 2004; Ryoo, 2001; Sevgi, 2009; Stemler, 2001; Webster & Fisher, 2000; Yang, 2003). Some of these models used structural equation modeling (e.g. Bos & Kuiper, 1999; Lokan & Greenwood (2000) Marsh, 1986; Meece, Wigfield, & Eccles, 1990) whereas some of them used multilevel and hierarchical linear modeling to examine student, teacher, and school level characteristics in order to investigate predominantly the mathematics achievement (e.g. Abu-Hilal, 2000; Akyüz, 2006; D'Agostino, 2000; İş Güzel, 2006; Lee & Bryk, 1989; Park, 2003; Rodriguez, 2004; Schiller, Khmelkov, & Wang, 2002; Sevgi 2009; Stemler, 2001; Van den Broeck, Van Damme & Opdenakker, 2005; Webster & Fisher, 2000).

Papanastasiou (2000) investigated the predictors of attitudes and beliefs related to school and family and also examined predictors of mathematics outcomes focusing on attitudes and beliefs in order to advance a conceptual model based on the literature and tested this model empirically using data collected within the TIMSS project. He used the Cyprus model, which evolved from TIMSS 1995 data, on US and Japanese data in order to see whether the model fits and to examine the strength of attitudes and beliefs as predictors of mathematics outcomes. The final samples were 1026, 4980, and 5249 eighth graders for Cyprus, Japan, and US, respectively. Data gathered from the TIMSS 1995 student questionnaire. The student variables included in the model were determined on the basis of factor analysis. The 35 questions used in this study were grouped into separate categories, related to the following:

1. Student views and attitudes on mathematics, and mother's and friends' opinions on the importance of mathematics;
2. The socioeconomic status and educational background of the family;
3. Teacher-initiated activities in the mathematics class, especially those implemented at the beginning of a new topic; and
4. School - the general climate of the school.

The educational background of the family include the highest level of parents' education and the size of the family home library except student textbooks. Whether the students' mother, friends and the student him- or herself think that to be a high-achieving student in the class is important associated with reinforcement measures. The teaching measures include questions on activities related to the mathematics lesson such as; do they work on math projects, do they use events from everyday life in solving mathematics projects, do they check and discuss homework, do teachers begin the lesson discussing a practical problem, and do they ask questions related to the new topics. The SES measures involved items that students have at home, such as calculators, dictionaries, and video recorders. The climate measures involved questions related to the school environment such as did the students think that student might hurt them, were friends ever hurt by other students, did some of their friends skip classes, was something ever stolen from school. Whether students like mathematics, and if do they enjoy mathematics, do they find it boring and think it is an easy subject were the questions related to attitudes measures. Lastly, the beliefs regarding success in mathematics involved questions on the need for naturally ability/talent, hard work, studying at home and memorization of textbooks and notes. Although the prediction that attitudes and beliefs about success in mathematics would have significant effect on mathematics outcomes, this was not proven in all three structural models. In the model of Cyprus, the paths from educational background to SES, to beliefs, and to climate were significant. The paths from reinforcement to attitudes and to beliefs about success in mathematics were also significant as were the paths from climate to teaching, the path from teaching to attitudes, the paths from beliefs to teaching and to attitudes. Besides, in the US model, the paths from educational background to SES and climate were significant, but the path from educational background to beliefs was not significant unlike the model of Cyprus. The paths from reinforcement to attitudes and to beliefs about success in mathematics were also significant, as were the paths from beliefs to teaching, from teaching to attitudes, from SES to climate, and from SES to attitudes. Unlike, the paths from climate to teaching and from beliefs to attitudes were not significant. Finally, in the model of Japan, the paths from reinforcement to attitudes and to beliefs about success in mathematics were significant as were the path from beliefs to teaching and the path from teaching to attitudes same with the models of Cyprus and US. Also the path from beliefs to attitudes was not significant unlike the model of Cyprus. The results of the study indicated that two factors – the educational background of the family and student reinforcement – define a second-order factor structure which includes the endogenous predictors, the socioeconomic status of the family, the student attitudes toward mathematics, the beliefs regarding success in mathematics, the type of teaching, and the school climate. Consequently, these results indicate that the phenomenon of mathematics achievement is multidimensional.

Similarly, Bos and Kuiper (1999) conducted a secondary analysis using TIMSS 1995 data to find relationships between achievement in mathematics and constructs at student and teacher levels. Their research question was “What can be learned about mathematics of grade 8 students, and the factors at student and classroom levels that may be associated with that achievement across 10 education systems?” The ten European education systems were, Belgium-Flemish, Belgium-French, Czech Republic, Denmark, England, Germany, Lithuania, Norway, Sweden, and the Netherlands. A principle component analysis was carried out to form latent variables. The latent variables were homework (from textbook, application), teaching style (student and teacher oriented), school climate (safety), student gender, maternal expectation, friends' expectations, success attribution mathematics (talent, luck, hard working, memorize), instructional formats (co-operative learning), mathematics class climate (neglect schoolwork, quiet in lessons, do as teacher says), attitude towards mathematics (like, importance), home educational background, class size, effective learning time (total number of minutes mathematics per week), assessment (evaluation, feedback, and corrective instruction), out-of-school activities (job, leisure). As a limitation of this study, the reliability coefficients of most of the latent variables for most of the education systems were not higher than 50. Then on the TIMSS data the Partial Least Squares path analysis technique was applied. First of all, the percentage of variance in students' mathematics scores explained by the latent variables of the path model was not higher than 19% (in England). Home educational background, out-of-school activities and attitude towards mathematics had significant influence on achievement in most of the 10 systems. Home educational background showed the highest (positive) path coefficients in most of the systems together with out-of-school activities. The path coefficient of out-of-school activities was negative, which meaned that the more time a student spends on jobs and watching television and playing games the less his or her achievement in mathematics is. Class climate, as perceived by the students, assessment usage, instructional formats, and effective learning time did not show significant path coefficients in the majority of the education systems. In all 10 systems home educational background has no direct link to the attitude. But in the majority of the educations systems, gender, maternal expectation, friends' expectation, and success attribution had a positive link to attitude.

Different from the previously mentioned studies, Lokan and Greenwood (2000) firstly examined and interpreted some important parameters of TIMSS 1995 in Australia in terms of such as; Australia's education systems and schools, test date, sample, response rate and adequacy of data, relative performance, areas of strength and weakness, and implications of TIMSS 1995 in terms of mathematics instruction. Then by using correlations they examined the relationships between selected student level; school and class-level characteristics and mathematics achievement. Among these correlations, parents' occupational status and education level, books in at home and family size were found to be significantly correlated with mathematics achievement. Moreover, whether the students liked mathematics was associated with achievement but the association was not strong. Additionally, "Self-efficacy" or believing that one is doing well in the subject had the highest correlation with the achievement. With regards to school and class level characteristics, "students-centered emphasis", "teacher-centered emphasis", and "class discipline" variables that were derived from classroom practices, had only low or negligible correlations with achievement. Interestingly it was found that the use of student-centered teaching strategies was negatively related to achievement. In terms of student-level factors, time spent out-of-school in on academic activities was correlated negatively with mathematics achievement while importance of mathematics to life, liking for mathematics, mother's, own, and friends' valuing of academic study were positively correlated with mathematics achievement. Finally, Lokan and Greenwood (2000) developed a path model for the Australian TIMSS 1995 data by using the results of previously conducted factor analyses. The dominating factors in relation to achievement were self-efficacy, own educational aspiration, and external attribution for success. Moreover, the students' liking for mathematics contributed achievement through its relationship with self-efficacy. They pointed that the importance of positive attitudes towards mathematics and a belief that one has ability to do well in mathematics is reinforced by these results. Also they emphasized that it is important for students to be encouraged to believe that their own actions can influence their success at school, since believing that success is due to luck rather than to one's own efforts was shown to be to be negative predictor of achievement in this study. As a result they concluded that it may be worthwhile that teachers can play a role in influencing students' attitudes, self-perceptions and beliefs.

In another analysis performed with German data of First International Mathematics Study (FIMS), Second International Mathematics Study (SIMS), and TIMSS 1995, Köller, Baumert, Clausen and Hosenfeld (1999) tested model of educational productivity provided by Walberg and colleagues in 1981 (cited in Köller, Baumert, Clausen, & Hosenfeld, 1999). They believed that ability, motivation, developmental stage, mass media, home environment, and peers are variables affecting achievement at student level, while quality and quantity of instruction as well as that class environment can be considered class level variables that affect achievement. According to the model they developed the cognitive variables were found to be the most powerful predictors of mathematics achievement. However, motivational determinants, leisure activities, and students gender were also significant predictors of mathematics achievement while, mass media that is measuring amount of watching TV and playing computer games, and home educational background that is measuring education level of parents, their job prestige and their number of books at home had no direct impact on learning. Moreover, home environment had a significant path on academic leisure time behavior. That was students with higher educational parental background spent more time an academic out-of-school activities. Also, mathematics achievement in grade 8 was influenced by achievement in grade 7 and non-academic leisure activities with fear of failure had negative effects on mathematics achievement.

Differently from the previously mentioned modeling studies, Yang (2003) used only the socioeconomic status variable. He examined the dimensionality of socioeconomic status and its relationships with mathematics and science performance at student and school levels. In the study, data of 13-year-olds from 17 countries participated in TIMSS 1995 were used. The dimensions of socioeconomic status were measured by the items asking information about the ownership of a set of household materials. Yang (2003) interpreted the results of the study as the ownership of set household materials can be used as socioeconomic indicators.

Using multilevel modeling, Webster and Fisher (2000) investigated the resource availability in rural and urban Australian schools and included the variables of students' attitudes towards science and mathematics and career aspirations of these students as well as socioeconomic status and gender of these students. They used multilevel model accounting school, classroom, and student level variance focusing on the effect of available school resources, students' attitudes, and students' career choices on mathematics and science achievement in both rural and urban schools by using data of 12852 thirteen-year-old students in TIMSS 1995. One of the control variables was socioeconomic status. It was measured with father's occupation, father's and mother's education. In multi-level analysis, the effects were positive for the school average SES that is achievement was higher for those students attending schools where their peers came from higher socioeconomic backgrounds. According to the results a strong and negative effect of rurality was observed on student mathematics and science achievement. Besides, there was no strong or significant effect of the availability of recourses in school on student achievement in mathematics and science. In accordance with most researches, students' attitudes towards mathematics have a strong and significant effect on achievement, and as expected the more positive the attitude the higher the standard of achievement. Also the career aspirations of the students have a strong and positive effect on achievement.

In another study carried out by Schiller, Khmelkov, and Wang (2002), Hierarchical Linear Modeling (HLM) was used to explore the relationship between nations' level of economic development and the influence of students' social backgrounds; parents' education and family structure, on their mathematics achievement using data of TIMSS 1995. The researchers found that the positive effect of higher parents' education on middle school students' mathematics test scores is considerably consistent among the 34 nations investigated. However, the relative advantage of living in a traditional family for mathematics achievement differs from systematically among nations, being significantly greater in those with stronger economy. They pointed that more educated parents appear to be able to provide their children with academic and social supports important for educational success.

Schreiber (2002) examined advanced mathematics achievement with 1839 students from 162 schools with the data from TIMSS 1995. He used hierarchical (multilevel) linear modeling to examine student- and school-level factors. According to the results average parents' education was observed to be associated with the magnitude of the coefficient for attitude toward mathematics on achievement. Especially, at the student level, students whose parents had lower levels of formal education scored lower than did those students whose parents had higher formal education levels. One explanation for this result may be that in schools that have higher average parent education, attitude has more of an influence on achievement. If a student's level is low and the student is in a school with high average formal parent education, the impact may be stronger on that student than on one with a similar poor attitude in a school with a lower formal average parent education. Also, it was reported that the magnitude of this relationship varied from school to school. With regards to students' beliefs, it was found that the students who had a poor attitude toward mathematics tended to perform poorly on the test. Additionally, the more students who believe the key success is based on hard work traditionally perform better than those students who do not. While the amount of the time spent studying mathematics was not significantly related to advanced mathematics achievement in the model, the amount of time spent engaging non-academic activities (television, employment, sports) was negatively associated with advanced mathematics scores.

Abu-Hilal (2000) assumed that achievement plays a central role in the academic and psychological development of children, namely being both an outcome and an antecedent variable. He tested his model using data of 215 male and 179 female six and nine grade students. In the model, academic effort was defined as the amount of time spend on studying, and for the mathematics anxiety three indexes were computed; dread index, anxiety index, and mathematics dislike index. Mathematics self-concept was defined as general feelings of doing well or poorly in mathematics and mathematics achievement was the aggregate scores of assignments, quizzes, and examinations. EQS program was used to test the models using structural equations modeling. As predicted, Abu-Hilal (2000) found that perceived mathematics importance was positively related to effort exerted in learning. Also the findings showed that mathematics importance or attitude relates positively to achievement. The results of this study showed that achievement was more strongly related to effort than to importance. Achievement found to be the strongest predictive power concerning predictors of self-concept. In addition to that the students, who perceive mathematics as an important subject, tend to develop positive self-concept in mathematics. In accordance with his expectations, Abu-Hilal found a strong negative direct relationship between achievement and anxiety.

In terms of evaluating achievement behaviors with gender issue, Ethington (1991) sought to determine the degree to which the key constructs within the model developed by Eccless and colleagues (as cited in Ethington 1991); students' expectations for success and task value, directly influence achievement behavior and serve as mediators for the indirect influence of prior constructs. She used the data of 869 eighth graders in United States collected in the Seconds International Mathematics Study (SIMS). The variable of family socioeconomic status was constructed by mother's and father's level of education and current occupation. Other variables were parental help, parents' attitudes and expectations, appropriate sex-role behaviors, the perceived difficulty of mathematics, the value of mathematics, self-concept in mathematics, goals, expectations for success, and intention to take more mathematics. In the study the causal model was estimated with ordinary least squares procedures. The indirect effects and their standard errors also with the usual regression results were computed. It was found that self-conception and perception of the difficulty of mathematics show direct significant effects on expectations for success for both gender. The socioeconomic status found to exert additional influence for females, while self-concept and perception of the difficulty of mathematics show additional effects for males.

Meece, Wigfield, and Eccles (1990) used structural modeling techniques to assess the influence of the past math grades, math ability, perceptions, and performance expectations on the level of math anxiety using the data of 250 7th through 9th graders. The perceived math ability measure includes three items asking students' sense of their math ability and how well they were doing in math. The importance measure consisted of two items asking students to rate how important it was to them to be good at math and to get good grades in math. The findings showed that math anxiety was most directly related to students' math ability perceptions, performance expectations, and value perceptions. Students' performance expectations predicted subsequent math grades, whereas their value perceptions predicted course enrollment intentions. Additionally math anxiety did not have significant direct effects on either grades or intentions.

Demir-Gülşen (1998) developed a model in order to see the effects of cognitive, metacognitive and affective characteristics of students on their mathematics achievement in general and probability in particular. She indicated that the model testing showed that in predicting math achievement metacognitive skills and as an affective variable only motivation were significant variables whereas in predicting probability achievement not the affective variables but the cognitive and metacognitive variables were found as significant. Similarly, Tağ (2000), modeled the reciprocal relationship between the attitude toward mathematics and achievement in mathematics. According to the results, it was reported that there was reciprocal relationship between attitudes toward mathematics and achievement in mathematics. Additionally, confidence in learning mathematics which was measured as students' beliefs about their ability to learn and perform well on mathematical tasks, success attribution in mathematics, mathematics anxiety, importance of mathematics referring to students' beliefs about the importance of mathematics in relationship to their life, effectance motivation, usefulness of mathematics positively and significantly loaded on attitudes toward mathematics. Furthermore, father's quality reflecting students' perceptions of father's attitudes toward them as learners of mathematics had a positive statistically significant direct effect on both attitudes toward mathematics and achievement in mathematics while mother quality had a positive statistically significant direct effect on achievement in mathematics but a negative statistically significant direct effect on attitudes toward mathematics.

Marsh (1986) examined the empirical support for the internal-external model that describes the relation between Verbal and Math self-concepts, and between these academic self-concepts and verbal and math achievement. Basing on the data gathered from 6010 students, Marsh found that (1) verbal and math self-concepts are nearly uncorrelated with each other although verbal and math achievement are substantially correlated each other; (2) the direct effects of math achievement of verbal self-concept, and of verbal achievement on math self-concept are both negative.

Lee and Bryk (1989) examined how various aspects of the normative environment and academic organization of schools influence the distribution of mathematics achievement in regard to students' social, racial, and academic backgrounds. The data of 10.187 students from 160 high schools was analyzed HLM statistical technique. High average mathematics achievement is related to school social composition and to the school's academic emphasis.

D'Agostino (2000) assessed the relationships between the schooling effects and students' longitudinal mathematics and science achievements by conducting three-level HLM analyses. The results show that particular instructional variables were related to students' achievement, but compositional and organizational features of the schools did not predict teachers' levels of these instructional practices. According to the results, teaching practices those having a positive effect on student learning changed across grade levels. For instance, teachers who emphasized a teacher-directed, basic skill orientation appeared to be most effective in both mathematics and reading in grades 1 and 2. The student-centered, advanced-skill focus did not appear to be an effective strategy for students in the early primary grades.

Ryoo (2001) investigated to what degree student, school, and education policy factors are related to improving student achievement and to reducing the school achievement gap. The student characteristics affecting achievement are family background and student effort whereas school characteristics affecting achievement are teacher quality, ability grouping and other aspects of school quality and education systems, levels of national income, and national exam and secondary school stratification policies at the national level. Ryoo (2001) used the empirical data provided by TIMSS 1995. According to the results, television watching hours among the student-level variables showed significant regression coefficients, and of the school-level variables, mean SES – the contextual effect of SES – appeared most important. In addition the results show a number of student-level variables to be significant predictors of mathematics achievement. Firstly, the composed variable indicating family socioeconomic status is significant in the positive direction. Also, at the school level, having an exam policy in effect increases the gap between high SES school and low SES schools, as it also does in developed countries. The traditional school resourse variables such as student-teacher ratio, class size, teaching experience and teacher education display very small magnitudes whether they are significant or not. Additionally, the school mean for study hours has a significant positive effect on school achievement whereas class size is significant but in opposite direction. Students who studied in larger-size classess are more likely to show higher achievement.

Stemler (2001) investigated school effectiveness in mathematics and science by using the data of TIMSS at the fourth grade. The variables used in the two-level HLM analyses were selected from student, teacher, and school questionnaire. These variables were related to student involvement, instructional methods, classroom organization, school climate, and school structure. The results indicated that approximately one quarter of the variability in mathematics and science achievement could be attributed to schools. When the differences in student backgrounds across schools were controlled, the most effective schools in mathematics and science had students who reported seeing a positive relationship between hard work, belief in their own abilities, and achievement. Additionally, the students of more effective schools had reported less frequent use of computers and calculators in the classroom.

Park (2003) examined the effects of teacher empowerment on teacher commitment and student achievement by using two-level HLM technique. In the study teacher empowerment was defined by using a four-dimension structure. These four dimensions were formal authority, autonomy, collaboration, and trust. The results revealed teacher perceptions of their empowerment were clearly shaped and facilitated by their teacher individual characteristics of gender, race, age, teaching experience, education level, and subjects taught, by the school characteristics of sector, percentage of white students, school size, school location and mean school SES, and by the environmental factors that contributed to its variations among schools. Additionally, it was found that teacher empowerment did not directly affect student achievement in reading, math, science, history/social studies.

Lee (2004) investigated the effectiveness and the use of instructional resource allocation across the states and also explored the potentials and limitations of setting outcome-based standards of instructional resources and practices. The results revealed that human and physical resources were weakly related to each other, implying that each measure may tap a somewhat unique aspect of school resources for teaching and learning. Additionally, the availability of both human and physical resources was positively associated with the level of desirable instructional practices. Based on the results it was concluded that the effect of human resources was greater than the effect of physical resources.

Rodriguez (2004) examined the relationships between the assessment practices and achievement and the mediating roles of student self-efficacy and effort. In the study the data set of American student participated in TIMSS was used. These relationships were investigated through the HLM statistical technique. The results show that the level of prior mathematics experience was a significant contributor for explaining variation in classroom performance. The average level of uncontrolled attributions such as natural talent and luck made by students in a classroom had a significant negative relationship with classroom performance. Nevertheless, the average level of self-efficacy of the classroom had a significant positive relationship with classroom performance. More frequent moderate levels of assigned homework were associated with higher performing classrooms; and larger proportions of students who did no homework were associated with lower performing classrooms.

Van den Broeck, Van Damme and Opdenakker (2005) focused on the variance in mathematics scores situated at the student, the class, and the school levels. Moreover in the study, the variance in mathematics scores reduced by background characteristics of the students at each level was also investigated. With respect to the differences, 57%, 29%, and 14% of the variance of mathematics scores was situated at the student, class, and the school level, respectively. Among the background characteristics of the students, the numerical and spatial intelligence score appear to be the most important variable to reduce the variance in mathematics scores. The other student characteristics such as attitude towards mathematics and the subject chosen were found to have an additional effect.

İş Güzel (2006) investigated the impact of human and physical resource allocations and their interaction on students' mathematical literacy skills across Turkey, member and candidate countries of European Union by using data of PISA 2003. She used hierarchical linear modeling techniques for student and school level characteristics. Basing on the findings of the analyses, she reported that in Turkey, member and candidate countries of European Union who performed higher on the mathematical literacy assessment tended to have the characteristics such as, enrolled at higher grade levels, more educational resources at home, higher levels of mathematics self-efficacy, lower levels of mathematics anxiety, more positive self-concept in mathematics, less preferences for memorization strategies, and more positive disciplinary climate in mathematics lessons. Moreover, the influence on mathematical literacy assessment varied from school to school with respect to grade level and disciplinary climate in Turkey and European Union countries.

Akyüz (2006) investigated the effects of mathematics teacher and classroom characteristics on students' mathematics achievement across Turkey, member and candidate countries of European Union by using TIMSS 1999 data sets. She used Hierarchical Linear Modeling (HLM) to build explanatory models after the home educational resources (HER) of students were controlled. Mathematics teacher characteristics were divided into three groups as teacher's background variables, teacher's instructional practices and class characteristics. She concluded that there were substantial differences among the countries, especially in the teacher's instructional practices.

Sevgi (2009) investigated the effects of school characteristics on students' mathematics achievement across Turkey by using the data of TIMSS 2007. The student level characteristics investigated in the study were highest level of education of either parent, student speaks the language of test at home, students' parents born in country, books at home, computer and internet connection, computer use index of time students spend doing mathematics homework in a normal school week, index of students' positive effect toward mathematics, index of students' valuing mathematics, index of students' self confidence in learning mathematics. The school level factors were the percentage of students coming from economically disadvantages homes, percentage of students having the language of test as their native language, index of good attendance, principals' time spent on various school related activities, schools encouragement of parental involvement, index of school resources for mathematics instruction, and index of principals' perception of school climate. The results of HLM statistical technique revealed that mathematics achievement score of the Turkish students were predicted by the school variables of SES, parent volunteer for school progress, school recourses, and school climate.

2.16 Summary of the related literature

The result of literature review related to problem and problem solving displays that there are many different definitions of both problem and problem solving. This causes a nonagreement and an ongoing difficulty in the terminology associated with problem and problem solving. Although, a consensus on the definition of problem solving has not been reached in the literature by the researchers in the field, many of them have agreed that problem solving is an activity which is very complex by its nature. Additionally, many researchers agreed on the importance of problem solving and on the necessity of integrating problem solving in the mathematics curricula. The reason for the necessity of problem solving is the role of it carries in making the connection between the classroom and real world. To explain and characterize the process of problem solving many models have been proposed by the researchers. These models include a series of tasks and some thought processes that the problem solver should maintain. In fact, most of the proposed models are similar to each other and have common phases or steps.

In the light of related literature, *problem* is defined as a situation or statement that requires the use of mathematical content, application, and processes to reach a conclusion and *problem solving* is defined as a process from the beginning and a final situation in which the student performs a series of action to reach a conclusion. To identify whether the given situation is a problem or not two important criteria should be considered;

- The problem should be real life related, within the interest of the students, and challenging to the students.

- The problem should be presented in a concrete manner considering the mathematical level of the students.

As it can be easily noticed, the related literature is generally focused on the students' mathematics achievement or performance; however, it should be emphasized that the current study precisely focuses on problem solving skills of the students as the outcome variable. In this sense, there are many factors perceived to influence the achievement of the students have been cited in literature. These factors can be grouped as student, teacher and classroom related factors (see Figure 1.1). The correlations of these factors between mathematics achievement or general achievement have been repeatedly investigated. Most studies reported that SES demonstrated to have a high correlation with students' achievement. Similarly, whether reciprocal, average direct, indirect, and causal or not, it can be claimed that there is a consistent and positive relationship between mathematics self-concept and mathematics achievement. It is highly stressed that education systems should improve students' motivation and interest to continue their learning by this way engagement in learning and the depth of understanding are enhanced. On the other hand, whether indirect or not, it is often assumed that mathematics anxiety hinders students to learn mathematical tasks and high levels of anxiety affects performance of the students negatively. Learning habits of students have not been investigated as much as the affective domain variables have been investigated. Although the definition and categorization of learning strategies, or the way to teach students learning strategies are frequently mentioned topics, there are not many studies investigating the relationship between particular learning strategies and academic performance. Two of mostly cited types of preferences for learning situations are cooperative and competitive learning situations. The results of the research studies display that cooperative learning enhances students' academic achievement and social relations among the students. However, the results of the studies conducted just a bit in number, it is reported that, competitive challenge can have both positive and negative effects on student engagement and performance.

The importance, value, and necessity homework that is one of the classroom related factors in Figure 1.1 have always been part of the educational debate. The review of correlational studies revealed that the relationships found between different homework variables and achievement are inconsistent. Then it is hard to claim that there is a definitive relationship between some sort of homework variables and achievement. In addition to the use of homework, classroom practices are important, since the instruction begins formally in the classrooms and influences on the learning of students. These influences can be relationships with peers, peer groups in general, teachers and textbooks.

The teacher related factors especially, their perceptions about mathematics, mathematics teaching and learning as well as their relationships with teaching practices have been investigated. Although the results of review studies display that teachers' perceptions teaching and learning affect their teaching practices, in some studies, it was reported that teachers' beliefs are not always consistent with their teaching practices. Another important teacher perception is the perception about teacher efficacy. In some research it was reported that teachers' sense of efficacy is found to be related to students' achievement gains and a strong link exists between teacher self-efficacy and improved student achievement.

The identification and examination of the factors that explain achievement have long been searched by the researchers. Though the investigation of individual factors that affect achievement is important, modeling suggests an advantage of examination and investigation of not only each individual factor but also the relationships among those factors. Literature review about mathematics achievement and modeling shows that many studies proposing theoretical models have been conducted to explain mathematics achievement and its relationships between psychological, pedagogical, social, and cognitive constructs. Most of these models were tested with the data of international studies by using structural equation modeling or multilevel and hierarchical linear modeling to examine student, teacher, and school level characteristics in order to investigate predominantly the mathematics achievement.

CHAPTER 3

METHODOLOGY

This section of the study is devoted to the presentation of major characteristics of population and sample and participant teachers, procedures for validation of the problem solving framework, reliability and validity of the instruments used in the study, the procedures followed to collect data, and finally the statistical methods used to analyze the collected data.

3.1 Population and sample

The target population of the current study is defined as all sixth grade public elementary school students in Turkey. Since it is not feasible to reach this population, an accessible population is defined. The accessible population of the study is defined as all sixth grade students in public schools in the eight central districts of Ankara. These central districts are Altındağ, Çankaya, Etimesgut, Gölbaşı, Keçiören, Mamak, Sincan, and Yenimahalle. This is the population for which the results of this study will be generalized. The rationale for selecting the sixth grade is that this grade level is a transition grade between early elementary and the secondary school levels. According to the Ministry of National Education (MNE) (2008), the number of sixth grade students attending to public elementary schools in the central districts of Ankara in 2007-2008 school year was 74.304. The percentages of the male and the female students was approximately 52% and 48%, respectively.

The initial intention for selecting the sample of the study was the use of stratified cluster random sampling in which the strata would be central districts of

Ankara and the clusters would be schools. However, several uncontrolled issues such as the problems in getting the permission of school administration, the special dates celebrated in these schools, or common exams administered to all classes at the same time created some obstacles for the researcher to select the schools randomly and reach many students in one school year by herself. Therefore, it was decided to select crowded schools with relatively large number of students to increase the probability of reaching as many students as possible in only one school year. Considering all of these mentioned issues, the sampling type used in the current study is called two stage cluster sampling design integrated with convenience sampling. The first stage clusters were thought as schools and the second stage clusters were thought as classrooms. The public elementary schools and the sixth grade classrooms from sampled schools were selected conveniently. In addition to the student questionnaire, their mathematics teachers were also given questionnaires. Therefore one of the criteria for selecting the sixth grade classrooms was the consent of their mathematics teacher for responding the mathematics teacher questionnaire. In this sense, the number of public elementary schools found in each of the eight districts, the number of sampled schools and classrooms are displayed in Table 3.1. The study was conducted in 74 sixth grade classrooms selected from 37 public elementary schools.

Table 3.1 Number of public elementary schools, sampled schools and classrooms for each central district of Ankara

District	Number of schools	Number of sampled schools	Number of sampled classes
Altındağ	65	2	5
Çankaya	104	2	3
Etimesgut	36	4	10
Gölbaşı	35	6	11
Keçiören	83	5	9
Mamak	91	8	15
Sincan	44	6	13
Yenimahalle	82	4	8
Total	540	37	74

To define the sample in sufficient detail major characteristics and socio-economic status (SES) such as gender, mathematics grade of the first semester, general grade, highest education level of the parents, number of siblings and books, some home possessions of the sample are displayed in Table 3.2, Table 3.3, and Table 3.4. As displayed in Table 3.2 a total of 2562 sixth grade students (48.8% females and 49.5% males) participated in the study. Also the participant students were asked to write their mathematics grades and grade point averages (gpa) obtained at the end of the first semester 2007-2008 school year. Since most of the students could not remember their general grade point averages they were asked to write whether they obtained certificate of success and certificate of higher success or not at all. Generally, if the grade point average is between 70 and 84.99, students obtain certificate of success, if grade point average is between 85 and 100, students obtain certificate of success. Approximately 60% of the students obtained 3 or above 3 out of 5 in mathematics. Moreover, approximately 40% of the students' grade point averages were 70 or above 70.

Table 3.2 Major characteristics of the sample

	Frequency	Percentage
Gender		
Female	1249	48.8
Male	1268	49.5
Missing	45	1.8
TOTAL	2562	100
Mathematics grade		
1	442	17.3
2	482	18.8
3	607	23.7
4	593	23.1
5	356	13.9
Missing	82	3.2
General grade		
Nothing (gpa < 70)	1278	49.9
Certificate of success ($70 \leq$ gpa ≤ 84.99)	810	31.6
Certificate of higher success ($85 \leq$ gpa ≤ 100)	266	10.4
Missing	208	8.1

The education level of parent's, number of siblings and books, and some home possessions were regarded as indicators of SES of the sample. This information is provided in Table 3.3 and Table 3.4. According to Table 3.3 the percentages of students whose mothers and fathers continued their education after lycee are 10% and 20%, respectively. Furthermore, approximately half of the sample has either no or one sibling and one thirds of the sample has number of books ranging from 0 to 25.

Table 3.3 Education level of parents, number of sibling and books

Educational level	Mother		Father	
	f	%	*f*	%
Left elementary school or did not go to school	163	6.4	59	2
Finished elementary school	939	36.7	574	22.4
Left secondary school	179	7	214	8.4
Finished secondary school	316	12.3	372	14.5
Left lycee	104	4.1	159	6.2
Finished lycee	437	17.1	502	19.6
Obtain technical education after lycee	31	1.2	50	2
Left university	39	1.5	37	1.4
Finished university	203	7.9	409	16
I don't know	108	4.2	136	5.3
Missing	43	1.7	50	2
Number of sibling				
No sibling	153	6		
1	1147	44.8		
2	765	29.9		
3	283	11		
4 and above	146	5.7		
Missing	68	2.7		
Number of books at home				
None or very few (0-10 books)	205	8		
Enough to fill one shelf (11-25 books)	747	29.2		
Enough to fill one bookcase (26-100 books)	874	34.1		
Enough to fill two bookcases (101-200 books)	392	15.3		
Enough to fill three or more bookcases (more than 200)	286	11.2		
Missing	58	2.3		

Table 3.4 displayed several home possessions of the participant students. As given in the table, most of the students have calculator, computer, study desk

for their use, and dictionary. Additionally approximately half of the students have dishwasher in their homes.

Table 3.4 Home possessions

Home possessions	Yes		No		Missing	
	f	%	f	%	f	%
Calculator	2254	88	155	6	153	6
Computer	1651	64.4	713	27.8	198	7.7
Study desk for your use	1991	77.7	387	15.1	184	7.2
Dictionary	2380	92.9	36	1.4	146	5.7
Dishwasher	1497	58.4	828	32.3	237	9.3

A socioeconomic status score was computed by converting the responses of the students to standardized scores and then summing these standardized scores to assess students' SES levels. Based on these SES scores, the students were grouped as low, medium, and high. The students having SES scores lower than one standard deviation were categorized as low SES group. Similarly, the students having SES scores higher than one standard deviation were categorized as high SES group. Thus, the rest of the students were categorized as medium SES group. Table 3.5 displays the frequencies and the percentages of the students according to three SES groups. The data given in Table 3.5 indicates that more than half of the students are coming from medium SES group.

Table 3.5 Frequencies and percentages of students in three SES groups

SES group	*f*	%
Low	418	16.3
Medium	1691	66.0
High	453	17.7

3.2 Participant teachers

The participant teachers were not the sample of the current study. Rather they were the mathematics teachers of the sampled students. Therefore, the students were the unit of analysis as in the design of TIMSS. The mathematics teachers of the sampled students responded to questions regarding their demographic and professional characteristics, mathematics homework, beliefs about mathematics and mathematics teaching, classroom activities, and self efficacy beliefs towards mathematics teaching. For defining the participant teachers in sufficient detail major characteristics such as gender, age, and teaching experience are given in Table 3.6 and Table 3.7, respectively. As indicated in the Table 3.6, the numbers of female and male teachers are approximately close to each other.

Table 3.6 Frequency and percentages of gender of the participant teachers

	Frequency	Percentage
Gender		
Female	23	46
Male	27	54
TOTAL	50	100

According to the Table 3.7, half of the teachers' ages are between 24 and 38. The other half of the teachers are 39 years old and above 39 years old.

Table 3.7 Frequency and percentages of age of the participant teachers

Age	Frequency	Percentages	Cumulative percentages
24 – 28	9	18	18
29 – 33	10	20	38
34 – 38	6	12	50
39 – 43	4	8	58
44 – 48	7	14	72
49 – 53	10	20	92
54 – 58	4	8	100
Total	50	100	

According to the Table 3.8, approximately half of the teachers (52%) have an experience between 1 and 15 years. The years of experience of the other half are between 16 and 40.

Table 3.8 Frequency and percentages of teaching experience of the participant teachers

Teaching experience	Frequency	Percentages	Cumulative percentages
1-5	7	14	14
6-10	12	24	38
11-15	7	14	52
16-20	5	10	62
21-25	3	6	68
26-30	14	28	96
31-35	0	0	96
36-40	2	4	100
Total	50	100	

Approximately 58% of the teachers graduated from faculty of education or three-year education institution. The rest of the teachers graduated from the department of mathematics and obtained teaching profession certificate from various faculties of education. Moreover, none of the teachers have a degree in neither master of science nor doctor of philosophy in mathematics education. The number of class-hour they teach mathematics in a week ranges from 15 to 28 with 4 missing data. Approximately half of the teachers reported that they come together with other mathematics teachers once in a week or twice or three times in a week to discuss and to plan curriculum or instructional approaches.

In order to understand the mode of the instruction teachers were asked about the frequency of certain classroom activities they usually follow. The Table 3.9 displays the frequency of the responses of the participant teachers for their teaching habits. As seen in the table, more than half of the participant teachers ask their sixth grade students to explain the reasoning behind an idea in most or every lesson. Additionally, one fifth of the participant teachers never or almost never ask their students to work on problems for which there is no immediately obvious method of solution. Moreover, most of them (86%) ask their sixth grade students to practice computational skills in most or every lesson.

Table 3.9 Frequency of the responses of the participant teachers for their teaching habits

	Never or almost never	Some lessons	Most lessons	Every lesson	Missing
Explain the reasoning behind an idea	0	22	48	28	2
Represent and analyze relationships using tables, charts, or graphs	2	50	30	18	0
Work on problems for which there is no immediately obvious method of solution	20	66	14	0	0
Use computers to solve exercises or problems	48	42	8	2	0
Practice computational skills	0	14	42	44	0

In addition to these items, some items were also asked to the participant teachers to obtain information about their perceptions related to their teaching profession. For instance, approximately half of them (52%) reported that teaching was their first choice as a career when beginning university or teaching profession certificate program. When they were asked whether they would change to another career if they had the opportunity, 40% of them responded as “YES.” Seventy-four percent of them thought that their students appreciate their work whereas only 28% of them thought that the society appreciates their work. Only half of them participated to an in-service program related with mathematics subjects, teaching mathematics and mathematics curriculum in the last two years. The percentages of participant teachers range from 22% to 26% attending for in-service programs related with the use of information technologies in mathematics instruction, the development of critical thinking or problem solving skills of students or methods, and assessment of mathematics lesson.

3.3 Validation of the framework

In order to construct a usable, accurate, and a valid test measuring students' problem solving skills, a framework for the problem solving processes is needed. As it was mentioned in the previous chapter, in the related literature there are many proposed models of problem solving processes (Charles, Lester, & O'Daffer, 1987; Krulik & Rudnick, 1989; Noddings, 1985; Lester & Kroll, 1990; Polya, 1957; Teare, 1980). In some of these models together with the phases or steps, some of the sample behaviors, objectives, or questions underlying each phase or step were also identified. When these models were investigated in detail, it was observed that most of the steps of different models are similar to each other to some extend and some steps of each model overlap. Based on this investigation, a framework for problem solving processes was constructed by the researcher. The reference model of this framework was the problem solving processes proposed by Polya (1957). However, the last step of Polya (1957) was modified as "looking back and evaluating". There is a couple of benefits for using such a framework in the present study. The first benefit is that compiling the steps of different proposed models using a reference model makes it easy to identify the behaviors underlying each step. The second benefit is the construction of one dimension of the table of specification consistent with the current literature.

Since the researcher constructed the framework by herself, it is important to validate the common steps of the framework for avoiding subjectivity. Therefore a simple validation procedure was conducted by consulting two experts. The steps of the validation procedure are as follows;

1. The models of problem solving processes proposed by different researchers were given to two doctorate students in the department of mathematics education. The main steps, brief explanations of steps, and the names of the researchers proposed the models were all provided. These given models are included in Appendix A.

2. They were asked to examine these models of problem solving processes individually.

3. Then, they were given an empty table only including the framework of Polya (1957). This table is also given in Appendix A. They were asked to decide where the steps of each different model should be placed in the table according to the model of Polya.

4. They were asked to fill this table in a meaningful and reasonable way individually.

5. The three tables filled by the researcher and the two doctorate students were compared. The comparison revealed that only the places of three steps displayed discrepancy. These discrepancies were discussed and a consensus was reached. The final framework was provided in the introduction chapter, in Table 1.1.

As a result, it can be claimed that the final framework is validated by the other experts. Thus, this framework can be used safely for identifying the objectives underlying each step considering all different models of problem solving processes.

3.4 Data collection instruments

Since in the current study both student and teacher level variables are considered, instruments used for collecting data are explained and presented in two main parts as student level and teacher level instruments. The student level instruments include problem solving skills test and a student questionnaire. The student questionnaire is consists of demographical information part, mathematics homework scale, mathematics classroom practices scale, mathematics self concept scale, mathematics learning situation scale, mathematics learning strategy scale, and motivation and anxiety scale. On the other hand, teacher level instruments include demographical and professional information part, mathematics homework scale, mathematics classroom practices scale, scale of perceptions about mathematics, and mathematics teaching efficacy beliefs scale. In the following subsections, each of the data collection instrument is explained in detail.

3.4.1 Student level instruments

3.4.1.1 Problem solving skills test

The problem solving skills test used in the present study was developed by the researcher. The whole process of developing the problem solving test was carefully and systematically planned by the researcher to ensure the reliability and validity of the results obtained in the study. Essentially, the problem solving skills test developed for this study is an ability test focusing on measuring cognitive processes skills of the students (Millman & Greene, 1989). It was suggested that cognitive processes such as problem solving strongly interacts with development and utilization of organized bodies of conceptual and procedural knowledge structures (Glaser, 1984). Therefore, although in the current study the main focus is on problem solving processes, the subjects from sixth grade mathematics program was tried to be linked to problem solving processes. In this sense, the purpose of the problem solving skills test is to measure the problem solving skills of the sixth grade students. This test also was used to identify the sub-domains of the problem solving skills of the sixth grade students. After the purpose of the test was determined, table of specification was constructed based on the problem solving framework as the cognitive processes dimension and the subjects of sixth grade mathematics curriculum as the content dimension. The objectives underlying each step of the problem solving framework were written based on the related literature (Charles, Lester, & O’Daffer, 1987, p. 42). The cognitive processes dimension together with objectives and the content dimension of the table of specification are provided in Appendix B and Appendix C, respectively.

3.4.1.1.1 Writing items

In the current study the items of problem solving skills test were written, adapted or taken from the international and national exams by the researcher. The reason for adapting or taking the items from other sources is to increase the number of items as much as possible. The first issue considered in the process of writing and adapting items was that whether the each situation could be considered as a problem or not for a sixth grade student. The decision was given based on the definition of the *problem* and two important criteria that a problem should have mentioned in the introduction part of the study. Second issue taken into consideration was that the cognitive dimension was tried to be integrated with the content dimension of the table of specification. In this process, the objectives were listed and a link was tried to be constructed between the problem situation and the observable behaviors. However, it was admitted that this process was a demanding and a complicated task because the distinction between the content and cognitive processes dimension became blurred (Millman & Greene, 1989).

Another issue considered was the decision of item formats. The two item formats used in this test were multiple-choice and free-response. There are many rules presented in the textbooks on educational measurement for writing especially multiple-choice items. These rules are not laws that should never be broken; rather they are written rules based on common sense and conventional wisdom of experts in the field of educational measurement (Haladyna, 1997; Millman & Greene, 1989). Therefore, in the current study these rules were reviewed and taken account as much as possible while writing and adapting the items. Moreover, consistently with the item format, appropriate scoring schemes giving partial credit to free-response items were prepared. In deciding the partial credit, the degree of completeness of accuracy of the response was considered.

In the adaptation process, the appropriate items were identified and afterwards these items were translated by two doctorate students in the foreign language department. Then, these translations were examined by the researcher. As a result of this investigation, context of the items such as special names or situations those may be inconvenient for Turkish culture, or the numbers were changed considering the target examinee population.

It is suggested that developing more items than needed is important for having sufficient number of items in the final test after eliminating items because of accuracy, content validity, appropriateness, bias, or lack of empirical properties (Millman & Greene, 1989). Therefore, many items were written or adapted before the pilot study was conducted. Actually, in the item pool there was at least one item for each of the objectives included in the cognitive processes dimension. As a result, a total of 75 items were prepared. Twenty-seven of these items were written by the researcher, 32 of them were adapted by the researcher, 12 of them were taken from international studies (adapted by Department of Educational Research and Development [EARGED]) and finally 4 of them were taken from national studies. According to the table of specification, 21, 8, 34, and 12 of the items were measuring the processes of understanding the problem, devising a plan, carrying out the plan, and looking back and evaluating, respectively. Additionally, 45 of these items were multiple-choice whereas 30 of them were free-response items.

3.4.1.1.2 Taking expert opinions

After 75 items were prepared, their content and format were investigated by three mathematics teachers and one doctorate student in the mathematics education department. The experts were presented a group of questions for judging the appropriateness of the items. The issues asked to the experts are as follows;

- Identify whether the given situation is a problem or not considering the definition of the *problem* and the two important criteria given in the introduction of the study.

- Identify whether a sixth grade student might encounter to the presented situation or not.

- Identify what the items are measuring with respect to the step of the problem solving framework and the related objective.
    - The experts were given the list of problem solving processes and corresponding objectives, and the list of subjects in the content domain of the table of specification. They were asked to match each item to the related problem solving process, objective, and the related subject.

- Evaluate the suitability, difficulty, and appropriateness of the content and format of the items for the sixth grade students.

- Identify whether the items had only one correct answer.

Finally, they were asked to specify whether they had any additional ideas about the items. The template given to the experts is provided in Appendix D. After the experts filled the templates for each of the items, the interpretations and evaluations of the experts were investigated by the researcher. As a result, necessary revisions such as simplifying and shortening some items were conducted with the guidance of the experts. Additionally, after discussions, some of the disagreements about what the items were measuring were reached consensus.

3.4.1.1.3 Pilot study

The total of 75 items was pilot tested in order to identify and to select the best items for the final version of the problem solving skills test. Since there were 75 items, the items were divided into six forms for ensuring that students would spend more than enough time for answering the items, and thus each form had number of items ranging from 12 to 14. The forms were administered in ten seventh grade classes by the researcher in the classroom environment. The students were given one-class hour and they were also requested to specify whether there was anything that they did not understand in the items. In each class the six different forms were given randomly to the students. The number of students responding to each form ranged from 70 to 97. The group of students used for pilot testing was average students attending two public schools in Ankara and they were not much different from the target population.

The answers of the students attended to the pilot study were entered into computer by using Statistical Package for the Social Sciences (SPSS). The ITEMAN and SPSS programs were used for evaluating the item responses. The quality of the items were evaluated by investigating item difficulty and discriminating indexes for selecting the appropriate items for the final version of the problem solving skills test. The proportion correct value used for the item difficulty index of dichotomously coded items was ranged from 0.12 to 0.7. Some of free response items were graded out of two. For such items, item means were used as an index of item difficulty. The item means for partially graded items ranged from 0.01 to 0.89. As an item discrimination index, corrected item-total correlations were evaluated. According to the results, this correlation ranged from -0.09 to 0.68. Based on the evaluation of both item difficulty and discrimination indexes of all the items as well as considering what these items were measuring a total of 20 items were selected to be used in the final version of the problem solving skills test. The criterion of the item difficulty for dichotomously coded items was being around 0.5 whereas for partically graded items was being around

1.0. Additionally, the criterion for the corrected item-total correlation was being around 0.20. Also in selecting the appropriate items, time constraints, students' attention span and a balanced distribution of items measuring the four problem solving processes of the framework were taken into account. Before the actual administration, the final version of the test was administered to a group of sixth grade students for evaluating whether one class-hour was appropriate for completing the test. The final version of the problem solving test and scoring guides for the free response items were given in Appendix E and Appendix F, respectively. The problem solving processes and the objectives the items measured and the related content of the items were provided in Appendix G. The results of the pilot study with respect to item difficulty and discrimination for the selected items together with the key, format, and the source of the items were presented in Appendix H.

3.4.1.1.4 Validity and reliability

The final version of the problem solving skills test was administered to 2562 sixth grade students by the researcher in the classroom. Each class was given one-class hour that was 40 minutes to complete the test. For the multiple choice items the correct ones were coded as 1 and the incorrect ones were coded as 0. For free response items the detailed scoring guides were used (see Appendix F). Initially, all the free response items were scored very carefully by the researcher. After all the scoring procedures were completed, the researcher selected approximately 10% of the data randomly and rescored them. The consisteny between two scoring was quite high (97%). Moreover, again approximately 10% of the data selected randomly and a mathematics teacher was asked to score the free-response items of this selected data. The consistenty was again quite high (95%). These procedures guaranteed that the consistency of the scoring of the free-response items was quite high across the all data.

The coded data was entered by using Excel and then the data was converted into SPSS data file. The mean, standard deviation, and the corrected inter correlations of the items were given in Table 3.10.

Table 3.10 Mean, standard deviation, corrected item-total correlations of the items

Name of the item	Mean	Standard deviation	Corrected item-total correlation
Ela	0.59	0.49	0.20
Dergi	0.46	0.50	0.28
Hesap makinesi*	0.94	0.98	0.45
Halı	0.59	0.49	0.38
Canan*	0.47	0.77	0.52
Televizyon	0.39	0.49	0.23
Kitaplık	0.19	0.40	0.36
Kaykay	0.24	0.43	0.50
Akdeniz	0.50	0.50	0.35
Hız	0.29	0.45	0.27
Petşişe	0.55	0.50	0.38
Basketbol	0.63	0.48	0.35
Çimbiçme	0.51	0.50	0.21
Alp	0.48	0.50	0.29
Beden eğitimi	0.48	0.50	0.35
Telefon 1*	0.15	0.43	0.26
Telefon 2*	0.09	0.14	0.17
Telefon 3*	0.11	0.29	0.20
Dans	0.42	0.49	0.25
Bölgeler	0.47	0.50	0.20

* Partially coded items

The reliability of the problem solving skills test was found as 0.74 as indicated by the Cronbach's alpha coefficient in the actual administration.

Two validity evidences were found for the problem solving skills test. The first evidence is concerned with the relationship between gender and problem solving performances of the students. On the other hand, the second one is relevant to the relationship between mathematics and problem solving performances of the students. In PISA 2003 relationship between gender and problem solving performance of the students was explored in 41 countries (OECD, 2004a). The investigation of differences between the mean performances of female and male students indicated only minor gender differences with these slightly in favour of females overall. Parallelly, Gallagher and De Lisi (1994) proposed that females do better on problems that are well defined. Based on the results of the related studies an independent-samples *t* test was conducted to evaluate the hypothesis that female students performed better than male student in the problem solving skills test. The test was significant, t (2515) = 2.88, p = .004. Female students (M = 8.16, SD = 4.09) on the average performed better than male students (M = 7.99, SD = 4.29) on the problem solving skills test. The result indicating a difference in favor of female students with respect to problem solving performance provided a construct related evidence for the problem solving skills test.

Having assessed different areas other than problem solving skills in PISA 2003, the relationships between students' problem solving performances and students' performances in other assessment areas such as reading, science, and mathematics were analyzed. These analyses displayed that all the relationships were significant and among all the relationships problem solving correlated most highly with mathematics in 41 countries (OECD, 2004a). Additionally, Schwieger (1999) noted that teaching of problem solving is formed at the same time of teaching of other mathematical concepts and processes. He also indicated that problem solving is highly interconnected with mathematics. Based on these findings, correlation coefficients were computed between students' problem solving skills test scores and students' mathematics and general grades in the current study. The results of the correlational analyses showed that both correlations were statistically significant. The correlations of problem solving skills with mathematics and general grades were .60 and .61, respectively. These significant results also provided a construct related evidence for the problem solving skills test.

3.4.1.2 Demographical information part

The demographical information part was used to obtain information about students' major characteristics such as, gender, parent education level, number of sibling and books, and home possessions, and extra mathematics lesson taken outside of school. The items found in this part of the questionnaire were taken from the student questionnaires used in international studies. This part was also used for describing the major characteristics of the participant students (see Appendix I).

3.4.1.3 Mathematics homework scale

This scale is about mathematics homework practices. The purpose of this scale is to obtain information from students about the frequency, amount, type, and the use of mathematics homework assigned (see Appendix I). Students respond to the items in a four point Likert scale (1=never to 4=almost always) for the third and the fourth parts. This scale is taken from Turkish version of TIMSS 1999 Mathematics Teacher Questionnaire and adapted for students.

3.4.1.4 Mathematics classroom practices scale

The purpose of this scale is to obtain information from students about the frequencies of mathematics classroom practices (see Appendix I). In this scale there are 30 items containing students' perceptions about the frequency of classroom practices in mathematics instruction. Students respond to the items in a four point Likert scale (1=never to 4=almost always). This scale is taken from Turkish version of TIMSS 1999 Student Questionnaire.

3.4.1.5 Mathematics self concept scale

The purpose of this scale is to measure students' perceptions about their mathematics performance (see Appendix I). Students respond to the items in a four point Likert scale (1=strongly disagree to 4=strongly agree). The scale is consists of 10 items. The first five items are taken from Turkish version of PISA 2003 Student Questionnaire. The last five items are taken from Turkish version of TIMSS 1999 Student Questionnaire.

3.4.1.6 Mathematics learning situation scale

The purpose of this scale is to obtain information from students about their preferences for mathematics learning situations (see Appendix I). The scale consists of two parts including co-operative and competitive learning in mathematics classroom. Students respond to the items in a four point Likert scale (1=strongly disagree to 4=strongly agree). The scale is consists of 10 items. The first five items are related to competitive learning preferences whereas the other five items are related to co-operative learning preferences. This scale is taken from Turkish version of PISA 2003 Student Questionnaire.

3.4.1.7 Mathematics learning strategy scale

The purpose of this scale is to obtain information from students regarding their strategies used for learning mathematics (see Appendix I). These learning strategies include memorization, control, and elaboration strategies in learning mathematics. The four items are related to memorization strategy, five items are related to control strategy and five items are related to elaboration strategy. Students respond to the items in a four point Likert scale (1=strongly disagree to 4=strongly agree). The 14 items are taken from Turkish version of PISA 2003 Student Questionnaire.

3.4.1.8 Motivation and anxiety scale

The purpose of this scale is to obtain information about students' motivation and anxiety in mathematics (see Appendix I). The scale consists of three parts including intrinsic and instrumental motivation and anxiety. Five items are related to intrinsic motivation, four items second items are related to instrumental motivation to learn mathematics, and five items are related to mathematics anxiety. Students respond to the items in a four point Likert scale (1=strongly disagree to 4=strongly agree). These 14 items are taken from Turkish version of PISA 2003 Student Questionnaire. One item is added from TIMSS 1999.

3.4.1.9 Pilot study of student level instruments

The pilot study of the student level instruments except problem solving skills test was conducted with 87 seventh grade students attending a public school in Ankara. After the responses of the students were entered into computer by using Excel and then SPSS, they were evaluated by using ITEMAN. The values given in the related tables indicated that all of the items functioned as expected so all of them were retained and used in the actual study.

The Table 3.11 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics homework scale. The reliability of the total 21 items was found to be 0.71 as measured by Cronbach's alpha coefficient.

Table 3.11 Mathematics homework scale item statistics

Item	Item mean	Item variance	Item-scale correlation
1	2.62	0.31	0.54
2	3.57	1.01	0.21
3A	2.16	0.25	0.27
3B	3.24	0.44	0.23

Table 3.11 (Continued)

Item	Item mean	Item variance	Item-scale correlation
3C	3.31	0.42	0.29
3D	2.69	0.71	0.30
3E	2.12	0.43	0.36
3F	2.33	0.36	0.51
3G	2.24	0.32	0.39
3H	2.29	0.44	0.39
3I	2.31	0.60	0.47
3J	1.91	0.55	0.45
3K	1.24	0.62	0.31
4A	2.31	0.56	0.37
4B	2.05	0.56	0.38
4C	2.29	0.51	0.51
4D	3.03	0.68	0.47
4E	3.02	0.59	0.34
4F	1.90	0.77	0.60
4G	2.14	0.72	0.50
4H	2.71	0.98	0.56

The Table 3.12 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics classroom practices scale. The reliability of the total 30 items was found to be 0.81 as measured by Cronbach's alpha coefficient.

Table 3.12 Mathematics classroom practices scale item statistics

Item	Item mean	Item variance	Item-scale correlation
1	3.29	0.81	0.46
2	3.61	0.34	0.55
3	2.47	0.78	0.46
4	2.80	0.63	0.46
5	2.59	0.68	0.50
6	1.96	0.76	0.19
7	1.69	0.75	0.30
8	2.55	0.72	0.36
9	2.25	0.65	0.40
10	3.57	0.43	0.32
11	1.93	0.74	0.39
12	2.47	0.67	0.35
13	2.38	1.22	0.54
14	2.30	0.90	0.52
15	3.40	0.66	0.34
16	1.86	1.33	0.28
17	2.95	0.87	0.39

Table 3.12 (Continued)

Item	Item mean	Item variance	Item-scale correlation
18	1.72	1.02	0.15
19	2.18	0.62	0.28
20	1.92	0.89	0.34
21	2.95	0.96	0.37
22	2.52	1.05	0.45
23	2.43	0.83	0.35
24	2.86	0.72	0.47
25	2.80	0.93	0.52
26	2.91	1.02	0.53
27	3.39	0.71	0.38
28	3.39	0.53	0.51
29	3.36	0.52	0.42
30	3.20	0.86	0.38

The Table 3.13 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics self concept scale. The reliability of the total 10 items was found to be 0.76 as measured by Cronbach's alpha coefficient.

Table 3.13 Mathematics self concept scale item statistics

Item	Item mean	Item variance	Item-scale correlation
1*	2.73	0.92	0.64
2	2.75	0.79	0.67
3	2.39	0.80	0.63
4	2.87	0.81	0.66
5	2.77	1.03	0.71
6*	2.40	1.24	0.36
7*	2.36	1.01	0.52
8*	2.29	0.97	0.21
9*	2.38	1.00	0.36
10*	2.10	0.81	0.31

* Revised items

The Table 3.14 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics learning situation scale. The reliability of the total 10 items was found to be 0.82 as measured by Cronbach's alpha coefficient.

Table 3.14 Mathematics learning situation scale items statistics

First part – competitive learning preferences			
Item	Item mean	Item variance	Item-scale correlation
1	3.53	0.62	0.80
2	3.14	0.29	0.48
3	3.26	0.52	0.74
4	3.23	0.52	0.54
5	3.01	0.55	0.52
Second part – co-operative learning preferences			
Item	Item mean	Item variance	Item-scale correlation
6	3.28	0.80	0.52
7	3.40	0.61	0.57
8	3.13	0.45	0.59
9	3.39	0.60	0.72
10	3.17	0.76	0.55

The Table 3.15 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics learning strategy scale. The reliability of the total 14 items was found to be 0.87 as measured by Cronbach's alpha coefficient.

Table 3.15 Mathematics learning strategy scale items statistics

First part – memorization strategy			
Item	Item mean	Item variance	Item-scale correlation
1	2.74	0.65	0.70
2	2.63	0.82	0.33
3	3.21	0.48	0.62
4	3.15	0.60	0.62
Second part –elaboration strategy			
Item	Item mean	Item variance	Item-scale correlation
5	3.04	0.56	0.68
6	2.84	0.66	0.58
7	2.95	0.72	0.69
8	2.84	0.71	0.68
9	2.83	0.80	0.68
Third part – control strategy			
Item	Item mean	Item variance	Item-scale correlation
10	3.32	0.71	0.63
11	3.21	0.49	0.64
12	3.07	0.79	0.64
13	2.81	0.62	0.53
14	3.29	0.55	0.51

The Table 3.16 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of motivation and anxiety scale. The reliability of the total 14 items was found to be 0.76 as measured by Cronbach's alpha coefficient.

Table 3.16 Motivation and anxiety scale item statistics

First part – intrinsic motivation			
Item	Item mean	Item variance	Item-scale correlation
1	3.18	0.64	0.39
2	3.09	0.71	0.45
3	3.29	0.51	0.42
4	3.27	0.58	0.31
5*	2.29	0.86	0.30
Second part – instrumental motivation			
Item	Item mean	Item variance	Item-scale correlation
6	3.30	0.51	0.40
7	3.61	0.57	0.49
8	3.46	0.65	0.43
9	3.26	0.73	0.54
Third part – mathematics anxiety			
Item	Item mean	Item variance	Item-scale correlation
10*	2.65	0.90	0.49
11*	2.28	0.93	0.54
12*	2.17	1.05	0.50
13*	2.34	1.11	0.44
14*	2.83	1.17	0.48

* Reversed item

3.4.1.10 Reliability of the student level instruments

After the pilot study, the student level instruments were administered to 2562 students in the main study. The results of the item analyses revealed that the items statistics of the main study were not much different than the results of the pilot study in terms of item means and variances, and item-scale correlations. The reliability values of the six instruments as measured by Cronbach's alpha coefficient are displayed in Table 3.17. Moreover, the items of the each scale were investigated in order to find the missing value percentages. These also are presented in Table 3.17. It can be observed that the percentages of missing values of all the items range from 2.4 to 9.4. All missing values were replaced by the means of the items.

Table 3.17 Reliability and missing value of student level instruments

Student level instruments	Reliability	Missing value
	Cronbach's alpha coefficient	Percentage
Mathematics homework scale	0.85	2.6 to 8
Mathematics classroom practices scale	0.85	2.4 to 7.2
Mathematics self concept scale	0.86	3.9 to 6
Mathematics learning situation scale	0.83	4.3 to 6.
Mathematics learning strategy scale	0.86	5.5 to 9.4
Motivation and anxiety scale	0.86	3.7 to 6

3.4.1.11 Factor analysis of student level instruments

A Principle Components Factor Analysis with Varimax rotation method was conducted by using SPSS 15.0 for Windows in order to verify the factor structure of the student level instruments. The analysis was run with 100 items included in the student questionnaire. As a result of the analysis, factors were interpreted and the student level variables were represented by using factor scores.

Since the number of students participated in the current study was 2562, the sample size was large enough to produce reliable factors (Stevens, 2002). The measure of Kaiser-Meyer-Olkin was checked for evaluating the distribution of values is adequate for conducting factor analysis. The value was found as .914 that is called as marvelous (George & Mallery, 2003). The other two assumptions were checked through Bartlett's test of sphericity. The first one was the multivariate normality of the distribution and the second one was that the correlation matrix is not an identity matrix. Since the significance value of this test was found to be $<.05$, it was safe to conduct a factor analysis without violating these two important assumptions.

The scree test was used in deciding the number of factors to retain. The examination of the plot showed that the curve begins to start level off around factor 15. Therefore in the analysis 15 factors were retained and these factors explained 56% of the variance in the responses given to the selected items. After the number of factors was determined, the rotated components matrix was interpreted based on the factor loadings and the content of the items. The number of variables per factor was determined by retaining the items with loadings equal to or greater than .4 in absolute value. After the determination of the items to retain, the factors were named based on the content of the items and the research literature (see Appendix J).

To use factor scores obtained from this analysis for the subsequent analyses, it is required to conduct reliability analysis for displaying internal consistencies of these constructs. The factors, number of items that represent the each factor, and internal consistencies of each factor indicated as Cronbach's alpha values are presented in Table 3.18.

Table 3.18 Internal consistencies of the student questionnaire factors

Factors	Number of items	Cronbach's alpha
Socioeconomic status (SES)	6	.70
Different types of homework (TYPEHOME)	7	.79
Activities related with homework (ACTHOME)	8	.73
Giving homework (GIVEHOME)	3	.48
Teacher support (TCSUPP)	4	.82
Projects, daily life examples and problems (PRODAILY)	5	.70
Use of technology (TECHNO)	3	.77
Mathematics self concept (MSCONCEPT)	6	.82
Preference for competitive learning situation (COMPE)	5	.83
Preference for cooperative learning situation (COOPE)	5	.80
Learning strategies – Use of control strategies (CONTROL)	5	.78
Learning strategies – Use of elaboration strategies (ELAB)	5	.74
Math anxiety (ANXIETY)	5	.81
Intrinsic motivation (INTMOT)	4	.84
Extrinsic motivation (EXTMOT)	4	.78

3.4.1.12 Confimatory factor analysis of student level instruments

The results of the explanatory factor analysis were further investigated with confirmatory factor analysis by using structural equation modeling (SEM). After some minor modifications, the fit indexes to be used for interpreting the appropriateness of the proposed model were goodness-of-fit index (GFI = 0.91), adjusted goodness-of-fit index (AGFI = 0.91), root mean square error of approximation (RMSEA = 0.06), and standardized root mean square residuals (S-RMR = 0.06). The values for GFI and AGFI equal to or greater than .90 (Jöreskog & Sörbom, 1993) whereas the values for RMR and S-RMR equal to or less than .08 (Schreiber, Stage, King, Nora, & Barlow, 2006) are acceptable for interpreting a good data fit. Thus, these obtained values the fit of this model was proved to be good.

As previously mentioned the factor scores of the interpreted factors were computed and used as student level variables in the hierarchical linear modeling. It is crutial to identify the meaning of these factor scores to interpret the results of the subsequent analyses. In this sense, as the factor scores of all factors increase the amount of the related construct increases. For instance, the higher the SES scores mean that the higher the socioeconomic status of the students.

3.4.2 Teacher level instruments

The mathematics teacher questionnaire has composed of five different parts. These parts are demographic and professional information part, mathematics homework scale, scale of ideas and beliefs about mathematics, belief scale towards towards mathematics. Since it was not feasible to conduct pilot study for these scales, item statistics of the actual administration was reported for each scale. Detailed information is given for each of the scales under related headings.

3.4.2.1 Demographic and professional information part

The demographic and professional information part of the teacher questionnaire is used to obtain information about teachers' characteristics such as, age, gender, teaching experience, formal education and teacher training, instructional time devoted to mathematics and other teaching activities, textbook use, frequency of some tasks performed in mathematics classrooms, participation in in-service training programs (see Appendix K). Additionally, this questionnaire also contains items seeking information about teachers' ideas about their career choices and appreciation of their work. These items are taken from TIMSS 1999 Mathematics Teacher Questionnaire. This part was also used for describing the major characteristics of the participant teachers.

3.4.2.2 Mathematics homework scale

This scale is the teacher version of the scale for obtaining information about mathematics homework practices. Similarly, the purpose of the scale is to obtain information from teachers about the frequency, amount, type, and the use of mathematics homework assigned. Teachers respond to the items in a four point Likert scale (1=never to 4=almost always) for the third and the fourth parts. This scale is taken from Turkish version of TIMSS 1999 Mathematics Teacher Questionnaire (see Appendix K).

3.4.2.3 Mathematics classroom practices scale

This scale is the teacher version of the scale named mathematics classroom practices scale. The purpose of the scale is to obtain information about teachers' perceptions about mathematics classroom practices. The scale contains 30 items. Teachers respond to the items in a four point Likert scale (1=never to 4=almost always). The items were taken from Turkish version of TIMSS 1999 Student Questionnaire and they are adapted for teachers (see Appendix K).

3.4.2.4 Scale of perceptions about mathematics

This scale is used to obtain general information about teachers' perceptions regarding mathematics teaching and learning. Specifically, in the scale there are three parts. Items are seeking information about teachers' perceptions related to necessary skills for students to be good at mathematics, various factors limiting classroom instruction for mathematics, and nature of mathematics, for the first, second and the third parts of the scale, respectively. For the first part, teachers respond to items in a three point Likert scale (1=not important 3=very important). In the second part, they respond to items in a four point Likert scale (1=a great deal, 4=not at all). For the last part they respond to items in a four point Likert scale (1=strongly disagree 4=strongly agree). The items are taken from Turkish version of TIMSS 1999 Mathematics Teacher Questionnaire (see Appendix K).

3.4.2.5 Mathematics teaching efficacy beliefs scale

This scale is used to measure mathematics teachers' self efficacy perceptions regarding mathematics teaching (see Appendix K). The scale was adapted to Turkish by Işıksal and Çakıroğlu (2006). It is composed of two sub dimensions. Specifically, the first dimension is the personal teaching efficacy beliefs whereas the second one is mathematics teaching outcome expectancy. Teachers respond to items in a five point Likert scale (1=strongly disagree 5=strongly disagree). The items 2, 3, 5, 6, 8, 11, 15, 16, 17, 18, 19, 20, and 21 are related to the first dimension and the items 1, 3, 4, 7, 9, 10, 12, 13, and 14 are related to the second dimension. The possible scores range from 1 to 105. As Işıksal and Çakıroğlu (2006) reported, the reliability of the first and the second dimensions were found to be 0.83 and 0.77 as indicated Cronbach's alfha coefficient, respectively.

3.4.2.6 Item analysis of the teacher level instruments

The teacher level instruments were administered to 50 mathematics teachers whose sixth grade classes participated in the study. After the responses of the teachers were entered into computer by using Excel and then SPSS, they were evaluated by using ITEMAN. The Table 3.19 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics homework scale.

Table 3.19 Mathematics homework scale item statistics – teacher

Item	Item mean	Item variance	Item-scale correlation
1	2.63	0.23	0.03
2	2.61	0.36	0.08
3A	2.63	0.72	0.37
3B	3.60	0.28	0.19
3C	3.44	0.49	0.36
3D	2.75	0.91	0.52
3E	1.80	0.85	0.54
3F	2.49	0.65	0.74
3G	2.09	0.42	0.49
3H	2.11	0.49	0.42
3I	2.47	0.54	0.51
3J	1.90	0.51	0.47
3K	1.44	0.50	0.55
4A	2.96	0.52	0.19
4B	1.92	0.83	0.22
4C	2.25	0.90	0.26
4D	3.33	0.47	0.48
4E	2.72	0.72	0.62
4F	1.74	0.59	0.35
4G	2.22	0.57	0.62
4H	3.26	0.63	0.13

It should be noted that, the rationale for asking the same questions regarding mathematics homework to both the students and their teachers was to check the reliability of the responses. The correlations between the means of students' responses within the classroom and the responses of the teacher of the corresponsing classroom were calculated. The results show that among the 21 correlations, only 5 of them are found to be significant. Although the numbers of significant correlations are less than expected, the means of the students' responses are very similar to the means of the teachers' responses considering in the total sample. In this context, for the homework scale only the students' responses were taken into consideration.

The Table 3.20 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics classroom practices scale.

Table 3.20 Mathematics classroom practices scale – teacher

Item	Item mean	Item variance	Item-scale correlation
1	3.53	0.29	0.39
2	3.47	0.41	0.41
3	2.37	0.40	0.36
4	2.33	0.31	0.31
5	2.80	0.65	0.33
6	1.69	0.34	0.25
7	1.78	0.51	0.35
8	3.14	0.25	0.17
9	2.29	0.42	0.37
10	3.42	0.29	0.34
11	1.90	0.54	0.27
12	2.80	0.45	0.25
13	2.31	0.87	0.30
14	2.25	0.63	0.38
15	3.88	0.11	0.29
16	1.56	0.54	0.25
17	3.37	0.44	0.29
18	1.43	0.37	0.12
19	1.33	0.47	0.28
20	1.50	0.46	0.43
21	2.88	0.73	0.28
22	3.02	0.51	0.19
23	2.06	0.38	0.45
24	3.04	0.33	0.24
25	2.20	0.61	0.28
26	2.33	0.38	0.44

Table 3.20 (Continued)

Item	Item mean	Item variance	Item-scale correlation
27	3.33	0.42	0.32
28	3.65	0.23	0.25
29	3.39	0.28	0.42
30	3.53	0.25	0.29

Similar to mathematics homework scale, also mathematics classroom practices scale was administered to the participant teachers for checking the reliability. When the relationships between the students' and the teachers' responses for the items included in this scale are investigated, the results show that among 30 correlations, only 10 of them are found to be significant. Also, the means of the students' responses are very similar to the means of the teachers' responses considering in the total sample. Therefore, for the classroom practices scale only the students' responses were taken into consideration.

The Table 3.21 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of scale of perceptions about mathematics. Since the first and the third part of the scale have items representing opposite ideas some of them were reversed. Moreover the last item of third part of the scale is not representing any similar idea with the rest of the items, so this item was not included in the item analysis.

Table 3.21 Items statistics for the scale of perceptions about mathematics

	First part		
Item	Item mean	Item variance	Item-scale correlation
1A*	1.56	0.29	0.56
1B*	1.29	0.25	0.38
1C	2.84	0.13	0.28
1D	2.82	0.15	0.49
1E	2.74	0.23	0.67
1F	2.60	0.36	0.75
	Second part		
Item	Item mean	Item variance	Item-scale correlation
2A	2.50	0.58	0.62
2B	2.42	0.56	0.34
2C	2.20	0.68	0.53

Table 3.21 (Continued)

Second part			
Item	Item mean	Item variance	Item-scale correlation
2D	2.63	0.72	0.56
2E	2.36	0.67	0.42
2F	2.18	0.71	0.77
2G	3.62	0.36	0.37
2H	3.04	0.69	0.63
2I	3.00	0.65	0.60
2J	2.52	0.61	0.53
2K	2.26	0.55	0.49
2L	1.68	0.58	0.65
Third part			
Item	Item mean	Item variance	Item-scale correlation
3A*	2.58	0.58	0.45
3B	3.34	0.26	0.58
3C	3.19	0.28	0.73
3D*	2.25	0.52	0.29
3E*	1.82	0.43	0.46
3F	3.44	0.33	0.22
3G*	2.57	0.53	0.59
3H*	2.78	0.79	0.51

* Reversed items

The Table 3.22 displays the item statistics such as item mean, variance, and item-scale correlation of the responses for the items of mathematics teaching efficacy beliefs scale.

Table 3.22 Mathematics teaching efficacy beliefs scale item statistics

First dimension – Personal teaching efficacy beliefs			
Item	Item mean	Item variance	Item-scale correlation
2	4.10	0.38	0.59
3*	4.12	0.56	0.50
5	4.14	0.37	0.58
6*	3.92	0.73	0.48
8*	4.50	0.29	0.69
11	4.27	0.24	0.70
15*	4.00	0.90	0.63
16	4.61	0.24	0.65
17*	4.63	0.23	0.65
19*	4.29	0.49	0.55
20	4.50	0.54	0.38
21*	4.18	1.01	0.55

Table 3.22 (Continued)

Second dimension – Mathematics teaching outcome expectancy			
Item	Item mean	Item variance	Item-scale correlation
1	3.71	0.83	0.63
4	3.78	0.83	0.63
7	2.90	1.03	0.62
9	4.00	0.69	0.51
10	3.79	0.71	0.76
12	2.88	0.88	0.71
13	3.79	1.00	0.75
14	3.90	0.75	0.74

* Reversed items

3.4.2.7 Reliability of the teacher level instruments

The reliability values of the six instruments as measured by Cronbach's alpha coefficient are displayed in Table 3.23. Moreover, the items of the each scale were investigated in order to find the missing value percentages. These also are presented in Table 3.23. It can be observed that the percentages of missing values of all the items range from 2 to 10. All missing values were replaced by the means of the items.

Table 3.23 Reliability and missing value of teacher level instruments

Teacher level instruments	Reliability	Missing value
	Cronbach's alpha coefficient	Percentage
Mathematics homework scale	0.74	2 to 10
Mathematics classroom practices scale	0.67	2 to 4
Scale of perceptions about mathematics		2 to 4
• First part	0.52	
• Second part	0.79	
• Third part	0.51	
Mathematics teaching efficacy beliefs scale		2 to 4
• Personal teaching efficacy beliefs	0.79	
• Mathematics teaching outcome expectancy	0.82	

3.4.2.8 Factor analyses of teacher questionnaire

A Principle Components Factor Analysis with Varimax rotation method was conducted by using SPSS 15.0 for Windows in order to identify the factor structure of the teacher level instruments. The analysis was run with 48 items included in the teacher level instruments. As a result of the analysis, factors were interpreted and the teacher level variables were represented by using factor scores.

Although the number of participant teachers is small to run a factor analysis, we are safe to interpret the factors as reliable because the analysis produced factors with four or more items with high loadings around .500 (Guadagnoli & Velicer, 1988). The measure of Kaiser-Meyer-Olkin was checked for evaluating the distribution of values is adequate for conducting factor analysis. The value was found as .642 that is called as mediocre (George & Mallery, 2003). The other two assumptions were checked through Bartlett's test of sphericity. The first one was the multivariate normality of the distribution and the second one was that the correlation matrix is not an identity matrix. Since the significance value of this test was found to be <.05, it was safe to conduct a factor analysis without violating these two important assumptions.

The scree test was used in deciding the number of factors to retain. The examination of the plot showed that the curve begins to start level off around factor 8. Therefore in the analysis 8 factors were retained and these factors explained 58% of the variance in the responses given to the selected items. After the number of factors was determined, the rotated components matrix was interpreted based on the factor loadings and the content of the items. The number of variables per factor was determined by the retaining the items with loadings more than .4 in absolute value. After the determination of the items to retain, the factors were named based on the content of the items and the research literature (see Appendix L).

To use factor scores obtained from this analysis for the subsequent analyses, it is required to conduct reliability analysis for displaying internal consistencies of these constructs. The factors, number of items that represent the each factor, and internal consistencies of each factor indicated as Cronbach's alpha values are presented in Table 3.24. Since the number of the participant teachers was quite small, the results of the explanatory factor analysis could not be investigated by using confimatory factor analysis technique.

Table 3.24 Internal consistencies of the teacher questionnaire factors

Factors	Number of items	Cronbach's alpha
Personal teaching efficacy (PEREFFI)	10	.81
Outcome expectancy (OUTCOME)	7	.83
Perceptions about being successful in mathematics (PERSUCC)	4	.59
Perceptions about mathematics (PERMATH)	4	.67
Perceptions about physical limitations (PHYLIM)	5	.75
Perceptions abot limitations aroused from students (LIMSTU)	4	.56

Similar to student level factors, as the factor scores of all teacher level variables increase the amount of the related construct increases. For instance, as the PEREFFI scores increase, teachers' personal teaching efficacy increases indicating they believe that they teach mathematics effectively and they have necessary skills to teach mathematics.

3.5 Procedure

Previously mentioned, the aim of this non-experimental quantitative study is to investigate the relationships between student and teacher characteristics measured by the instruments explained in the previous sections and the problem solving skills of the students. As can be understood from the aim, the study seeks relationships among a set of variables by using hierarchical linear modeling. Thus, the design of the study can be named as cross-sectional and predictive.

After the schools were selected, the official permission was taken from MNE for administering the measuring instruments (see Appendix M). Both the pilot and the main studies were conducted in the 2007-2008 educational period. Before the administration, the school principals, teachers, and the students were given information about the aim and the administration of the study. The consents of school principals, participant teachers and students were taken orally and they were informed that they could withdraw at any time of the administration or after the administration as well. They were also informed that they can learn about their scores and the final results of the study if they desired. The necessary information explaining that no physical or psychological harm or discomfort would come to the participant teachers and the students during administration of the study was given. The school principal, the participant techers and the students were also assured that the data collected will be kept confidential and names of the schools, teachers and students would not be used in any kind of publication. Especially the students were informed that the results of the measuring instruments they responded would not affect any of their grades in the school.

The criterion to include any student in the data analysis was that the student had completed all the instruments in the questionnaire. Otherwise, the student was completely excluded from the study during the entering process. Thus, in order to minimize the loss of subjects, the sample size was kept as large as possible at the beginning of the study.

It was probable that location might be a threat for the present study, since the measuring instruments were administered different schools and classrooms from different districts. In the study, all the data was collected by the researcher in all classrooms except one classroom. In each classroom, it took students two class-hours to respond all the instruments. First of all, the problem solving skills test and afterwards the student questionnaine were given. The responding time was same for all the participant students. Moreover, the researcher tried to hold constant the physical conditions such as lightening and air condition of all the classrooms. All effort was spent for keeping the class silent during the administration of the measuring instruments. The physical arrangements of all the classrooms were nearly the same. Additionally, the researcher took some field notes in case of an unexpected event during the study. This field notes helped the researcher to claim that the administration process reached a standard for all classrooms and to exlude the data of students whether it was necessary.

Since the problem solving skills test contained some free-response items, scoring procedure might be a threat for the internal validity of the study. To avoid this threat as explained in the construction of problem solving skills test a very clear and detailed item scoring guides were prepared. In addition to using these scoring guides, the researcher selected approximately 10% of the data randomly and rescored them. The consisteny between two scoring was very high (97%). Moreover, again approximately 10% of the data selected randomly and a mathematics teacher was asked to score the free-response items of this selected data. The consistenty was again very high (95%). These procedures guaranteed that the consistency of the scoring of the free-response items was quite high across the all data. As previously mentioned, the researcher administered the instruments by her own in all classrooms except one. Thus, the threat of data collector characteristics was not valid for this study. In the study, the teachers and the students responded to many instruments, however constructs measured in the instruments were different from each other. Since it was not likely that the responses given to an instrument influenced the responses given another instrument, testing was not a treat for the internal validity of the present study.

3.6 Analysis of data

The data analysis was conducted in three sequential phases. In the first phase, initial data analyses including data cleaning and missing data analysis were conducted. In the second phase, descriptive statistics of the scales were obtained and explanatory factor analyses were conducted for investigating the constructs of the scales. After the factor scores were calculated the outlier and influential data points were checked. In the last phase, Hierarchical Linear Modeling (HLM) was conducted to investigate the factors related to problem solving skills of the students. All the analyses were conducted by using two statistical packages. SPSS 15.0 for Windows was used for missing data analysis, checking for outlier and influential data points, explanatory factor analyses, descriptive statistics. HLM 6.0 was used for building hierarchical linear models.

3.6.1 Data cleaning

After the data was collected, the responses of both the students and the teachers were entered to Microsoft Office Excel by the researcher in a very carefully manner during a six-month period. Then the data was converted to Statistical Package for Social Sciences (SPSS 15.0). After that, the frequencies of the responses of all the items were checked carefully to detect whether there was any misentered data. It was observed that only five of the responses were misentered and they were corrected. Moreover, a second control was conducted. Approximately 10% of the students were randomly selected and the results of both problem solving skills test and questionnaire were checked. No misentered data was found.

3.6.2 Missing data analysis

Since, missing data in the variables may affect the results of the statistical analyses and the process of handling of missing data is an important issue, in the current study the investigation and analysis of missing data were performed before the HLM analysis. First of all, the criterion for including the data of a student or a teacher was that each student or teacher should have scores on each of the scales they were given. If a student or a teacher did not answer approximately 30% of the items in one scale, left one scale completely empty, and drew a clearly apparent pattern when responding items in a scale, such student or teacher data were exluded from the further analyses. After entering data, frequencies of all items were analyzed to identify the missing data percentages. Missing data of the items included in the student and the teacher questionnaires that were less than 10% were replaced by the mean of that item. Missing data less than 10% in the problem solving skills test were replaced by zero. This indicates that the student responded this as incorrect. Additionally, the missing data in the categorical items such as gender, mathematics and general grades, teacher age and experience were not replaced.

3.6.3 Outliers and influencial data points

In general statistical procedures can be affected from both outliers and influential data points. Outliers are the values that are different from the rest of the points whereas influencial data points are the values when deleted produce a substantial change in at least one of the regression coefficient (Stevens, 2002).

In the current study for the student level variables both the outliers and influential data points were analyzed. However, for the teacher level variables only outliers were analyzed. For student level variables outliers on the outcome variable that is problem solving skills were analyzed by using standardized residuals. A standardized residual that is greater than about 3 in absolute value is unusual and may be detected as an outlier (Stevens, 2002). Outliers on the student level predictor variables were analyzed by using Leverage values. As it is suggested Leverage value that is greater than 3p/n is unusual and may be detected as outlier. In the expression of 3p/n, p = k +1, k represents the number of predictor variables whereas n represents the sample size (Stevens, 2002). Influencial data points either in outcome or predictor variables were analyzed by using Cook's distance value. It is reported that Cook's distances greater than 1 are generally considered as large and may be detected as influential data points (Stevens, 2002). Additionally, the outliers in the teacher level variables were analyzed by using z scores. Z score that is around 3 in absolute value is unusual and should be considered as potential outlier (Stevens, 2002). In the present study the outliers and influential data points were analyzed by using appropriate statistical values.

3.6.4 Data analysis

After the initial analyses were performed, two principle component analyses with varimax rotation method were conducted to identify the constructs underlying the student and the teacher questionnaires by using SPSS 15.0 for Windows. The results of principle component analyses were interpreted and the factors were named to identify the student and teacher level variables. The factor scores of the interpreted factors were calculated and these scores were used as student and teacher level characteristics in HLM analyses. Two-level hierarchical modeling was used for investigating the relationships between student and teacher characteristics and the problem solving skills of the students. In modeling, the student characteristics were regarded as the level-1 variables, whereas the teacher characteristics were regarded as the level-2 variables. Consequently, the problem solving skills of the students was regarded as the outcome variable in the models. By using these variables four submodels; one-way ANOVA model with random effects; regression model with means-as-outcomes; random-coefficients regression model; model with intercepts- and slopes-as-outcomes were developed and interpreted.

3.7 Conceptual background for two-level hierarchical linear modeling

Much behavioral and social research includes hierarchical data structures. For instance, educational researchers might investigate how school characteristics influence student achievement. In such a design, both students and schools are units in the analysis and variables are measured at both levels. This data have a hierarchical structure with individual students nested within schools. Although the nature of data in social research is hierarchical, the conventional statistical techniques for the estimation of linear models have been inadequate for nested data structures. However, hierarchical linear modeling provides a superior analytic method for investigating relations occurring at each level and across levels and also assess the amount of variation at each level (Raudenbush & Bryk, 2002). Therefore, in the present study two-level hierarchical modeling was used for investigating the relationships between student and teacher characteristics and problem solving skills of the students. During the analyses procedure four submodels; one-way ANOVA model with random effects; regression model with means-as-outcomes; random-coefficients regression model; model with intercepts- and slopes-as-outcomes were developed. These submodels are defined briefly in the subsequent parts.

3.7.1 One-way ANOVA with random effects

The simplest hierarchical linear model is equal to a one-way ANOVA with random effects. In this case level-1 (e.g., student) model is;

$$Y_{ij} = \beta_{0j} + r_{ij}$$

It is assumed that each level-1 error, r_{ij} is normally distributed with a mean of zero and a constant level-1 variance, σ^2. The level-2 (e.g., teacher, class, or school) model for the one-way ANOVA with random effects is;

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

In this equation, γ_{00} represents the grand-mean outcome in the population and u_{0j} is the random effect associated with unit *j* (level-2 unit) and is assumed to have a mean of zero and variance τ_{00} (Raudenbush & Bryk, 2002).

3.7.2 Regression with means-as-outcomes

In this model, the equation of level-1 remains unchanged. The intercept is predicted by level-2 (e.g., teacher, class, or school) variables (Raudenbush & Bryk, 2002).

Level-1 (e.g., student) model is;

$$Y_{ij} = \beta_{0j} + r_{ij}$$

Level-2 (e.g., teacher, class, or school) variables

$$\beta_{0j} = \gamma_{00} + \gamma_{01} W_j + u_{0j}$$

Raudenbush and Bryk (2002) indicated that "the variance in u_{0j}, τ_{00}, is now the residual or conditional variance in β_{0j} after controlling for W_j" (p. 25).

3.7.3 Random-coefficients regression model

In this model level-1 (e.g., student) slopes are conceived as varying randomly over the population of level-2 (e.g., teacher, class, or school) units. Both level-1 intercept and one or more level-1 slopes vary randomly, but no attempt is made to predict this variation (Raudenbush & Bryk, 2002).

Level-1 (e.g., student) model is;

$$Y_{ij} = \beta_{0j} + \beta_{1j} (X_{ij} + \overline{X}_{.j}) + r_{ij}.$$

Level-2 (e.g., teacher, class, or school) is;

$$\beta_{0j} = \gamma_{00} + u_{0j}$$

$$\beta_{1j} = \gamma_{10} + u_{1j}$$

3.7.4 Intercepts- and slopes-as-outcomes

In this phase, the variability in the regression coefficients (both intercepts and slopes) across the level-2 (e.g., teacher, class, or school) units is modeled. Intercepts- and slopes-as-outcomes model is named as full model (Raudenbush & Bryk, 2002).

3.7.5 Location of variables (Centering)

In hierarchical linear models, the intercepts and slopes in the level-1 model become outcome variables at level-2 model. Understanding the meaning of these outcome variables is very important for relating the statistical results to the theory. The meaning of the intercept in the level-1 model depends on the location of the level-1 predictor variables. Two frequently used options for the location of level-1 variables are centering around the grand mean and centering around the level-2 mean (group-mean centering). In the former one, the intercept is the expected outcome for a subject whose value on X_{ij} is equal to the grand mean. This centering produces an intercept that can be interpreted as an adjusted mean for level-2 units. On the other hand, in the latter centering option, the level-1 variables are centered around their corresponding level-2 unit means. In this centering, the intercept becomes the unadjusted mean for level-2 units (Raudenbush & Bryk, 2002).

As in the case of level-1 model, interpretations regarding the intercepts in the level-2 models depend on the location of the level-2 variables. However, the choice of location for level-2 variables is not as critical as for level-1 variables (Raudenbush & Bryk, 2002). In the current study, the level-1 variables were group-mean centered whereas level-2 variables were grand mean centered.

3.7.6 Random versus fixed variables

It is important to decide whether the level-1 variables are random or fixed in hierarchical linear models. The random variables include an error term in the equation. However, the fixed variables are considered as the same across the level-2 units and they do not include an error term in the equation. Actually, when the variables are fixed in reality and they are taken as fixed, the model is simpler and the results are more precise. Nevertheless, when the variables are random in reality and they are taken as fixed, the estimations are biased. In the current study, all the level-1 variables were treated as random varying during model building process. If the results were significant the variables were considered as random. If the results were not significant the variables were considered as invariant across the level-2 units and they were fixed.

CHAPTER 4

RESULTS

This section firstly presents the results of the descriptive statistics of the problem solving skills test, student and teacher level instruments and the outlier analyses of the identified student and teacher level variables. Then the assumptions of hierarchical linear modeling and the results of the models built for investigating the relationships between student and teacher level variables and problem solving skills of the students.

4.1 Results of descriptive statistics

4.1.1 Problem solving skills test

The results of the descriptive statistics reveal that the sixth grade students participated in the current study show low performance in the problem solving skills test. As displayed in Table 4.1, the percentages of correct responses of dichotomously coded items ranged from 19.4 to 65.3. The percentages of correct responses of partially coded items range from 0.3 to 45.3. Additionally, the percentages of incorrect responses range from 27.8 to 79.6. Also, as can be seen in the table, especially free response items have quite high percentages of missing responses. It can be claimed that sixth grade students performed better in multiple choice items than they perform in free response items. Also it can be claimed that they are not able to produce responses to the open ended questions.

Table 4.1 Percentages of correct, incorrect, and missing responses of items

Problem solving processes		Correct		Incorrect	Missing
	Items	Partially coded (1)	Partially coded (2)		
Understanding problem					
	Ela	59.2		40.0	0.1
	Halı	58.6		39.3	2.1
	Televizyon	39.3		57.5	3.5
*	Kaykay	23.7		42.2	34.1
	Petşişe	54.8		42.5	2.7
Devising a plan					
	Dergi	46		53	1
*	Hesap makinesi	3.5	45.3	27.8	23.3
	Basketbol	65.3		33	1.7
	Çimbiçme	51.1		44.3	4.6
	Dans	42.2		54.7	3.1
Carrying out the plan					
*	Kitaplık	19.4		50.8	29.8
	Akdeniz	50		44.2	5.9
*	Telefon 2	0.8	0.3	76.3	22.6
*	Telefon 3	5.7	0.8	53.6	40
	Bölgeler	46.8		49.8	3.3
Looking back and evaluating					
*	Canan	12.4	17.3	60.4	9.9
	Hız	29		67.9	3.1
	Alp	47.7		49	3.3
	Beden eğitimi	48.1		48.1	3.8
*	Telefon 1	5.3	3.8	79.6	11.3

* Free-response items

The performances of the sixth grade students are investigated across four problem solving processes by replacing missing values by zero. The minimum and maximum values, mean and standard deviation for the scores of each problem solving process are given in Table 4.2. As the table indicates the performances of sixth grade students are low in all of the problem solving processes, however when the performances of students are compared within four processes, the performances in understanding problem and devising a plan processes are seemed better than the performances in carrying out the plan and looking back and evaluating processes.

Table 4.2 Scores across four problem solving processes

Problem solving processes	Possible maximum score	Min.	Max.	*M*	*SD*
Understanding problem	5	0	5	2.36	1.33
Devising a plan	6	0	6	2.99	1.69
Carrying out the plan	7	0	6	1.25	0.99
Looking back and evaluating	7	0	7	1.85	1.55

Since the free response items have high missing percentages, replacing missing values by zero may mislead the results. So it would be useful to reevaluate the performances of students by omitting the items with missing percentages higher then 10%. Hereby, six free-response items were omitted and performances for each of the problem solving process were recomputed. Similar to the previous table, the minimum and maximum values, mean and standard deviation for the scores of each problem solving process were given in Table 4.3.

Table 4.3 Recomputed scores across four problem solving processes

Problem solving processes	Possible maximum score	Min.	Max.	*M*	*SD*
Understanding problem	4	0	4	2.12	1.12
Devising a plan	4	0	4	2.05	1.11
Carrying out the plan	2	0	2	0.97	0.73
Looking back and evaluating	5	0	5	1.72	1.40

One-way repeated-measures analysis of variance (ANOVA) was conducted with the performance scores of the students across four problem solving processes to investigate whether there were significant mean differences. The results for the ANOVA indicated a significant mean difference, Wilks' Λ = .45, F (3, 2559) = 1058.42, p = 0.001, multivariate η^2 = .55. Based on the significant mean difference of performance scores among the four problem solving processes, post hoc analyses consisting pairwise comparisons were conducted to find at which process or processes the students performed better. The six pairwise comparisons were tested by using Holm's sequential Bonferroni procedure to set the level of significance. All the six comparisons were found to be significant. This means that the performances of students across problem solving processes were different from each other. In this sense, the students perform best in the process of understanding problem whereas they show the worst performance in the process of looking back and evaluating.

The total problem solving skills of the students were computed by summing the scores obtained in four different processes. As presented in Table 4.4, approximately 60% of the students had scores between 3 and 7. Only 131 (5.1%) of the 2562 students had the highest three scores of 13, 14, and 15. The number of students who obtained 2 or below was 137 (5.4%) and only 2 students could not give correct answer to any of the items in the problem solving skills test.

Table 4.4 Frequencies and percentages of problem solving skills test scores

Problem solving skills scores	*f*	%	Cumulative %
0	2	0.1	0.1
1	38	1.5	1.5
2	97	3.8	5.3
3	204	8.0	13.3
4	287	11.2	24.6
5	353	13.8	38.3
6	323	12.6	50.9
7	271	10.6	61.5
8	251	9.8	71.3
9	205	8.0	79.3
10	164	6.4	85.8
11	123	4.8	90.6
12	113	4.4	95.0
13	74	2.9	97.8
14	44	1.7	99.5
15	13	0.5	100.0
Total	2562	100	

4.1.2 Student level instruments

The tables displaying descriptive statistics for the items of student level instruments are presented in Appendix N. When the descriptive statistics of the items of mathematics homework scale is examined, it is observed that mathematics teachers give homework at almost each class hour and the average amount of time spend on homework is between 15 and 60 minutes. The students report that the most frequently given homework is answering problems or questions in the course textbook, on the other hand the most rarely given homework is keeping a mathematics diary. Considering the homework related practices, it is observed that the most frequent practice is that teacher gives explanatory information about the homework, whereas the rarest practice is that teacher makes students exchange their homework and correct each other's homework.

When the means of the items referring mathematics classroom practices are examined, it is observed that some practices those may be referred as the indicators of a teacher centered mathematics classroom environment. For instance these practices are "teacher shows us how to do problems," "we copy notes from the board," "teachers uses the board," "we use the board," or "teacher explains the rules and definition when we begin on a new topic." On the other hand, some practices indicating the use of technology such as calculator, overhead projector, or computer are seemed to be more rarely conducted.

For the affective domain characteristics, the means of the items reveal that the participant students do not have high mathematics self concept. In other words, they perceive that they do not understand difficult problems and they are not good at mathematics. It is also observed that, more than half of them have anxiety for the probability of getting bad marks in mathematics. Additionally, they mainly think that mathematics is important for their future professional and education life.

When the means of the items of the scales related to learning strategies and preferences for learning situations are investigated, it is observed that the students mainly prefer being the best student and taking the best grade in their mathematics courses. Additionally, it is seen that all of the learning strategies are used by the participant students to some extent. In other words, there is no one strategy dominantly used by the students.

4.1.3 The teacher level instruments

The tables displaying descriptive statistics for the items of teacher level instruments are also presented in Appendix N. When the means of the items of the perceptions about mathematics scale, it is observed that most of the mathematics teachers believe that understanding mathematical concepts, principles, and methods, thinking creatively, and understanding how the mathematics are used in real life are highly important for being successful in mathematics. On the other hand, most of the participant teachers believe that recalling formulas and operations and thinking sequent and operation oriented are not so important for being successful in mathematics. Moreover, most of the teachers believe in the idea that using multiple representations and understanding the students are important in mathematics instruction. The idea that some students have natural ability for mathematics whereas some of them do not is accepted by most of the participant teachers.

The means of the items referring teaching self efficacy beliefs reveal that the participant teachers have considerably high personal teaching self efficacies. Mainly, they strongly believe that they are good at answering students' questions about mathematics, have necessary skills to teach mathematics and they have good performance in teaching mathematics effectively. When the scores of two dimensions of mathematics teaching self efficacy beliefs scale ar investigated, it can be seen that the participant teachers' beliefs regarding their own capabilities to teach mathematics is higher than their expectations with regards to the outcomes of mathematics teaching.

4.1.4 Student level variables

The results of the factor analysis conducted with student questionnaire items were used to identify the student level factors to be used in the hierarchical linear models. Since there are missing values in gender, mathematics and general grades of the students, these could not be included as student level variables. It should be pointed out that all these variables are the perceptions of the students. In this sense the student-level variables are as the following;

1. Socioeconomic status (SES)
2. Different types of homework (TYPEHOME)
3. Activities related with homework (ACTHOME)
4. Giving homework (GIVEHOME)
5. Teacher support (TCSUPP)
6. Projects, daily life examples and problems (PRODAILY)
7. Use of technology (TECHNO)
8. Mathematics self concept (MSCONCEPT)
9. Preference for competitive learning situation (COMPE)
10. Preference for cooperative learning situation (COOPE)
11. Learning strategies – Control strategies (CONTROL)
12. Learning strategies – Elaboration strategies (ELAB)
13. Math anxiety (ANXIETY)
14. Intrinsic motivation (INTMOT)
15. Extrinsic motivation (EXTMOT)

4.1.5 Teacher level variables

The results of the factor analysis conducted with teacher questionnaire items were used to identify the teacher level factors to be used in the hierarchical linear models. In this sense the teacher level variables are as the following;

1. Teacher age (TAGE)
2. Teacher gender (TGENDER)
3. Teacher experience (TEXPER)
4. Personal teaching efficacy (PEREFFI)

5. Outcome expectancy (OUTCOME)
6. Perceptions about being successful in mathematics (PERSUCC)
7. Perceptions about mathematics (PERMATH)
8. Perceptions about physical limitations (PHYLIM)
9. Perceptions about limitations aroused from students (LIMSTU)

4.1.6 Controlling variables

Since some of the student characteristics those highly correlated to the outcome or the dependent variable might interfere with the affect of other variables, it is important to control such characteristics. For this reason, the variables, socioeconomic status (SES) and mathematics selfconcept (MSCONCEPT) are controlled in the current study. These variables are selected based on the results of the correlational analyses and related literature. These two variables are the most highly correlated variables to the problem solving skills test scores of the students. Moreover, it has been frequently cited that socioeconomic status and self concept are two notable factors associated with students' academic achievement or performances. To control these variables the average socioeconomic status and mathematics selfconcept of the students were computed and they were added separately to the teacher level file as tenth and eleventh factors, respectively.

4.2 Outlier analysis

After the student and the teacher level variables were identified based on the factor analyses, the outlier analyses were held to investigate whether these variables included any outliers or influential data points. These analyses were conducted in two steps. In the first step, the outliers on the student level variables were analyzed. The outliers on the outcome variable that is problem solving skills scores of the student were investigated through standardized residuals. A standardized residual that is greater than about 3 in absolute value is unusual and may be detected as an outlier (Stevens, 2002). Table 4.5 displays descriptive statistics of the standardized residuals of the problem solving skills scores of the students. As the table indicates this residual variable changes between -3.01 and 3.26. When the frequencies are investigated it is observed that there are three cases greater than about 3 in absolute value and these cases might be detected as outliers according to Stevens (2002).

The outliers on the student level predictor variables were analyzed by using Leverage values. For the present study, the Leverage values those greater than 0.020 might be considered as outliers. As it can be noted in the table there are such cases in the data set.

To investigate whether these outliers in either outcome or predictor variables were influencial data points Cook's distance value was used. As Stevens (2002) reported, Cook's distances greater than 1 are generally considered as large and may be detected as influential data points. Since the obtained Cook's distance values ranged from .000 to .006, the outliers found in both the outcome and the predictor variables were not influential data points. Therefore these cases are included in the subsequent analyses.

Table 4.5 Residual statistics

	Min.	Max.	*M*	*SD*
Standardized residual	-3.01	3.26	.000	.996
Centered leverage value	.001	.033	.008	.004
Cook's distance	.000	.006	.000	.001

In the second step, the outliers on the teacher variables were investigated by using z scores. As Stevens (2002) indicated z scores around 3 in absolute value should be considered as potential outlier. The descriptive summary of the teacher variables are computed and given in Table 4.6. According to these values, teacher variables do not include any potential outlier.

Table 4.6 Descriptive summary of teacher variables

Z scores of teacher variables	Min.	Max.	*M*	*SD*
Teacher age (TAGE)	-1.49	1.75	0.00	1.00
Teacher experience (TEXPER)	-1.54	2.10	0.00	1.00
Personal teaching efficacy (PEREFFI)	-1.95	1.74	0.00	1.00
Outcome expectancy (OUTCOME)	-2.79	1.93	0.00	1.00
Perceptions about being successful in mathematics (PERSUCC)	-2.74	1.37	0.00	1.00
Perceptions about mathematics (PERMATH)	-2.49	2.09	0.00	1.00
Perceptions about physical limitations (PHYLIM)	-2.18	1.90	0.00	1.00
Perceptions about limitations aroused from students (LIMSTU)	-2.14	2.50	0.00	1.00

4.3 Results of hierarchical linear modeling (HLM) analyses

After the student and the teacher level variables were identified based on the results of the factor analyses of the questionnaire items, the problem solving skills of the students was investigated by using HLM analyses. But previously, the assumptions underlying HLM are checked to identify whether they are tenable or not. During HLM analyses four models were built in order to investigate the relationships between student and teacher level factors and students' problem solving skills. These models were presented in four parts; one-way ANOVA with random effects, means-as-outcomes regression, random-coefficients regression model, and finally intercepts – and slopes-as-outcomes.

4.3.1 Assumptions of a two-level hierarchical linear modeling

In a general two-level model there are two equations; Level 1 and Level 2;

The equation at Level 1

$$Y_{ij} = \beta_{0j} + \sum_{q=1}^{Q} \beta_{qj} X_{qij} + r_{ij}$$

In the equation above,

Q is the number of independent variables in the level 1 model

X is may be centered or uncentered level 1 predictors

The equation at Level 2

$$\beta_{qj} = \gamma_{q0} + \sum_{s=1}^{S_q} \Upsilon qs\ Wsj \quad + u_{qj}$$

In the equation above,

Sq is the number of level 2 predictors for the q^{th} level 1 effect

Raudenbush and Bryk (2002) listed assumptions of a general two-level hierarchical linear modeling as follows (p. 255);

1. Each r_{ij} is independent and normally distributed with a mean of 0 and variance σ^2 for every level-1 unit i within each level-2 unit j.
2. The level-1 predictors, X_{qij}, are independent of r_{ij}.
3. The vectors of Q + 1 random errors at level-2 are multivariate normal, each with a mean of 0, some variance τ_{qq}, and covariance among the random elements, q and q', or $\tau_{qq'}$. The random-error vectors are independent among the J level-2 units.
4. The set of level-2 predictors (i.e., all the unique elements in W_{sj} across the Q + 1 equations) are independent of every u_{qj}.
5. The errors at level 1 and level 2 are also independent.
6. The predictors at each level are not correlated with the random effects at other level.

As Raudenbush and Bryk (2002) reported “Assumptions 2, 4, and 6 focus on the relationship between the variables included in the structural portion of the model- the *X*s and *W*s- and those factors related to the error terms, r_{ij} and u_{ij}. They pertain to the adequacy of model specification. Their tenability affects the bias in estimating γ_{qs}. Assumptions 1, 3, and 5 focus only on the random portion of the model (i.e., r_{ij} and u_{ij}). Their tenability affects the consistency of the estimates of se(γ_{qs}) , the adequacy of β^*_{qj}, σ^2, and T, and the accuracy of hypothesis tests and confidence intervals" (p. 255).

It is indicated that the tenability of the assumptions can be investigated by means of analyses of HLM residual file (Raudenbush, Bryk, Cheong, & Congdon, 2001). A residual file includes some information such as values predicted on the basis of the level-2 model, discrepancies between level-1 coefficient and fitted values, expected and observed Mahalanobis distance measures, or selected level-2 predictors useful in exploring possible relationships between such predictors and level-2 residuals (p. 13). The assumption tests used for the current study were given in Appendix M. As the given figures investigated it can be claimed that the assumptions underlying HLM are tenable.

4.3.2 One-way ANOVA with random effects

The one-way ANOVA with random effects model gives information about the research question regarding whether there are differences in the problem solving skills of students instructed by different teachers.

The two equations representing student and teacher level models are given as follows;

For i = 1,......,n_j students instructed by teacher j, and j = 1,.........,50 teachers

Level-1 model (student-level);

$Y_{ij} = \beta_{0j} + r_{ij}$

Level-2 model (teacher-level);

$\beta_{0j} = \gamma_{00} + u_{0j}$

where

Y_{ij}	=	problem solving skills of *i* th student instructed by *j* th teacher
β_{0j}	=	the intercept (the mean of problem solving skills of students instructed by *j* th teacher)
r_{ij}	=	the level-1 error (student-level)
γ_{00}	=	the grand mean
u_{0j}	=	the random effect associated with unit *j* (teacher)

The final estimation of fixed effects obtained from the one-way ANOVA with random effects model is presented in Table 4.7. In the analyses the grand mean of problem solving skills are the average teacher means representing the means of problem solving skills of students instructed by the same teacher. It is found that grand mean of problem solving skills is significantly different from zero. This means that there are significant differences among teachers with respect to students' problem solving skills. The grand mean of problem solving skills is 6.85 with a standard error of 0.18, indicating a 95% confidence interval of;

Confidence interval = 6.85 ± 1.96 (0.18) = (6.50, 7.20)

Table 4.7 Final estimation of fixed effects obtained from the one-way ANOVA with random effects model

Fixed effects	Coefficient	Standard error	t-ratio	p-value
Average teacher mean, γ_{00}	6.85	0.18	38.19	0.000

The final estimation of variance components obtained from the one-way ANOVA with random effects model is presented in Table 4.8. At the student level the variance component is $\sigma^2 = 6.15$ and at the teacher level, τ_{00} is the variance of the true teacher means, β_{0j}, around the grand mean. The variance component of teacher means is $\tau_{00} = 1.38$. The chi-square statistics takes on a value of 379.32

with 49 degrees of freedom (J = 50 teachers). The significance value is found to be $p < .001$ indicating significant variation does exist among teachers in problem solving skills of their students.

Table 4.8 Final estimation of variance components obtained from the one-way ANOVA with random effects model

Random effect	Variance component	df	χ^2	p-value
Teacher mean, u_{0j}	1.38	49	379.32	0.000
Level-1 effect, r_{ij}	8.18			

As auxiliary statistics the estimations of intraclass correlation (ICC) and reliability of the sample mean are also provided in the results of one-way ANOVA with random effects model. The intraclass correlation (ICC), which represents the proportion of variance in problem solving skills between teachers, is

$$ICC = \rho_{ic} = \tau_{00} / (\tau_{00} + \sigma^2) = 1.38 / (1.38 + 8.18) = 0.14$$

indicating that about 14% of the variance in problem solving skills is between teachers. It means that 14% of the total variability in problem solving skills can be attributed to the teachers.

The reliability of the sample mean in any teacher for the true teacher mean can be calculated by the equation;

$$\text{Reliability} = \tau_{00} / [\tau_{00} + (\sigma^2 / n_j)].$$

In general the reliability of the sample mean will vary from teacher to teacher because of the sample size, n_j, varies. However, an overall measure of the reliability can be obtained by averaging the individual teacher estimates. In this current model, reliability = 0.86, indicating that the sample means tend to be quite reliable as indicators of the true teacher means.

4.3.3 Regression with means-as-outcomes

Regression with means-as-outcomes model gives information about the research question investigation which teacher level factors are associated with the differences in students' problem solving skills. In the current analysis, the student-level model remains unchanged and student problem solving skill scores are viewed as varying around their teacher means.

The two equations representing student and teacher level models are given as follows;

For $i = 1,......,n_j$ students instructed by teacher j, and $j = 1,.........,50$ teachers

Level-1 model (student-level);

$Y_{ij} = \beta_{0j} + r_{ij}$

Level-2 model (teacher-level);

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{TAGE}) + \gamma_{02}(\text{TGENDER}) + \gamma_{03}(\text{TEXPER}) + \gamma_{04}(\text{PEREFFI}) + \gamma_{05}(\text{OUTCOME}) + \gamma_{06}(\text{PERSUCC}) + \gamma_{07}(\text{PERMATH}) + \gamma_{08}(\text{PHYLIM}) + \gamma_{09}(\text{LIMSTU}) + \gamma_{10}(\text{ASES}) + \gamma_{11}(\text{ASCONCEPT}) + u_{0j}$

where

Y_{ij} = problem solving skills of i th student instructed by j th teacher

β_{0j} = the teacher mean on problem solving skills

γ_{00} = intercept (grand mean for problem solving skill, that is the average of the teacher means on problem solving skills across the population of teachers)

γ_{01} = the effect of teacher age on the teacher mean on problem solving skills

γ_{02} = the effect of teacher gender on the teacher mean on problem solving skills

γ_{03} = the effect of teacher experience on the teacher mean on problem solving skills

γ_{04} = the effect of teacher perceptions about personal teaching efficacy on the teacher mean on problem solving skills

γ_{05} = the effect of teacher perceptions about outcome expectancy on the teacher mean on problem solving skills

γ_{06} = the effect of teacher perceptions about being successful in mathematics on the teacher mean on problem solving skills

γ_{07} = the effect of teacher perceptions about mathematics on the teacher mean on problem solving skills

γ_{08} = the effect of teacher perceptions about physical limitations on the teacher mean on problem solving skills

γ_{09} = the effect of teacher perceptions about limitations aroused from students on the teacher mean on problem solving skills

γ_{10} = the effect of teacher average socioeconomic status on the teacher mean on problem solving skills (controlling)

γ_{11} = the effect of teacher average mathematics selfconcept on the teacher mean on problem solving skills (controlling)

u_{0j} = the residual

On the first model run all the eleven of the teacher level factors are included. However, it is found that the factors except TGENDER, LIMSTU, ASES, and ASCONCEPT are not significantly associated with the teacher mean on problem solving skills. Therefore, the nonsignificant teacher level factors were removed from the final analysis and the model was run again. The final estimation of fixed effects obtained from regression with means-as-outcomes model is presented in Table 4.9.

Table 4.9 Final estimation of fixed effects obtained from regression with means-as-outcomes model

Fixed effect	Coefficient	Standard error	t-ratio	p-value
Model for teacher means[1]				
Intercept, γ_{00}	6.87	0.11	64.01	0.000
ASCONCEPT, γ_{01}	1.99	0.66	3.02	0.005
ASES, γ_{02}	1.42	0.21	6.78	0.000
TGENDER, γ_{03}	-0.61	0.21	-2.84	0.007
LIMSTU, γ_{04}	-0.27	0.09	-3.09	0.004

[1] The teacher level variables were grand mean centered before analysis

The results indicate that TGENDER (γ_{03} = -0.61, se = 0.21) and LIMSTU (γ_{04} = -0.27, se = 0.09) are significantly and negatively related to teacher mean on problem solving skills whereas ASCONCEPT (γ_{01} = 1.99, se = 0.66) and ASES (γ_{02} = 1.42, se = 0.21) are significantly and positively related. These teacher level factors will be reexamined in the development of the final full intercepts and slopes as outcomes model.

The final estimation of variance components obtained from regression with means-as-outcomes model is presented in Table 4.10.

Table 4.10 Final estimation of variance components obtained from the regression with means-as-outcomes model

Random effect	Variance component	df	χ^2	p-value
Teacher mean, u_{0j}	0.40	48	136.58	0.000
Level-1 effect, r_{ij}	8.18			

The residual variance between teachers (τ_{00} = 0.40) obtained in the regression with means-as-outcomes model is smaller than the variance obtained in one-way ANOVA model (τ_{00} = 1.38). The reason for this reduction is the inclusion of ASCONCEPT, ASES, TGENDER, and LIMSTU variables in the model. The proportion of variance explained in β_{0j} is;

[τ_{00} (ANOVA) - τ_{00} (Means-as-outcomes)] / τ_{00} (ANOVA)

Thus, the proportion of variance explained in the teacher mean on problem solving skills is;

[1.38 – 0.40] / 1.38 = 0.71

This indicates that 71% of the true between-teacher variance in problem solving skills is accounted for by ASCONCEPT, ASES, TGENDER, and LIMSTU. In the model, chi-square statistics is found to be 136.58 with 48 degrees with freedom (50 – 2 = 48). This result indicates that ASCONCEPT, ASES, TGENDER, and LIMSTU do not account for all the variation in the intercept. This means that after controlling for ASCONCEPT, ASES, TGENDER, and LIMSTU, significant variation among teacher means on problem solving skills remains to be explained.

Briefly, the analysis of the regression with means-as-outcomes model reveals that ASCONCEPT, ASES, TGENDER, and LIMSTU are significantly related to mean problem solving skills. However, even after controlling for ASCONCEPT, ASES, TGENDER, and LIMSTU, teacher means still vary significantly in their students' problem solving skills.

4.3.4 The Random-coefficient model

The random-coefficient model gives information about which student level factors explain the differences in students' problem solving skills.

The two equations representing student and teacher level models are given as follows;

For i = 1,......,n_j students instructed by teacher j, and j = 1,.........,50 teachers

Level-1 model (student-level);

$Y_{ij} = \beta_{0j} + \beta_{1j}(SES) + \beta_{2j}(TYPEHOME) + \beta_{3j}(ACTHOME) + \beta_{4j}(GIVEHOME) + \beta_{5j}(TCSUPP) + \beta_{6j}(PRODAILY) + \beta_{7j}(TECHNO) + \beta_{8j}(MSCONCEPT) + \beta_{9j}(COMPE) + \beta_{10j}(COOPE) + \beta_{11j}(CONTROL) + \beta_{12j}(ELAB) + \beta_{13j}(ANXIETY) + \beta_{14j}(INTMOT) + \beta_{15j}(EXTMOT) + r_{ij}$

Level-2 model (teacher-level);

$\beta_{0j} = \gamma_{00} + u_{0j}$

$\beta_{qj} = \gamma_{q0} + u_{qj}$

where

Y_{ij}	=	problem solving skills of i th student instructed by j th teacher
β_{0j}	=	the teacher mean on problem solving skills
β_{1j}	=	the differentiating effect of socioeconomic status
β_{2j}	=	the differentiating effect of different types of homework
β_{3j}	=	the differentiating effect of activities related with homework
β_{4j}	=	the differentiating effect of giving homework
β_{5j}	=	the differentiating effect of teacher support
β_{6j}	=	the differentiating effect of projects, daily life examples, and problems
β_{7j}	=	the differentiating effect of use of technology
β_{8j}	=	the differentiating effect of mathematics selfconcept
β_{9j}	=	the differentiating effect of preference for competitive learning situation

β_{10j} = the differentiating effect of preference for cooperative learning situation

β_{11j} = the differentiating effect of use of control strategies

β_{12j} = the differentiating effect of use of elaboration strategies

β_{13j} = the differentiating effect of mathematics anxiety

β_{14j} = the differentiating effect of intrinsic motivation

β_{15j} = the differentiating effect of extrinsic motivation

β_{qj} = the coefficient for variable *q* for teacher *j* after accounting for other variables

γ_{00} = the average of the teacher means on problem solving skills across the population of teachers

γ_{q0} = the average *q* variable – problem solving skills slope across those teachers

u_{0j} = the unique increment to the intercept associated with teacher *j*

u_{qj} = the unique increment to the slope associated with teacher *j*

In building the model process the strategy which is recommended by Raudenbush and Bryk (2002) was used. The student level variables are entered to the model one by one in order to detect whether there is any significant relationship between the predictors and problem solving skills as well as whether they randomly vary or not. The student level variables, SES, MSCONCEPT, ANXIETY, INTMOT, EXTMOT, CONTROL, ELAB, COMPE, COOPE, TCSUPP, GIVEHOME, ACTHOME, TYPEHOME, PRODAILY, and TECHNO are entered in the model respectively. Out of 16 variable 11 of them are found to be significantly related to problem solving skills. The final random coefficient model includes the variables; SES, MSCONCEPT, ANXIETY, EXTMOT, CONTROL, COMPE, TCSUPP, GIVEHOME, ACTHOME, and TYPEHOME. Among these variables only TCSUPP variable is found to be random variable. Therefore the other ten variables are non-randomly varying and are fixed in the final model. The final estimation of fixed effects obtained from random coefficient model is given in Table 4.11.

Table 4.11 Final estimation of fixed effects obtained from random coefficient model

Fixed effect	Coefficient	Standard error	t-ratio	p-value
Overall mean problem solving skills[1], γ_{00}	6.85	0.18	38.20	0.000
SES, γ_{10}	0.36	0.07	5.17	0.000
MSCONCEPT, γ_{20}	0.47	0.07	6.64	0.000
ANXIETY, γ_{30}	-0.28	0.08	-3.69	0.000
EXTMOT, γ_{40}	0.19	0.06	2.98	0.003
CONTROL, γ_{50}	0.24	0.07	3.57	0.001
COMPE, γ_{60}	0.44	0.07	6.11	0.000
TCSUPP, γ_{70}	0.25	0.08	3.10	0.004
GIVEHOME, γ_{80}	-0.43	0.07	-5.77	0.000
ACTHOME, γ_{90}	-0.19	0.06	-3.13	0.002
TYPEHOME, γ_{10}	-0.24	0.06	-4.39	0.000

[1] The student level variables were group mean centered before analysis

The SES-PSS slope coefficient (γ_{10} = 0.36, se = 0.07) indicates that students coming from families with higher socioeconomic status also demonstrate higher performance in the problem solving skills test. The MSCONCEPT-PSS slope coefficient (γ_{20} = 0.47, se = 0.07) indicates that students who have higher levels of mathematics self concept performed better on the problem solving skills test. On the other hand, the ANXIETY-PSS slope coefficient (γ_{30} = -0.28, se = 0.08) indicates that students who have higher levels of mathematics anxiety performed lower on the problem solving skills test. The EXTMOT-PSS slope coefficient (γ_{40} = 0.25, se = 0.06) indicates that students who have higher levels of external motivation to learn mathematics also performed higher on the problem solving skills test. The CONTROL-PSS slope coefficient (γ_{50} = 0.24, se = 0.07) indicates that students who use control strategies more frequently performed higher on the problem solving skills test.

The COMPE-PSS slope coefficient (γ_{60} = 0.44, se = 0.07) indicates that students who preferred more competitive learning environments performed better on the problem solving skills test. The TCSUPP-PSS slope coefficient (γ_{70} = 0.25, se = 0.08) indicates that students who reported that their mathematics teacher provided support for their learning, performed higher on the problem solving skills test.

The results for the variables related with mathematics homework are all reflect negative relationships. The GIVEHOME-PSS slope coefficient (γ_{80} = -0.43, se = 0.07) indicates that students who report that their mathematics teacher frequently gives mathematics homework, they frequently answer the questions in the course book and student exercise book perform worse on the problem solving skills test. Similarly, the ACTHOME-PSS slope coefficient (γ_{90} = -0.19, se = 0.06) indicates that students who report that they frequently conduct different types of activities related to homework, also demonstrate low performance on the problem solving skills test. The TYPEHOME-PSS slope coefficient (γ_{10} = -0.24, se = 0.06) indicates that students who report that they frequently are assigned different types of mathematics homework also demonstrate low performance on the problem solving skills test.

The final estimation of variance components obtained from random coefficient model is presented in Table 4.12.

Table 4.12 Final estimation of variance components obtained from the random coefficient model

Random effect	Variance component	df	χ^2	p-value
Teacher mean, u_{0j}	1.43	49	501.62	0.000
TCSUPP, u_{60j}	0.09	49	69.79	0.021
Level-1 effect, r_{ij}	6.19			

As seen in the table variance component of the teacher means is found to be as 1.43. The chi-square statistics with the value of 501.62 is statistically significant ($p < .001$) which means that there is need to incorporate teacher level variables into the model that might account for some of the differences. Also, the value of the chi-square statistics for the variance of TCSUPP slope is found to be 69.79. Since the p-value of this slope is found to be smaller than .05, this slope varies significantly. This means this slope is much steeper in some teachers' classes than in other teachers' classes indicating the relationship with problem solving skills is much stronger in some teachers' classes than in other teachers' classes.

The variance explained at the student level can be examined by comparing the variances in the one-way ANOVA and random coefficient models;

$[\sigma^2 \text{ (ANOVA)} - \sigma^2 \text{ (Random coef.)}] / \sigma^2 \text{ (ANOVA)}$

$[8.18 - 6.19] / 8.18 = 0.24$

Thus, by including the student level variables such as, SES, MSCONCEPT, ANXIETY, EXTMOT, CONTROL, COMPE, TCSUPP, GIVEHOME, ACTHOME, and TYPEHOME as the predictors of the problem solving skills within teacher variance was reduced by 24%. It means that these factors account for about 24% of the student level variance in problem solving skills.

In the HLM analysis the reliabilities of the intercept and the slope of TCSUPP are estimated. The results indicate that reliabilities are found to be 0.88 and 0.33 for the intercept and the slope of TCSUPP, respectively. Although, the reliability of the intercept is quite reliable, the other reliability is found to be less reliable. Raudenbush and Bryk (2002) proposed two primary reasons for lower reliabilities. The first one is that the true slope variance across teachers is much smaller than the variance of the true means. The second one is that many teachers may be relatively homogeneous on the randomly varying variables such as TCSUPP.

Tau as correlations obtained from random coefficient model is given in Table 4.13. A high tau correlation means that the same variation across the teacher level units is being carried and a reduction in the model may be warranted by fixing one of the variables to be non-randomly varying. A low correlation was observed between Intercept and TCSUPP. When the variable TCSUPP is fixed and an analysis of deviance statistic computed. The results indicated that setting TCSUPP as non-randomly varying did not create a better explanatory model. Therefore, this variable is kept as randomly varying in the final random coefficient model.

Table 4.13 Tau as correlations obtained from random coefficient model

	Intercept	TSUPPORT
Intercept	1.00	0.22
TSUPPORT	0.22	1.00

4.3.5 Intercepts and slopes as outcomes

The intercepts and slopes as outcomes model gives information about which teacher variables influence the effect of student variables on students' problem solving skills. In this phase of the analyses, the aim is to build an explanatory model to account for the variability of the regression equations across teachers. The intercepts and slopes as outcomes model is the combination of all the models built previously. In the first step the intercept is modeled by using the results obtained from the random coefficients model and the means as outcomes model.

The equations for the first step are;

Level-1 model (student-level);

$Y_{ij} = \beta_{0j} + \beta_{1j}(SES) + \beta_{2j}(MSCONCEPT) + \beta_{3j}(ANXIETY) + \beta_{4j}(EXTMOT) + \beta_{5j}(CONTROL) + \beta_{6j}(COMPE) + \beta_{7j}(TCSUPP) + \beta_{8j}(GIVEHOME) + \beta_{9j}(ACTHOME) + \beta_{10j}(TYPEHOME) + r_{ij}$

Level-2 model (teacher-level);

$\beta_{0j} = \gamma_{00} + \gamma_{01}(ASCONCEPT) + \gamma_{02}(ASES) + \gamma_{03}(TGENDER) + \gamma_{04}(LIMSTU) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70} + u_{7j}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

$\beta_{10j} = \gamma_{100}$

All of the teacher level variables are found to be significantly related to problem solving skills. In the next step, the randomly varying slope is examined. The variables ASCONCEPT, ASES, TGENDER, and LIMSTU are included in the TCSUPP coefficient model with the previous results.

The equations for the second step are;

Level-1 model (student-level);

$Y_{ij} = \beta_{0j} + \beta_{1j}(SES) + \beta_{2j}(MSCONCEPT) + \beta_{3j}(ANXIETY) + \beta_{4j}(EXTMOT) + \beta_{5j}(CONTROL) + \beta_{6j}(COMPE) + \beta_{7j}(TCSUPP) + \beta_{8j}(GIVEHOME) + \beta_{9j}(ACTHOME) + \beta_{10j}(TYPEHOME) + r_{ij}$

Level-2 model (teacher-level);

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{ASCONCEPT}) + \gamma_{02}(\text{ASES}) + \gamma_{03}(\text{TGENDER}) + \gamma_{04}(\text{LIMSTU}) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70} + \gamma_{71}(\text{ASCONCEPT}) + \gamma_{72}(\text{ASES}) + \gamma_{73}(\text{TGENDER}) + \gamma_{44}(\text{LIMSTU}) + u_{7j}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

$\beta_{10j} = \gamma_{100}$

In this step of the model testing none of the teacher level variables are found to be significantly related to TCSUPP. Therefore they are removed from the model.

Finally, the full final intercepts and slopes as outcomes model analyzed and the related equations for the final full model are;

Level-1 model (student-level);

$Y_{ij} = \beta_{0j} + \beta_{1j}(\text{SES}) + \beta_{2j}(\text{MSCONCEPT}) + \beta_{3j}(\text{ANXIETY}) + \beta_{4j}(\text{EXTMOT}) + \beta_{5j}(\text{CONTROL}) + \beta_{6j}(\text{COMPE}) + \beta_{7j}(\text{TCSUPP}) + \beta_{8j}(\text{GIVEHOME}) + \beta_{9j}(\text{ACTHOME}) + \beta_{10j}(\text{TYPEHOME}) + r_{ij}$

Level-2 model (teacher-level);

$\beta_{0j} = \gamma_{00} + \gamma_{01}(\text{ASCONCEPT}) + \gamma_{02}(\text{ASES}) + \gamma_{03}(\text{TGENDER}) + \gamma_{04}(\text{LIMSTU}) + u_{0j}$

$\beta_{1j} = \gamma_{10}$

$\beta_{2j} = \gamma_{20}$

$\beta_{3j} = \gamma_{30}$

$\beta_{4j} = \gamma_{40}$

$\beta_{5j} = \gamma_{50}$

$\beta_{6j} = \gamma_{60}$

$\beta_{7j} = \gamma_{70} + u_{7j}$

$\beta_{8j} = \gamma_{80}$

$\beta_{9j} = \gamma_{90}$

$\beta_{10j} = \gamma_{100}$

$\beta_{11j} = \gamma_{110}$

The results of the final estimation of fixed effects obtained from the full final intercepts and slopes as outcomes model are displayed in Table 4.14.

Table 4.14 Final estimation of fixed effects obtained from the intercepts and slopes as outcomes model

Fixed effect	Coefficient	Standard error	t-ratio	p-value
Overall mean problem solving skills[1], γ_{00}	6.87	0.11	64.35	0.000
ASCONCEPT, γ_{01}	1.95	0.62	3.17	0.003
ASES, γ_{02}	1.47	0.20	7.23	0.000
TGENDER, γ_{03}	-0.63	0.21	-2.99	0.005
LIMSTU, γ_{04}	-0.27	0.09	-3.13	0.004
SES, γ_{10}	0.36	0.07	5.16	0.000
MSCONCEPT, γ_{20}	0.47	0.07	6.75	0.000
ANXIETY, γ_{30}	-0.28	0.08	-3.62	0.001
EXTMOT, γ_{40}	0.19	0.06	2.92	0.004
CONTROL, γ_{50}	0.24	0.07	3.56	0.001
COMPE, γ_{60}	0.44	0.07	6.11	0.000
TCSUPP, γ_{70}	0.25	0.08	3.14	0.003
GIVEHOME, γ_{80}	-0.43	0.07	-5.84	0.000
ACTHOME, γ_{90}	-0.20	0.06	-3.18	0.002
TYPEHOME, γ_{100}	-0.25	0.06	-4.42	0.000

[1] The student level variables were group mean centered before analysis

As previously mentioned, the intercepts and slopes as outcomes model is the combination of all the models built previously. The results of the final full model indicate that the teacher level variables affecting teacher mean on problem solving skills are ASCONCEPT, ASES, TGENDER, and LIMSTU as previously reported in regression with means-as-outcomes. Additionally, the results of the final full model indicate that the student level variables affecting students' problem solving skills are SES, MSCONCEPT, ANXIETY, EXTMOT, CONTROL, COMPE, TCSUPP, GIVEHOME, ACTHOME, and TYPEHOME, as previously reported in the random coefficient model.

Thus, the coefficient of ASCONCEPT (γ_{01} = 1.95, se = 0.62) displays a significant and positive relationship between average mathematics selfconcept and teacher mean on problem solving skills. This relationship indicates that as the average mathematics selfconcept of the students increases the mean of problem solving skills increases. The coefficient of ASES (γ_{02} = 1.47, se = 0.20) indicates that as the average socioeconomic status of the students increases, the mean of the problem solving skills increases. The coefficient of TGENDER (γ_{03} = -0.63, se = 0.21) indicates that gender of teacher is negatively related to mean of problem solving skills. This means that the means of problem solving skills of female teachers' classes are higher than the means of problem solving skills of male teachers' classes. The coefficient of LIMSTU (γ_{04} = -0.27, se = 0.09) is significantly and negatively related to the mean of problem solving skills. This negative relationship indicates that the more teachers perceive that the uninterested, unsuccessful, students with special needs or students with different academic abilities in the same classroom do not limit the mathematics instruction in the mathematics class, the lower the mean of the problem solving skills.

The SES slope coefficient (γ_{10} = 0.36, se = 0.07) indicates that students coming from families with higher socioeconomic status also demonstrate higher performance in the problem solving skills test. The MSCONCEPT slope coefficient (γ_{20} = 0.47, se = 0.07) indicates that students who have higher levels of mathematics self concept perform better on the problem solving skills test. On the other hand, the ANXIETY slope coefficient (γ_{30} = -0.28, se = 0.08) indicates that students who have higher levels of mathematics anxiety performed lower on the problem solving skills test. The EXTMOT slope coefficient (γ_{40} = 0.19, se = 0.06) indicates that students who have higher levels of external motivation to learn mathematics also perform higher on the problem solving skills test. The CONTROL slope coefficient (γ_{50} = 0.24, se = 0.07) indicates that students who use control strategies more frequently perform higher on the problem solving skills test.

The COMPE slope coefficient (γ_{60} = 0.44, se = 0.07) indicates that students who preferred more competitive learning environments perform better on the problem solving skills test. The TCSUPP slope coefficient (γ_{70} = 0.25, se = 0.08) indicates that students who reported that their mathematics teacher provided support for their learning, perform higher on the problem solving skills test.

The results for the variables related to mathematics homework all reflect negative relations. The GIVEHOME slope coefficient (γ_{80} = -0.43, se = 0.07) indicates that students who reported that their mathematics teacher frequently gives mathematics homework, they frequently answered the questions in the course book and student exercise book perform worse on the problem solving skills test. Similarly, the ACTHOME slope coefficient (γ_{90} = -0.20, se = 0.06) indicates that students who report that they frequently conduct different types of activities related to homework, also demonstrate low performance on the problem solving skills test. The TYPEHOME slope coefficient (γ_{10} = -0.25, se = 0.06) indicates that students who report that they frequently are assigned different types of mathematics homework also demonstrate low performance on the problem solving skills test.

As seen in the Table 4.15 the coefficients obtained from the intercepts and slopes as outcomes model display slight differences when compared to the coefficients obtained from random coefficients model. Moreover these slight differences are in magnitude and the directions of these coefficients are same. The reason for these slight differences is the fluctuations in the number of teachers and accordingly fluctuations in the number of students.

In the final full model of intercepts and slopes as outcomes, no significant relationships are observed between the student level slopes and teacher level variables.

The results of the final estimation of variance components obtained from the full final intercepts and slopes as outcomes model are displayed in Table 4.26. The degrees of freedom for this model is computed on the number of teachers with sufficient data and the number of teachers variables in the model.

Degree of freedom = J – Q – 1, where,

J = the number of teachers with sufficient data

Q = the number of teacher variables included in the model. There were 50 teachers with sufficient data. Thus,

df for Teacher Mean = J – Q – 1 = 50 – 4 – 1 = 45

df for TCSUPP = J – Q – 1 = 50 – 0 – 1 = 49

Table 4.15 Final estimation of variance components obtained from intercepts and slopes as outcomes model

Random effect	Variance component	df	χ^2	p-value
Teacher mean, u_{0j}	0.45	45	180.08	0.000
TCSUPP, u_{7j}	0.09	49	69.72	0.022
Level-1 effect, r_{ij}	6.18			

The proportion of variance explained in problem solving skills relative to random coefficients model is;

[τ_{00} (Random coefficient) - τ_{00} (Intercepts and slopes as outcomes)] / τ_{00} (random coefficient)

[1.43 – 0.45] / 1.43 = 0.69

Consequently, 69% of the variance in between teacher differences in mean problem solving skills is accounted for by ASCONCEPT, ASES, TGENDER, and LIMSTU. However, significant differences still remains ($\chi^2 = 180.08$, $p < 0.001$).

4.3.6 Summary of hierarchical linear modeling (HLM) analyses

After checking that the assumptions underlying HLM analyses were tenable, four models were built to investigate the relationships between student and teacher level factors and problem solving skills of the students. The result of the one-way ANOVA with random effects model indicated that significant variation does exist among teachers in problem solving skills of their students and 14% of the total variability in problem solving skills can be attributed to the teachers. The results of the means-as-outcomes regression model revealed that there were significant associations between a set of teacher level factors and mean problem solving skills. These factors were *teacher gender* (TGENDER), *perceptions about limitations aroused from students* (LIMSTU), *average socioeconomic status* (ASES), and *average self concept* (ASCONCEPT). The random-coefficients regression model indicated that student level variables such as *socioeconomic status* (SES), *mathematics self concept* (MSCONCEPT), *mathematics anxiety* (ANXIETY), e*xtrinsic motivation* (EXTMOT), *use of control strategies* (CONTROL), *preference for competitive learning situation* (COMPE), *giving homework* (GIVEHOME), *activities related with homework* (ACTHOME), and *different types of homework* (TYPEHOME) were associated with the problem solving skills. Finally, the model of intercepts – and slopes-as-outcomes that was the combination of all the models built previously. In addition to the relationships observed in the first three models, the final model revealed that there was no teacher level factor influencing the relationship that was between student level factors and problem solving skills of the students.

CHAPTER 5

DISCUSSION, CONCLUSIONS AND IMPLICATIONS

This section is devoted to the discussion of the results with regard to the performances of the students in the problem solving skills test and hierarchical linear modeling in the light of related literature. Afterwards, the conclusions are presented together with implications, limitations, and suggestions for further research.

5.1 Discussion of the results

5.1.1 Students' problem solving skills

In the current study the first aim of the study is to display the problem solving performances of the sixth grade Turkish students measured within the four-process problem solving framework. The results of the descriptive statistics of the problem solving skills test reveal that the sixth grade students participated in the present study show quite low performance in general. When the obtained results of the current study are compared to the results obtained from TIMSS 1999 and TIMSS 2007, it is observed that the results are not consistently parallel to each other. When the released mathematics items of TIMSS 1999 (The International Study Center [ISC], 2000) and TIMSS 2007 (Foy & Olson, 2009) are investigated, it is observed that problems similar to ones used in the present study are correctly responded approximately only 35% of Turkish students. However, in the current study the percentages of correct responses were found to be varying such as ranging from 1.1 to 65. When the results of the current study are compared to the results of PISA 2003 considering students' performances for processes of problem solving framework, a more consistent comparisons are obtained. Although the problem definitions used in the current study and in PISA 2003 are not exactly the same, there are some common points specific to the *problem* such as "the solution path is not immediately obvious" or "confronting and resolving real, cross-disciplinary situations." In the current study it is not possible to categorize the students with respect to the overall performances such as weak problem solvers or reflective problem solvers as done in PISA 2003. Nevertheless, the performances of the students for each process of the problem solving framework can be roughly compared with the performances of students in PISA 2003. In this sense, it may be claimed that the results of the current study are consistent with the results of PISA 2003. For instance, it is reported that 51% of the 4855 Turkish students participated in PISA 2003 were categorized as weak problem solvers those can only deal with straightforward problems with carefully structured tasks that require them to give responses based on facts or to make observations with few or no inferences (OECD, 2004a). Similarly, in the current study the correct response percentages of the students for the items representing the process of understanding the problem range from 23.7% to 59.2. Moreover, the mean of the students for this phase is 2.12 out of 4 with a standard deviation of 1.12. When this highest level of PISA 2003 categorization is roughly matched with the fourth process of the problem solving framework used in the present study, the results are not consistent such as the previous comparison. In PISA 2003, only 4% of Turkish students were categorized as reflective problem solvers who do not only analyse a situation and make decisions, but also think about the underlying relationships in a problem and relate these to the solution (OECD, 2004a). However, the correct response percentages of the students for the items representing the process of looking back and evaluating ranged from 9.1% to 48.1. In this sense, the correct percentages of some items those are supposed to measure the skills such as deciding whether the problem could be solved based on the the given data or selecting the appropriate statement whether the solution of the problem is reasonable or not are higher than expected. This may be the result of the format or the quality of these items. For instance, the distracters maybe reevaluated of these multiple-choice items. However, when the performance of the students in this phase were evaluated considering all the items representing the phase of looking back and evaluating, the mean is found as 1.72 out of 5 with a standard deviation of 1.40. Consequently, this performance of the students is quite low when considering all of the four processes.

The results of the one-way repeated-measures analysis of variance (ANOVA) conducted for investigating whether there are significant mean differences among four processes indicated that the students displayed different performances for across the four problem solving processes. When the mean differences are compared by using pairwise comparisons, it is observed that, the students display the best performance in the process of understanding the problem whereas they showed the worst performance in the process of looking back and evaluating. This result indicated that students are more successful in conducting some activities such as constructing relationships among problem elements, identifying the needed data to solve the problem, identifying the key condition or the question in the problem situation. On the other hand, students displayed lowest performance in conducting some activities such as verifying the solution of the problem, or deciding whether the problem could be solved based on the given data. As it was previously mentioned, the problem solving is defined as an activity including simple recall of facts, application learned procedures, coordination of previous experiences, and knowledge (Charles, Lester, & O'Daffer, 1987) or a thinking process including set of mental operations involving the use of several thinking skills (Marzano et al., 1988). Also, the complex nature of the problem solving including these different activities or thinking skills is frequently stressed by the researchers (Charles, Lester & O'Daffer, 1987; Lester & Kroll, 1990; Marzano et al., 1988; Posamentier & Krulik, 1998). In this sense, the problem solver should carry on a series of tasks and maintain some thinking processes that are closely linked together to reach the solution of the problem (Krulik &

Rudnick, 1989). When the results of the current study are interpreted in the light of these issues mentioned in the related literature, it seems that the students are more successful in carrying on simple activities or maintaining simple thinking skills than in carrying on complex activities or maintaining advanced thinking skills. Additionally, it may be also claimed that most of the students are at the beginning of this complex process and can not able to reach at the end of this process. In fact, it is an expected result for the present study since carrying on these activities or maintaining these thinking processes is a difficult skill and this skill takes a long time to learn (Krulik & Rudnick, 1989). One of the reasons for these low performances of the students may be that the students do not have any experiences in which they are asked to carry on such activities or maintain such thinking skills in the classroom environment. Maybe, they are not familiar with such situations in which they evaluate the reasonableness of the given solution or verify the solution by presenting justifications in the mathematics classrooms.

The detailed investigation of the responses given for some of the free-response items revealed important issues. One of the free-response items a response of which merits some interpretation was named as “Canan” (Item 5). In this item, students were presented two different 24-issue magazine advertisements. In the first advertisement four issues are free and the rest is 3 Turkish Liras each, whereas in the second one six issues are free and the rest is 3.5 Turkish Liras. In the item the students are asked which magazine is the least expensive for 24 issues and how much less expensive is also asked. When the responses of the students are investigated it is observed that quite considerable number of students (approximately 5%) compared the prices of only one issue of the two magazines ignoring the total price of 24-issue. This frequently encountered erroneous response may be interpreted as that many students are not able to evaluate the problem situations as a whole and had difficulty in considering the relationships among the elements of a problem. This deficiency of the students may be the consequence of disability in competing with the complex and multifaceted nature of problem solving process. Another free-response item a response of which should be interpreted was named as “Kaykay” (Item 8). In this item the students are given a situation such that “they make 20-unit-speed with their skateboard without wind. Their speed increase by wind blowing at the same direction where they go with skateboard” They are asked themselves’ resulting speed with skateboard in a windy air. Also at the beginning of the item they are informed that they do not need to solve the problem they are only asked to identify what additional data are needed to solve the problem. Suprisingly, a considerable number of students (approximately 17%) tended to conduct some computations although only one quantity (the speed of them with skateboard) is given in the problem situation and responded as the needed data was “time and distance”. One of the reasons for the response including computations may be that students are not familiar with such items and they only concentrate on the question to solve the problem. Moreover, they tend to make up some missing quantities to solve the problem. On the other hand, one of the reasons for the response including “time and distance,” may be that student encounter always same types of problems and tend to solve them by using a learned algorithm. In this sense, the problem asking the last speed of them with skateboard reminded them a well-known equation that is “speed = distance / time.” These interesting responses of the students may provide evidences for the claims of Noddings (1985) and Krulik and Rudnick (1989). Noddings (1985) indicated that school word problems are highly structured and predefined and they do not constitute a “problem” situation for students. In line with Noddings (1985), Krulik and Rudnick (1989) stress that many of the problems given in mathematics textbooks can not be considered as problems because generally the model developed and presented by teacher in classroom. In this manner the students only apply the presented model to solve the problem and by this way they practice an algorithm or a technique. Thus, such so-called problems those called “routine problems” by some of researchers do not require students to use higher-order thinking skills (Krulik & Rudnick, 1989). Consequently, it seems that solving same types of problems condition students to apply same of solving procedures.

5.1.2 Hierarchical linear modeling

The second aim of the present study is to test a model to investigate the effects of student and teacher characteristics on the problem solving skills of the students by using hierarchical linear modeling considering the relationships investigated in the previously developed models. The results of the hierarchical linear modeling will be presented under two topics as student and teacher level factors.

5.1.2.1 Student level factors

The results of the hierarchical linear modeling indicate that the only one variable slope (*teacher support* - TCSUPP) is significantly related to problem solving skills and randomly varying across teachers. This variable is found to be significantly and positively related to problem solving skills of the students. It means that the students who report that teacher helps them when they need help, repeats what he/she told until they understand, makes an effort for their learning, and gives them opportunity to explain their ideas more frequently, perform better in the problem solving skills test. When the percentages of these items representing the *teacher support* (TCSUPP) variable are examined, it is observed that the percentages of the students who strongly agree with these items range from 48.7% to 67.3%. In this sense, the relationship that is found between *teacher support* (TCSUPP) and problem solving skills of the students is consistent with the results found in PISA 2000 (OECD, 2001), in PISA 2003 (OECD, 2004a), and the results of Hill and Rowe (1998) as well. Thus, it can be claimed that teachers' supportive practices such as repeating the subjects until their students understand, making an effort for students' learning, or giving the students to explain their ideas in the mathematics classroom are important and valuable practices for increasing students' problem solving skills. Moreover, this result may also be interpreted from the view of *zone of proximal development* proposed by Vygotsky

(Gredler, 1992). Vygotsky indicated that there is a distance between the actual developmental level that is reflected in the child's independent problem solving and the problem solving level that is accomplished with guidance. Thus, it is probable that the performance of the students who can obtain teacher guidance and assistance is more than that of the others.

The *teacher support* (TCSUPP) variable slope randomly varies across teachers means that *teacher support* (TCSUPP) influences problem solving skills of the students more in some teachers' classes than it does in other teachers' classes. There may be many reasons affecting this relationship found between *teacher support* (TCSUPP) and problem solving skills. For instance, students' cognitive characteristics, performance in mathematics, the quality and the content of the teachers' communication to the student or to what extent the students need teacher support may be the possible factors affecting this association. However, investigating the reasons is beyond the scope of the present study's aim. Therefore, it requires further research and analysis to establish how teacher support affects students' problem solving skills.

The results of the hierarchical linear modeling indicate that ten student level variables are significantly related to problem solving skills and also these variables do not randomly vary across different teachers. These variables are *socioeconomic status* (SES), *mathematics self concept* (MSCONCEPT), *mathematics anxiety* (ANXIETY), e*xtrinsic motivation* (EXTMOT), *use of control strategies* (CONTROL), *preference for competitive learning situation* (COMPE), *giving homework* (GIVEHOME), *activities related with homework* (ACTHOME), and *different types of homework* (TYPEHOME).

The association between *socioeconomic status* (SES) and problem solving skills of the students is found to be significant and positive. This means that students whose parents' education level is higher, who have computer, dishwasher and more books in their homes, who have less number of siblings and take mathematics course out of school time tend to show better performance in the problem solving skills test. This result is consistent with the results of the many studies (Crane, 1996; Demir, Kılıç, & Depren, 2009; İş Güzel, 2006; O'Conner & Miranda, 2002; Okpala, Smith, Jones, & Ellis, 2000; Reynolds & Conaway, 2003; Yang, 2003). Although the variable *socioeconomic status* is not measured with exactly the same indicators in the mentioned and the current studies, the consistency across these results indicate that *socioeconomic status* (SES) positively relates to not only students' achievement in mathematics, science, or reading but also students' performance in the problem solving area. Since there is a significant and positive correlation between problem solving skills and students' achievement especially in mathematics and also problem solving is an integrated part of school mathematics, this result is an expected one. Schreiber (2002) proposed that parents who have more formal education may have more engaged in mathematics achievement of their children and provide more opportunity and resources for their academic studies. Moreover, Schreiber (2002) added that the lack of access or opportunity to learn can detrimentally affect achievement. Similarly, Baker and Stevenson (1986) indicated socioeconomic advantages of the family increase the likelihood of school attendance, and since more lengthy schooling increases access school achievement. Furthermore high socioeconomic status is related with easy access to financial social resources that parents can use improve their children's academic careers. Greater financial sources allow more educated parents to access better homes, health care, and educational services. Moreover, their experiences and the knowledge of the school system permit them to be more effective managers of their children's school careers (Baker & Stevenson, 1986). Lubienski (2000) investigated this relationship with respect to students' experiences in a problem-centered mathematics classroom. As a result, she reported that students coming from families with higher socioeconomic status tended to display confidence and solved problems considering the mathematical ideas, whereas students coming from families with lower SES preferred more external direction and sometimes they missed some mathematical ideas while solving problems. As a conclusion, all of these proposed reasons explain the significant and positive relationship between *socioeconomic status* (SES) and problem solving skills of the students.

The variable of *mathematics self concept* (MSCONCEPT) is found to be significantly and positively related to students' problem solving skills. This relationship indicates that the students who report that they are talented in mathematics, mathematics is one of their strengths, they are good at mathematics when they are compared with their classmates or such statements tend to perform better in the problem solving skills test. Because of the high correlation between mathematics achievement and problem solving skills, this positive relationship is anticipated when the results of the related studies (Byrne, 1984; Chiu & Klassen; 2009; Dermitzaki, Leondari, & Goudas, 2009; Eklöf, 2007; Wilkins, 2004) are examined at the beginning of the study. Byrne (1984) reported that students hold certain attitudes about themselves and their abilities, these attitudes have a strong effect on their academic achievement in school. Similar to the previous explanations, one of the reasons of these strong and positive relationship between *mathematics self concept* and problem solving skills may be that students hold certain attitudes about themselves and their abilities or performances in mathematics, these attitudes have a strong effect in using their mathematical knowledge and ideas in the problems they encountered and in coping with the problematic situations. Moreover, these positive perceptions about their performances may orient the students for using valuable and effective approaches in understanding and solving the problems.

The relationship between *mathematics anxiety* (ANXIETY) and problem solving skills of the students is found as significant and negative. This indicates that as students feel helpless when doing a mathematics problem, get very tense when have to do mathematics homework, get very nervous doing mathematics problems, worry about they will get poor marks in mathematics, they tend to display poorer performances in the problem solving skills test. As the mathematics anxiety has an important role in predicting mathematics achievement (Clute, 1984) and is negatively and significantly related to mathematics achievement (Aiken, 1970, 1976; Hembre, 1990; İş Güzel, 2006; Ma, 1999; OECD, 2004), this negative and significant relationship between mathematics anxiety and problem solving skills is an expected one. Also the inclusion of statements related to students' feelings of tension and nervousness in doing mathematics problems in measuring *mathematics anxiety* (ANXIETY) strengthens this expectation. It seems that, this complex construct which is a combination of low self-confidence, a fear of failure and a negative attitude towards learning math (Bandalos, Yates, & Thorndike-Christ, 1995) hinders students in using mathematical knowledge for understanding the problem situations, constructing relationships among elements of the problem or developing valuable and effective approaches for solving the problems.

The association between *extrinsic motivation* (EXTMOT) and problem solving skills is found to be as significant and positive whereas the association between *intrinsic motivation* (INTMOT) and problem solving skills is not significant. In this sense, students who agree that learning mathematics is worthwhile since it will improve their career, they will learn many things in mathematics that will help them get job, or mathematics is an important subject since they need it for what they want to study later on tend to get higher scores in the problem solving test. Nevertheless, no prediction can be made with students' *intrinsic motivation* (INTMOT) with respect to their problem solving skills. It seems that students' extrinsic motivation for learning mathematics is stronger predictability for their problem solving skills than that of intrinsic motivation for learning mathematics. Although in the related literature improving motivation in students is strongly recommended, it is also noted that encouraging student interest and motivation is a very complex task because students may have various goals and reasons for studying (Husman, & Lens, 1999). Thus, it is claimed that a student's total motivation is often a combination of intrinsic and extrinsic motivation (Husman & Lens, 1999). In fact, many researchers indicate that increased motivation in students leads to the use of effective and deeper cognitive strategies and complete understanding of the subject taught and hereby it lead to improved overall academic achievement (Pintrich, 2003; Pintrich & DeGroot, 1990; Wolters, Yu, & Pintrich, 1996; Zimmerman & Bandura, 1994; Zimmerman, Bandura, & Martinez-Pons, 1992). However, when the motivation is separately investigated with respect to intrinsic and extrinsic motivation different pictures occur. For instance, OECD (2004b) report indicates that no trend is observed across the participant countries such as students with greater intrinsic motivation tend to have better performances in mathematics. On the other hand, the relationship between extrinsic motivation and mathematics performance students is much weaker than with intrinsic motivation (OECD, 2004b). The complex and mixed results are also obtained in other studies (İş Güzel, 2006; Ross, 2008). Specifically, Ross (2008) indicates that the relationships between two types of motivation and academic achievement reflected some cultural differences. Since the related studies report mixed results, the findings of the current study are both consistent and not consistent with the mentioned studies to some extent. It may be proposed that learning mathematics for the sake of external factors such as for finding job or improving career is a more important driving force for Turkish students than for the sake of their enjoyments and interests or for themselves only. The motivation for external rewards may lead them to use their mathematical knowledge in problems, use effective and deeper cognitive strategies to ınderstand and solve the problems. As a conclusion, the current study indicates that these two different but highly correlated motivation types behave differently in predicting the same outcome variable for Turkish students.

When the associations between learning strategies and problem solving skills are considered, it is observed that there is a positive and significant relationship between *the use of control strategies* (CONTROL) and problem solving skills whereas there is no significant relationship between *the use of elaboration studies* (ELAB) and problem solving skills. This means that, as students try to figure out which concepts they have not understood, try to work out the most important parts to learn, start by working out exactly what they need to learn, they make themselves check to see if they remember the work they have already done when they are studying mathematics, or they always search for more information to clarify the problem when they can not understand something in mathematics, they perform better in the problem solving skills test. However, as students think how the mathematics they have learnt can be used in everyday life, think about how the solution might be applied to other interesting questions or often think of new ways to get the answer when they are solving mathematics problems, try to relate the work to things they have learnt in other subjects when learning mathematics, they perform neither better or worser in the problem solving skills test, surprisingly. Although, it is expected that both learning strategies are significantly related to problem solving skills even it is thought that *the use of elaboration strategy* is more probably related to problem solving skills than *the use of control strategy* is related to it, the use of elaboration strategy is not significantly related to problem solving skills of the students. It seems that only the habit of using control strategy when studying mathematics has a positive effect on the problem solving performances of the students. In the related literature, it is reported that use of control strategy is strongly related to reading performance (OECD, 2001) and mathematics achievement (İş Güzel, 2006; Thiessen & Blasius, 2008). Although no studies investigating the relationship between the use of control strategy in mathematics and problem solving skills have been encountered, a positive relationship is expected with regard to the results of the related literature. As reported that control strategy is important for the mathematics performance (Thiessen & Blasius, 2008), it may be claimed that the use of control strategy in studying mathematics is also important for problem solving performance. It is likely that the behaviors engaging students in the use of control strategies help them to understand the problem context and the relationships among the problem elements, to organize or integrate mathematical knowledge in the problem context. In this way, this engagement of the student affects him/her problem solving performance. An unexpected result related with the use of elaboration strategy is also observed in the study of İş Güzel (2006). She reports that although she expects a positive correlation, she finds negative relationships between elaboration strategies and mathematical literacy in the models of Turkey and member countries of European Union, and nonsignificant correlation for the same relationship in the candidate countries of European Union. She proposes that unreliable responses of Turkish students may be one of the reasons for this unexpected association. It can be concluded that this explanation may also be valid for the present study. Another reason may be the frequencies of the items representing the elaboration strategy. The observation of the frequencies indicates that control strategy is used more frequently than the elaboration strategy. This rare usage of elaboration strategy may not be enough to be effective in enhancing students' problem solving skills as in the case of control strategy.

The results with respect to preferences for learning situations indicate that *preference for competitive learning situation* (COMPE) is positively related to problem solving skills whereas *preference for cooperative learning situation* (COOPE) is not significantly related to problem solving skills of the sixth grade students. It means that as students try hard in mathematics to do better in the mathematics exams than their classmates, make real effort to be one of the best or would like to be the best in their classes in mathematics, they get better grades in the problem solving skills test. However, enjoyment in working with other students in groups, enjoyment in helping others to work well in a group, preference for working with other students or preference for combining the ideas of all the students do not affect the problem solving performance positively or negatively. The related studies investigating the association between competitive learning and performance reveal that there are both positive and negative effects of competitive learning on the performance of the students (Schaper, 2008). It seems that the preferences of students for suchlike learning situation in mathematics classes motivate them to keep up and help them to set goals for their learning. This motivation and setting goals for learning may be helpful in understanding the problem situation, the relationships among the problem elements, using mathematical knowledge in the problems or solving the problems.

Actually, based on the results of the many studies investigating the association between the preference for cooperative learning and achievement or performance of the students (Cohen, 1994; Johnson & Johnson, 1999; Slavin, 1995; 1991), in the current a positive and significant relationship is expected between preference for cooperative learning situation and problem solving skills of the students. However the results indicate that there is no significant association between these two. In fact, this result is consistent with that of İş Güzel (2006) who find nonsignificant relationship between cooperative learning and mathematical literacy performance of students in Turkey, member and candidate countries of European Union. In fact, the preferences of students for the learning situation may be different from the actual classroom practices conducted in the mathematics classroom. When the frequencies of the mathematics classroom practices are investigated it is observed that the frequencies of the practices associated with working in pairs or small groups are reported as rarely by both the students and their teachers. However, the students agree with the statements reflecting their preferences for cooperative learning situation. Thus, it can be claimed that although the students prefer such learning situation such practices are not frequently carried out in the mathematics classroom. In that case, it is probable to expect a nonsignificant relationship between these two variables. Since such practices are not carried out in the classroom frequently, the students may not benefit from the advantages of cooperative learning practices such as enhancing cognitive skills or academic achievement as cited in literature.

The results indicate that the variables related to homework are significantly and negatively associated with problem solving skills of the students. In this case, the variables *giving homework* (GIVEHOME), *activities related with homework* (ACTHOME), and the use of *different types of homework* (TYPEHOME) are significantly and negatively related to problem solving skills. In this manner, as students are given more homework such as answering the problems or questions in the course book or making exercises in the student exercise book, as teachers conduct more activities related to homework such as making explanations about homework in class, making students correct their homework or discussing homework in the class, collecting, correcting, keeping their homework, or giving their homework back, or checking their homework, and as teachers frequently give different types of homework such as working long term project by small groups, preparing oral presentations independently or by small groups, working on long term projects individually, conducting small research or collecting data, finding the use of math subject in daily life, reading course book, or making exercises on the worksheets, the students get lower scores in the problem solving skills test. This negative association between homework related variables and problem solving skills is one of the most notable findings of the current study. Since the related literature reports mixed results, the finding observed in the present study is consistent with some of these studies (Chen & Stevenson, 1989). It seems that giving students mathematics homework especially such as answering the problems or questions in the course book or making exercises in the student exercise book or conducting homework related activities in mathematics classroom have negative effects on the performance of the students in problem solving. One of the reasons of these negative effects may be that increasing the amount of mathematics homework including just drills and practices hinders students to think comprehensively for understanding problem situations and to use mathematical knowledge in these problems. By making such homework students may spend a lot of time for conducting algorithmic practices instead of thinking about problems and also this may cause some fatigue or negative attitude for thinking mathematically or solving problems. Actually, a positive association between checking and discussing the given homework and the problem solving skills of the students should be expected. However, when the given homework includes only basic and algorithmic drills or practices, it is probable to observe no or negative effect between checking and discussing such homework and problem solving skills. Also, when the frequencies of such activities are examined, it is observed that such activities are rarely conducted in the mathematics classroom. Similarly, it is observed that the frequencies of different types of homework such as making small researches, collecting data, conducting projects, or preparing oral presentations are also used rarely as mathematics homework. Of course, the conclusion of these findings should not be that "do not give mathematics homework to the students", however it can be concluded that there are some problematic situations in the actual practice of homework in mathematics classes (Berberoğlu, 2008). In Turkey there is a common judgement becoming widespread increasingly that the more amount of homework assigned the better the students learn, however the results of the studies conducted with Turkish students cause the suspicion whether the given homework is helpful in students' learning (Berberoğlu, 2008). This negative association should be investigated by focusing on the content, quality, and types of mathematics homework and the quality of homework activities conducted in the mathematics classrooms with regard to grade level and parent support in the further studies.

Finally, the remaining two student level factors are found to be nonsignificantly related to problem solving skills of the sixth grade students. They are *projects, daily life examples and problems* (PRODAILY) and *the use of technology* (TECHNO). It means that as students work in pairs or small groups on a problem or a project, use daily life examples while solving problems, or when beginning a new topic they discuss a practical problem or story, and as they use technology in mathematics classroom such as overhead projector or computer, their problem solving skill scores neither increase nor decrease consistently. The variable *projects, daily life examples and problems* (PRODAILY) used in the current study includes items related to cooperative learning such as working in pairs or small groups and items related to using daily life examples or solving problems. With regard to the indicators of cooperative learning activities, the literature suggests mixed results. For instance, Bos and Kuiper (1999) reports that cooperative learning no significant path coefficient in most of the models of European countries, whereas House (2001) reports that more frequent use of cooperative activities such as working together in pairs or small groups when learning new topics and working together in pairs or small groups in mathematics lessons, was associated with lower mathematics test scores. With regard to the items representing classroom practices such as using daily life examples or solving problems, House (2001) reports that, students who report that their teachers more frequently solved an example related to the new topic and they used things from everyday life to solve mathematics problems in mathematics classroom, show higher mathematics test scores. In fact, this nonsignificant association between *projects, daily life examples and problems* (PRODAILY) and problem solving skills is an expected one, since this variable includes different sorts of items suggesting mixed results in the literature. Moreover, when the frequencies of these items representing this variable are examined, it is observed that such practices are rarely conducted in mathematics classroom. Also, it is observed that the frequencies of the items indicating the use of technology are quite low representing almost never. Thus, it can be claimed that observing a nonsignificant association is quite meaningful.

5.1.2.2 Teacher level factors

The results of the hierarchical linear modeling display that none of the teacher level factors are significantly related to a student level slope indicating that there is no cross-level interaction.

When the teacher level factors are considered it is observed that only four of them are significantly related to problem solving skills of the sixth grade students. These teacher level factors are, *average self concept* (ASCONCEPT), *average socioeconomic status* (ASES), *teacher gender* (TGENDER), and teachers' *perceptions about limitations aroused from students* (LIMSTU).

There is a significant and positive association between *average self concept* (ASCONCEPT) in mathematics and problem solving skills of the students. This positive and strong association is also an expected one when the results of the related studies inestigating the relationship between self concept and achievement (Byrne, 1984; Chiu & Klassen; 2009; Dermitzaki, Leondari, & Goudas, 2009; Eklöf, 2007; Wilkins, 2004) are examined.

Similarly, the *average socioeconomic status* (ASES) variable is significantly and positively associated to the problem solving skills. This positive and strong association is also an expected one when the results of the related studies investigating the relationship between socioeconomic status and achievement (Crane, 1996; Demir, Kılıç, & Depren, 2009; İş Güzel, 2006; O'Conner & Miranda, 2002; Okpala, Smith, Jones, & Ellis, 2000; Reynolds & Conaway, 2003; Yang, 2003).

The factor of *teacher gender* (TGENDER) is significantly and negatively associated with the problem solving skills. It means that the students of female mathematics teachers get better grades in the problem solving skills test. This result is both consistent and inconsistent with the results of Akyüz (2006) who find that in Turkey and Czech Republic the students of male mathematics teachers get better grades in mathematics whereas in Hungary and the Netherlands the students of female mathematics teachers get better grades in mathematics. This result should be investigated whether this significant difference is caused by gender specific behaviors of the teachers or whether is caused by the quality of interaction between the students and the teacher or something else. The detailed explanations may be helpful for the teachers being aware of how their gender affects their students' performance or achievement. The other major characteristics of the teachers such as *teacher age* (TAGE) and *teacher experience* (TEXPER) in teaching are found not to be significantly related to the problem solving skills of the students. Although, in literature it is frequently mentioned that teaching experience is assumed to be one of the indicative factors in evaluating teachers' competence (Darling-Hammond, 2000) such as more than five years of experience are more effective teachers (Greenwald, Hedges, & Laine, 1996), the relationship between teaching experience and effectiveness is not always significant (Darling-Hammond, 2000). For instance Akyüz (2006) reports that experience of mathematics teachers is positively related to mathematics achievement of students in Turkey and the Netherlands, whereas she finds a negative association in Slovak Republic and Slovenia. In this sense, it is probable that students of a beginning mathematics teacher may get higher scores on the problem solving skills test or students of an experienced teacher may get lower scores on the same test. One of the reasons for this nonsignificant relationship may be the interaction of teachers' experiences with other student, classroom or school level factors.

The final teacher level factor that is significantly and negatively related to problem solving skills is the *perceptions about limitations aroused from students* (LIMSTU). This means that as mathematics teachers think that uninterested and unsuccessful students, students with special needs, students with different academic abilities in the same classroom do not limit classroom instruction for mathematics, their students get lower scores in the problem solving skills test. Actually, in the related literature no study investigating the relationships between teachers' perceptions about limitations for mathematics instruction aroused from students and mathematics achievement or problem solving skills of the students has been encountered. However, Akyüz (2006) investigated the relationship between teachers' conceptions about all limitations related with physical conditions, students, staff, resources and behaviors of parents and mathematics achievement. She reported a negative relationship in Belgium (Flemish), Italy, Slovenia, and the Netherlands. But she did not find a significant relationship for Turkey dataset. One of the reasons for this negative relationship may be that when teachers think that uninterested and unsuccessful students, students with special needs, students with different academic abilities in the same classroom do not limit the mathematics instruction, they do not consider individual differences of the students while selecting and carrying out the classroom practices. Thus, in the classroom each student can not benefit from the instruction equally and this decreases the general classroom performance. Considering this explanation, it is quite reasonable to observe a negative relationship between such perceptions and problem solving skills of the students. Based on this finding of the present study it can be suggested that how these perceptions affect teaching practices and indirectly affect the problem solving skills of the students should be investigated in the further studies. Although, a significant and negative association is observed between *perceptions about limitations aroused from students* (LIMSTU) and problem solving skills, no significant relationship is observed between *perceptions about physical limitations* (PHYLIM) and problem solving skills. As mathematics teachers think shortage of mathematics equipment, computer software and crowded classes limit mathematics instruction to a great extent, the scores of their students neither increases not decreases in the problem solving skills test. In fact this is also an expected result for the current study. Since developing problem solving skills does not depend too much on the use of mathematical equipments or computer software, it is likely not to observe such a significant relationship. Actually, when the descriptive statistics is analyzed it is observed that most of the participant teachers agree that such physical shortages do not limit mathematics instruction. Moreover, this result may point out that mathematics teachers rarely use mathematical equipments and computer software.

On the other hand, perceptions of mathematics teachers such as *perceptions about being successful in mathematics* (PERSUCC), and *perceptions about mathematics* (PERMATH) are found not to be significantly related to problem solving skills of the students. In fact, based on the literature it is expected that mathematics teachers' perceptions about being successful in mathematics reflecting process oriented point of view (Akyüz, 2006) is significantly and positively related to problem solving skills of the students. It is anticipated that mathematics teachers who think that for being successful in mathematics it is important to provide reasons to support the solutions, to understand how mathematics is used in the real world, or to think creatively, use classroom practices encouraging their students to think creatively, to explain their own ideas for supporting solutions and frequently give real-world examples for the use of mathematical ideas. In this sense, such classroom environment conducive to developing of problem solving skills of the students is helpful in increasing the performances of the students in the problem solving domain. However, in the current study no evidence can be obtained to confirm this positive association. One of the reasons may be inconstant responses of the mathematics teachers as Akyüz (2006) who also finds nonsignificant relationship between conceptions of mathematics teachers and mathematics achievement proposed for her study. Another reason may be that although the teachers think that it is important to think creatively or to understand how mathematics is used in the real world, they may not reflect these conceptions to their teaching practices in the classroom. Thus, no association can be constructed between these conceptions and performance of the students. This is also reported in the related literature that teachers' beliefs are not always consistent with their teaching practices (Fang, 1996; Raymond, 1997). Similarly, based on the literature it is expected that mathematics teachers' perceptions about mathematics reflecting discipline oriented point of view (Akyüz, 2006) is significantly and negatively associated with problem solving skills of the students. It is likely that mathematics teachers who believe that mathematics should be learned as sets of algorithms or rules, basic computational skills are sufficient for teaching elementary mathematics, and mathematics is an abstract subject indicating it is not a formal way of addressing real situations frequently emphazise drill and practice in the classroom and do not encourage their students to give real life examples or to think creatively. Thus, it is likely that such a classroom environment does not help students to develop their problem solving skills. Nevertheless, the present study provides no evidence for confirming this negative relationship. Similar to the previous explanation, one of the reasons for this nonsignificant relationship may be inconstant responses of the mathematics teachers. When the responses of the participant teachers are examined it is observed that some teachers agree with some ideas reflecting two different points of view such as "being able to provide reasons to support solutions is important for being successful in mathematics" and "mathematics should be learned as sets of algorithms or rules."

Finally, *personal teaching efficacy* (PEREFFI) and *outcome expectancy* (OUTCOME) of the mathematics teachers are found not to be significantly related to problem solving skills. It seems that personal teaching efficacy representing a teacher's belief that she or he has the skills to bring about student learning in mathematics and general teaching efficacy representing a teacher's belief that any teacher's ability to bring about change is limited by external factors such as home environment, family background, and parental influence are not significantly associated with problem solving skills. In fact, when the related literature is considered a positive and significant relationship is expected between teaching efficacy measures and problem solving skills. In literature a strong link existing between teacher self-efficacy and improved student achievement is reported (Dembo & Gibson, 1985; Tschannen-Moran & Hoy, 2001). Nevertheless, in the present study no evidence can be obtained to confirm the findings of the related literature. One of the reasons for this unexpected nonsignificant result may be the unreliable responses of mathematics teachers. It is observed that the participant teachers have quite high teaching efficacy beliefs; however how their teaching beliefs affect their teaching practices in mathematics classroom and how these beliefs indirectly affect students' problem solving skills should be investigated in the further studies.

5.2 Conclusions

There are two major aims in the present study. The first aim is to display the problem solving skills of the sixth grade Turkish students measured within the four-process problem solving framework. The second one is to test a model to investigate the relationships between student and teacher characteristics and the problem solving skills of the students by using hierarchical linear modeling considering the proposed model presented in Figure 1.1. Based on the results of the analyses conducted for answering the related research problems the following conclusions can be drawn;

1. In general, the sixth grade students display low performance in the overall problem solving skills test constructed based on the four-process problem solving framework.

2. The students display significantly different performances across the four processes of the problem solving framework. They perform best in the process of understanding problem whereas they show the worst performance in the process of looking back and evaluating.

3. The students level factors significantly related to the problem solving skills of the sixth grade students are *socioeconomic status*, *mathematics self concept*, *mathematics anxiety*, *extrinsic motivation*, *use of control strategies*, *preference for competitive learning situation*, *teacher support*, *giving homework*, *activities related with homework*, and *different types of homework.*

4. The *teacher support* slope is the only slope that is significantly related to problem solving skills of the students and randomly varying across teachers. In other words, this factor affects problem solving skills of the students more in some teacher's classes than it does in other teachers' classes. Moreover, this factor is found to be significantly and positively associated with problem solving skills. That is, students who report that their mathematics teachers help them when they need help, repeat what they told until they understand, make an effort for their learning, and give them opportunity to explain their ideas more frequently, tend to perform better in the problem solving skills test.

5. The *socioeconomic status* is found to be significantly and positively related to problem solving skills of the sixth grade students. Students whose parents' education level is high, who have computer, dishwasher,

and many books at home, and have less number of siblings and take mathematics course out of school time tend to show better performances in the problem solving skills test.

6. The *mathematics self concept* is significantly and positively associated to problem solving skills of the students. As students have higher levels of mathematics self concept representing the belief that they are good at mathematics, they perform better in the problem solving skills test.

7. The *mathematics anxiety* is found to be significantly and negatively related to problem solving skills of the students. As students have higher levels of mathematics anxiety representing the belief that they are helpless and nervous when they are doing mathematics problems, mathematics homework, and they worry about getting poor marks in mathematics, they tend to get lower scores in the problem solving skills test.

8. The *extrinsic motivation* is found to be significantly and positively related to problem solving skills of the students. As student more strongly believe that learning mathematics is important for improving career and getting job, they tend to perform better in the problem solving skills test.

9. The *use of control strategies* is found to be significantly and positively related to problem solving skills of the students. The students who use control strategies referring strategies through which they can plan, monitor, and regulate their learning more frequently tend to display better performances in the problem solving skills test.

10. The *preference for competitive learning situations* is found to be significantly and positively related to problem solving skills of the students. The students who try to do better than the others or liking to be

the best in mathematics tend to get better scores in the problem solving skills test.

11. The all homework related factors such as *giving homework*, *activities related with homework*, and *different types of homework* are found to be significantly and negatively related to problem solving skills of the students. As the students are given more homework, as their mathematics teachers conduct activities related to homework and give different types of homework, the students tend to get lower scores in the problem solving skills test.

12. The students level factors those not significantly related to the problem solving skills of the sixth grade students are *use of projects, daily life examples and problems*, *use of technology*, *preference for cooperative learning situation*, *use of elaboration strategies*, and *intrinsic motivation*.

13. No significant relationship is observed between student level slopes and teacher level factors. It means that there is no student level factor of which magnitude of relationship between problem solving skills differs depending on any teacher level factor.

14. The teacher level factors significantly related to the problem solving skills of the sixth grade students are *average mathematics self concept*, *average socioeconomic status*, *teacher gender*, and *perceptions about limitations aroused from students*.

15. The *average mathematics self concept* is strongly and positively correlated to mean problem solving scores of the classess instructed by different mathematics teachers.

16. The *average socioeconomic status* is strongly and posivitley correlated to mean problem solving scores of the classess instructed by different mathematics teachers.

17. The *teacher gender* is significantly associated with the problem solving skills referring that the students of female mathematics teachers get better grades in the problem solving skills test.

18. The teacher level factor, *perceptions about limitations aroused from students* is significantly and negatively related to problem solving skills. As mathematics teachers think that uninterested and unsuccessful students, students with special needs, students with different academic abilities in the same classroom do not limit classroom instruction for mathematics, their students get lower scores in the problem solving skills test.

19. The teacher level factors those not significantly related to the problem solving skills of the sixth grade students are *teacher age*, *teacher experience*, *personal teaching efficacy*, *outcome expectancy*, *perceptions about being successful in mathematics*, *perceptions about mathematics*, and *perceptions about physical limitations*.

5.3 Implications

Considering the results and conclusions of the study as well as the related literature following implications are recommended;

1. Since higher levels of problem solving skills provide students important opportunities and possibilities for future success in their careers and personal lives, the mathematics teachers should be aware of their students' performances in problem solving.

2. The students should be frequently exposed to different types of problems in the classroom environment integrating recently learned mathematical ideas into the problems. In the problem solving procedure each process but especially the process of looking back and evaluating should be specifically emphasized to increase students' skills in some activities such as verifying the solution of the problem, evaluating whether the problem can be solvable or not with the given elements or evaluating the reasonability of the solution. Although there are different processes of the problem solving framework, in fact this overall procedure is a whole in itself. Therefore, the mathematics teachers should explicitly reveal the transitions among the processes of the problem solving procedure to make students gain a holistic problem solving approach. Actually, this is not an easy task for mathematics teachers to achieve; therefore they should be supported by rich additional materials and sources to be used in the mathematics classroom.

3. Mathematics teachers should never forget that helping their students when they need help, making an extra effort for their learning or giving opportunity to explain their ideas in the mathematics classrooms are affirmative and important behaviors for constructing rapport with students. Probably this rapport causes students studying harder that leads to an increasing performance.

4. The mathematics teachers should be aware that students coming from families with lower socioeconomic status are disadvantaged with respect to family support for their additional studies at home or educational resourses provided to increase their academic performance. On account of this, teachers should identify such students and provide additional effort and materials to compensate their handicap for development of problem solving skills.

5. As it is the case in other subjects, affetive domain variables are also important in the development of problem solving skills of the students. Therefore, mathematics teachers and as well as the parents should be aware of the level the students have with regard to mathematics self concept and mathematics anxiety. They should make effort to increase the mathematics self concept positively and decrease the mathematics anxiety. It is unlikely that each example or exam is at the same difficulty level for all students. The samples of problems given always easy or always difficult may cause some students maintain negative feelings with regard to their own performances in due course. One of the solutions may be exposing the students to appropriate samples of problems beginning from the easiest to the hardest ones by considering the individual differences and the cognitive level of the students. Moreover, teachers and the parents may be informed and also trained with respect to handling such students and their negative feelings to increase the problem solving skills in a desired manner.

6. It is apparent that the students are affected by the common views of the society regarding the importance of mathematics and the crucial role of being successful at mathematics for finding job and improving their future careers. This effect may probably trigger the motivation of the students and in this way it may lead them to work harder in mathematics and achive. Both mathematics teachers and parents should be aware of the effect of this type of motivation on the students and help students to internalize and use this motivation in a positive manner for the development of their problem solving skills.

7. It is important for students to be aware of themselves with regard to how they can learn and study best in mathematics. Especially, the use of control strategies such as through which students can plan, monitor, and regulate

their learning in mathematics may be helpful for developing useful approaches to solve problems on their own. In this sense, mathematics teachers should inform students about effective learning strategies as they can use and make them aware which strategy is most appropriate for their learning mathematics in the way for developing problem solving skills.

8. Although it is known that competitive learning situation may impede the development of social and collaborative skills such as communicating, sharing ideas, or working with peers, it is likely that competitive learning situation in mathematics motivates students to keep up and encourages them to set goal for learning and in this way they increase their problem solving skills. Being aware of the disadvantages of the competitive learning situation, it is suggested that mathematics teachers create such situations in mathematics classess to trigger students' motivation in the way for developing problem solving skills.

9. Too many homeworks with higher difficulty levels or same types of homework only including drill and practice may cause students exhaust and bother. This may lead up to lower performances in the problem solving. Therefore, the mathematics teachers should carefully take into consideration the amount, quality, and level of the mathematics homework assign to their students.

10. The mathematics teachers should be aware that it is very natural there are students with different cognitive abilities or attitudes in a classroom. Unfortunately, this may create some limitations for mathematics instruction. Although it is quite hard for teachers to design their lessons by considering the all individual differences of their students, they should seek ways to cope with this limitation to some extend. For instance, identifying each student' cognitive levels and abilities in mathematics and

attitudes towards mathematics may be very helpful in integrating these differences into the instruction or the classroom practices. In this sense, each student may benefit from the instruction at optimum possible level on his/her behalf.

11. Although the teaching experience is one of the indicators of mathematics teacher competence, experience may not be directly related to students' problem solving skills. In this sense, the years of experience in teaching mathematics should not be set as a criterion for selecting teachers for inservice training programs designed for increasing students' problem solving skills.

12. At the same time, all of these conclusions should also be considered in terms of educational policies of the government. For instance, the definition of the problem and the problem solving and the steps in the problem solving process should be highly stressed in the mathematics curriculum with concrete examples. In-service training workshops or seminars focusing on increasing students' problem solving skills and the use of mathematics homework at the elementary level should be organized.

5.4 Limitations of the study

Probably the most important limitation of the many social science research studies is the self-reported questionnaires used for measuring especially affective domain constructs. Although some procedures are consucted to verify the reliability and validity of such self-reported questionnaires, relying on the responses of the participants are inevitable to some extent. Hereby, trusting on the responses of both students and teachers and as well as the constructs obtained from the questionnaires is one of the weaknesses of the current study.

The second limitation relates to the statistical analysis which is hierarchical linear modeling technique used in the current study. The results of this analysis are interpreted as positive or negative relationships between the student and teacher level factors and the problem solving skills without proposing cause and effect condition. Therefore, the information obtained in the study does not contain which school or teacher level factors directly affect the problem solving skills of the students.

The third limitation is related to the instrument used to measure problem solving skills of the students. Although the framework and the items are constructed based on the review of related literature, some of the item formats contain some unfamiliar parts the students have not encountered in their course or exercise books. For instance, some of the items ask students not to solve the problem but identify the the missing element to be able to solve the problem or select the appropriate statement explaining why the given solution is not reasonable. Although this has the advantage of being a *real problem* for them because they have firstly encountered, it also has the disadvantage that the unfamiliar format of the item may hinder students to use their actual problem solving skills. The researcher tries to overcome this disadvantage to some extent by warning students to read each item carefully and pay attention to what is asked in the items at the beginning of administration in all of the classrooms.

The next limitation concerns with the high missing response percentages of free response items. Excluding these items poses a threat for the validity of the problem solving skills test to some extent. This validity problem should be considered while assessing the interpretations made based on the results. Although, which skills the items were measuring was verified by expert opinions, no empirical evidence for the scores of the sub-domains of the problem solving skills test can be found.

The final limitation is related to empirical evidence obtained from the student questionnaire. As it was previously mentioned the items of learning strategy scale were taken from Turkish version of PISA 2003 Student

Questionnaire. These items obtain information from students about their strategies used for learning mathematics such as; memorization, control, and elaboration strategies. However, the results of the factor analysis revealed only the control and elaboration strategies constructs. Then the construct of memorization strategy could not be empirically verified for the students participated in the current study. Therefore, the relationship between the use memorization strategy and the problem solving skills of the students could not be investigated.

5.5 Suggestions for further research

1. As the results of the statistical analysis were interpreted with respect to positive or negative relationships between student and teacher related factors and problem solving skills of the students, further experimental studies should be conducted to investigate whether cause and effect relationships can be found between these student and teacher level factors and problem solving skills of the students.

2. Some of the student level factors such as *use of projects, daily life examples and problems*, *use of technology*, *preference for cooperative learning situation*, *use of elaboration strategies*, and *intrinsic motivation* are found not to be associated with problem solving skills of the student. Some of the factors such as *intrinsic motivation* or *use of projects, daily life examples and the problems* especially those which are expected to be correlated with problem solving skills should be investigated to understand in which conditions and to what extent these factors are related to problem solving skills of the students.

3. As previously mentioned, the construct of memorization strategy could not be verified by providing empirical evidence. Therefore the relationship between the construct of memorization strategy and problem solving skills

could not be investigated through hierarchical linear modeling, although this was supposed to be an important relationship to be investigated. In this sense, this relationship should be investigated by using different reliable and valid scales to measure the use of memorization strategy.

4. One of the most striking results was the negative relationship between homework related factors and problem solving skills of the students. This result merits further investigation to identify optimum amount of homework, the quality and type of homework, and appropriate homework related activities for developing sixth grade students' problem solving skills.

5. Similar to student level factors, some of the teacher level factors such as *personal teaching efficacy*, *outcome expectancy*, *perceptions about being successful in mathematics*, *perceptions about mathematics*, and *perceptions about physical limitations* are found not to be associated with problem solving skills. In literature it is indicated that perceptions of teachers seem to affect their behaviours and teaching practices in the classroom, and indirectly affect student performance. In this sense, more detailed studies should be conducted to investigate to when and to what extent these relationships between these perceptions of the mathematics teachers and problem solving skills can be constructed.

6. In the current study it was found that the gender of the mathematics teacher relates to problem solving skills of the students in favor of female teachers. However, this relationship should be investigated indepth with different types of methods such as classroom observations to explain the possible reasons why the students of male teachers perform lower in the problem solving skills test. Thus, more concrete implications can be proposed to make male teachers aware of their behaviors.

7. The results of hierarchical modeling indicated that there was no interaction between any school and teacher level factors. More detailed investigations should be conducted by using different research designs and by handling each variable one by one to examine when and to what extent an interaction can be identified between these two level factors when the outcome variable is problem solving skills.

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APPENDIX A

MODELS OF PROBLEM SOLVING PROCESSES

1. Problem solving processes proposed by Charles, Lester, and O'Daffer (1987);

1. **Understand / formulate the question in a problem**
   - Making sense of what is asked in the problem
   - Understanding the meaning of specific words
   - Recognizing how question relates to other statements in the problem
2. **Understand the conditions and variables in the problem**
   - Making sense about how the condition and variables relate to each other
   - Grasping meaning of the information given in the problem
   - Internalizing the problem.
3. **Select or find the data needed to solve the problem**
   - Identifying necessary data and eliminating unnecessary data
   - Collecting and using data from different sources such as graphs or tables
4. **Formulate subproblems and select appropriate solution strategies to pursue**
   - Planning of the solution strategy
   - Identifying the subproblems and subgoals to be solved if there is any
   - Deciding how to and when to use the identified strategy
5. **Correctly implement the solution strategy or strategies and solve subproblems**
   - Implementing the identified strategy or strategies
   - Performing computations, using logical reasoning, solving equations
   - Making a list or table, drawing a graph
6. **Give an answer in terms of the data in the problem**
   - Considering the characteristics of the variables and what is asked in the problem
   - Using the correct unit or expressing the answer in a complete sentence
7. **Evaluate the reasonableness of the answer**
   - Assessing whether the answer is reasonable or not
   - Checking the answer considering the conditions and variables

2. Problem solving processes proposed by Lester and Kroll (1990)

Lester and Kroll (1990) proposed the same seven steps those proposed by Charles, Lester, and O'Daffer (1987). Additionally, they added an eight step;

8. **Maintaining adequate control over the solution effort**
    - Monitoring one's thinking and actions
    - Knowing how to monitor one's behavior
    - Knowing what and when to monitor

3. Problem solving processes proposed by Teare (1980);

1. **Define the problem and devise a goal**
2. **Plan an attack by choosing a principle**
    - Planning how it will be used
    - Making simplifying assumptions
3. **Execute the plan**
4. **Check thoroughly**
5. **Look into the effect of assumptions**
    - Drawing conclusions
    - Seeing what has been learned that may be useful in other problems

4. Problem solving processes proposed by Dewey (as cited in Noddings, 1985);

1. **Identify a problematic situation**
2. **Define the problem**
3. **Engage in means-ends analysis; devising a plan**
4. **Execute; carry out the plan**
5. **Undergo or live through the consequence**
    - Describing problem solving in natural situations
    - Feeling something as a result of what we have done
6. **Evaluate**
    - Looking back to assess whether the result satisfies the initial conditions
    - Looking ahead to generalization of both methods and results

5. Problem solving processes proposed by Polya (1957);

1. **Understand the problem**
    - Trying to answer the questions; "What is the unknown?", "What are the data?", "What is the condition?", "Is it possible to satisfy the

condition?", "Is the condition sufficient to determine the unknown?", or "Is it insufficient?"

2. **Devise a plan**
   - Trying to answer the questions; Have you seen it before?", "Have you seen the same problem in a slightly different form?", "Do you know a related problem?", "Do you know a theorem that could be useful?"
3. **Carry out the plan**
   - Trying to answer the question; "Can you see clearly that the step is correct?"
4. **Look back**
   - Trying to answer the questions; "Can you check the result?", or "Can you check the argument?"

6. Problem solving processes proposed by Krulik and Rudnick (1989);

1. **Read the problem**
   - Noting key words
   - Describing the problem setting
   - Visualizing the action
   - Restating the problem in your own words
2. **Explore**
   - Organizing the information
   - Drawing a diagram or construct a model
   - Making a chart or a table
3. **Select a strategy**
   - Selecting one of the strategies from possible strategies such as; pattern recognition, working backwards, guess and test, simulation and experimentation, reduction/solve a simpler problem, organized listing/exhaustive listing, logical deduction, divide and conquer
4. **Solve**
   - Carrying out your strategy
   - Using computational skills, geometric skills, and algebraic skills
   - Using elementary logic
5. **Look back**
   - Checking the answer
   - Finding another way
   - Extending the conclusion

7. Problem solving processes proposed by Noddings (1985, p. 347);

1. **Translate words to mathematical expressions**
2. **Execute; that is calculate**
3. **Check results in initial equations**

8. Problem solving processes proposed by Noddings (1985, p. 349);

1. **Create a representation**
2. **Execute a plan based on the representation**
3. **Undergo the consequences**
4. **Evaluate the results**

Table A.1 Empty table given to experts

Framework Polya (1957)	**Researcher or Researchers**						
	Charles, Lester and O'Daffer (1987)	**Lester and Kroll (1990)**	**Teare (1980)**	**Dewey (as cited in Noddings, 1985)**	**Krulik and Rudnick (1989)**	**Noddings (1985, p. 349)**	**Noddings (1985, p. 347)**
UNDERSTANDING THE PROBLEM							
DEVISING A PLAN							
CARRYING OUT THE PLAN							
LOOKING BACK AND EVALUATING							

APPENDIX B

PROBLEM SOLVING PROCESSES AND CORRESPONDING OBJECTIVES

Table B.1. Cognitive dimension of table of specification

Problem Çözme Süreçleri	İlgili hedefler
1. Problemi anlama	a. Problem elemanları arasında ilişki kurar. b. Eksik bilgi ile verilmiş bir veride çözüm için gerekli olanı bulur/seçer/ayırt eder. c. Problemde sorulan soruyla aynı anlama gelen soruyu seçer/ayırt eder. d. Kullanılmayacak verilerle birlikte verilen bir bilgi bütününde çözüm için gerekli olanı seçer/ayırt eder. e. Problemde sorulan soruyu seçer/ayırt eder. f. Problemde sorulan soruyu kendi cümleleriyle ifade eder/yazar. g. Problemi anlamada önemli olan anahtar ifadenin anlamını seçer/ayırt eder. h. Problemi çözmek için gerekli olan veriyi seçer/ayırt eder.
2. Plan geliştirme	a. Problemin çözüm adımlarını sıralar. b. Uygun çözüm stratejisini seçer/ayırt eder. c. Uygun çözüm stratejisini oluşturur. d. Problemin çözümüne yardımcı olabilecek sorular yazar, yazılmış soruları seçer/ayırt eder.
3. Planı uygulama	a. Problemde verilen veriye uygun durumu/cevabı seçer/ayırt eder. b. Problemi çözer. c. Problemin çözümünün sayısal kısmı verildiğinde cevabı tam cümle kurarak yazar. d. Problemi çözmeye yardımcı olacak şekli çizer.
4. Çözümü 226ontrol etme/değerlendirme	a. Problemin çözümünü doğrulamak için kanıt gösterir. b. Çözümün mantıklı olup/olmadığını belirten ifadeyi seçer. c. Verileri değerlendirerek problemin çözülebilirliğinine karar verir. d. Çözümün mantıklı olup/olmadığını kanıt göstererek ifade eder.

APPENDIX C

CONTENT DIMENSION

Table C.1 Content dimension of table of specification

Öğrenme alanı	Alt öğrenme alanı	Konu başlığı	Kazanımlar
Geometri	Doğru, doğru parçası ve ışın	Doğrunun yolculuğu	1. Doğru ile nokta arasındaki ilişkiyi açıklar. 2. Doğru parçası ile ışını açıklar ve sembolle gösterir. 3. Bir doğru parçasına eş bir doğru parçası inşa eder. 4. Aynı düzlemdeki iki doğrunun birbirlerine göre durumlarını belirler ve sembolle gösterir. 5. Uzayda bir doğru ile bir düzlemin ilişkisini belirler.
Sayılar	Doğal sayılar	Toplama ve çarpma işlemlerinin özelliği	1. Doğal sayılarla işlemler yapmayı gerektiren problemleri çözer ve kurar. 2. Doğal sayılar kümesinde toplama ve çarpma işlemlerinin özelliklerini uygular.
Sayılar	Kümeler	Kümeler	1. Bir kümeyi modelleri ile belirler, farklı temsil biçimleri ile gösterir. 2. Kümelerle birleşim, kesişim, fark ve tümleme işlemlerini yapar ve bu işlemleri problem çözmede kullanır. 3. Bir kümenin alt kümelerini belirler.
Olasılık ve istatistik	Araştırmalar için sorular oluşturma ve veri toplama	Araştırmalar için ilk adım	1. Bir sorunla ilgili araştırma soruları üretir, uygun örneklem seçer ve veri toplar.
	Tablo ve grafikler		1. Verileri uygun istatistiksel temsil biçimleri ile gösterir ve yorumlar. 2. Sütun grafiklerinin hangi durumlarda yanlış yorumlara yol açabileceğini açıklar.
	Merkezi eğilim ve yayılma ölçüleri		1. Verilerin aritmetik ortalamasını ve açıklığını hesaplayarak yorumlar. 2. Verilere dayalı olarak tahminler yürütür.

APPENDIX D

TEMPLATE GIVEN TO THE EXPERTS

Table D.1 Template given to experts

Sorunun ismi	
Soru "sonuca ulaşmak için matematiksel içeriğin, uygulamanın ve süreçlerin kullanımını gerektiren durum ya da ifadelere problem denir" tanımına uygun bir problem durumu içermekte midir?	a. Evet b. Hayır
Verilen problem durumu aşağıdaki özellikleri içermekte midir? 1. Problem gerçek hayatla ilgili, öğrencinin ilgisini çekebilecek ve onu zorlayabilecek durumları içermelidir.	a. Evet b. Hayır
2. Problem öğrencilerin matematiksel durumlarına uygun olarak somut bir şekilde sunulmuştur.	a. Evet b. Hayır
Sorunun içerdiği durum ya da olay 6. sınıf öğrencisinin karşılaşabileceği bir durum mudur?	a. Evet b. Hayır
Problem çözme adımı	
İlgili davranış	
Sorunun matematik içeriği	
Sorunun içeriği 6. sınıf öğrencisinin bilişsel gelişim düzeyine uygun mu? (Zorluk ya da kolaylık açısından değerlendirin lütfen)	a. Uygun b. Uygun değil c. Değiştirilirse uygun olabilir (Lütfen belirtiniz)
Sorunun formatı 6. sınıf öğrencinin bilişsel gelişim düzeyine uygun mu? (soruluş biçimi, sorunun açık uçlu ya da çoktan seçmeli olması)	a. Uygun b. Uygun değil
Soru 6. sınıf öğrencisi için açık ve anlaşılır mı?	a. Evet b. Hayır (Hangi yönden? Lütfen belirtiniz)
Sorunun tek doğru cevabı mı var?	a. Evet b. Hayır
Soruyla ilgili belitrmek istediğiniz bir görüş var mı? Varsa lütfen belirtiniz	

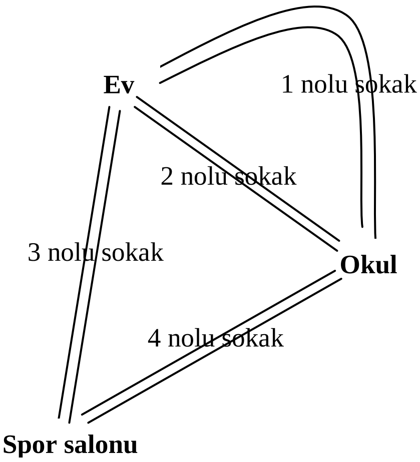
APPENDIX E

PROBLEM SOLVING SKILLS TEST

Soru 1 (Ela)

Ela bir an önce evden okula gitmek istiyor ve bunun için 2 nolu sokağı seçiyor. Ela'nın bu seçimi aşağıdaki matematiksel ifadelerden hangisi ile açıklanır?

a) Bir noktadan istenilen sayıda doğru geçer.
b) Noktalar bir araya gelerek doğruyu oluşturur.
c) İki nokta arasındaki en kısa mesafe doğrudur.
d) Doğrudaş olmayan üç noktadan üç doğru geçer.



Soru 2 (Dergi)

Sınıf arkadaşlarınızla beraber çıkardığınız dergi için okulda en çok sevilen spor türünü belirlemek istiyorsunuz. Bunun için okulunuzda okuyan öğrencilere en çok sevdikleri spor türünü sorarak veri toplamaya çalışıyorsunuz. Aşağıdakilerden hangisi veri toplamak için **en uygun yöntem** olur?

a) Basketbol klübündeki öğrencilere sorarsınız.
b) Öğlen saatinde kantinde yemek yiyen öğrencilere sorarsınız.
c) Tenis kursuna giden öğrencilere sorarsınız.
d) En yakın iki ya da üç arkadaşınıza sorarsınız.

Soru 3 (Hesap makinesi)

Aşağıda verilen problemin çözümünde kullanılacak matematiksel ifadede boş bırakılan yerleri uygun sayılar kullanarak tamamlayın.

Öğretmeniniz hesap makinesi kullanarak yapmanızı istediği 36 x 17 çarpma işlemini yaparken hesap makinenizin 7 rakamının bulunduğu tuşun çalışmadığını görüyorsunuz. Bu işlemi yine hesap makinesi kullanarak nasıl yaparsınız?

Problemin çözümü: _________ x (_______ + ________)

Soru 4 (Halı)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Verilen problemi çözebilmek için aşağıdaki bilgilerden hangisi gereklidir?

Odanızın tümünü metrekaresi 10 YTL olan halı ile kaplanmasını istiyorsunuz. Bu parayı harçlıklarınızdan biriktirip ailenize ödemeyi düşünüyorsunuz. Eğer her hafta 20 YTL biriktirebilirseniz, ailenize bu parayı kaç ayda ödersiniz?

a) Odanızın şekli
b) Haftada aldığınız harçlık
c) Odanızın kaç metrekare olduğu
d) Haftalığınızdan ne kadar harcadığınız

Soru 5 (Canan)

Canan 24 sayılık bir dergiyi sipariş etmeyi planlamaktadır. İki dergi ile ilgili aşağıdaki ilanları okuyor.

Gençlik Dergisi	**Genç Haber**
24 Sayı İlk 4 sayı ÜCRETSİZ Kalanların her biri 3 YTL	24 Sayı İlk 6 sayı ÜCRETSİZ Kalanların her biri 3.5 YTL

24 sayılık en ucuz dergi hangisidir? Ne kadar daha ucuzdur? Cevabınızı açıklamalı olarak gösteriniz.

Soru 6 (Televizyon)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Aşağıda verilen ifadelerden hangisi problemde altı çizili ifadeyi **en iyi şekilde** tanımlamaktadır?

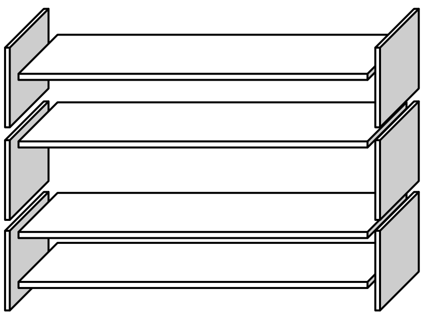
Aileniz size her hafta 35 saat televizyon izleme izni vermiştir. **Eğer haftasonu 20 saat televizyon izlerseniz** her bir hafta içi günde ortalama kaç saat televizyon izlersiniz?

a) Cumartesi günü 10 saat ve Pazar günü 10 saat televizyon izlerseniz.
b) Cumartesi günü toplam 20 saat ve Pazar günü toplam 20 saat televizyon izlerseniz.
c) Haftasonu en fazla 20 saat televizyon izlerseniz.
d) Cumartesi ve Pazar günü toplam 20 saat televizyon izlerseniz.

Soru 7 (Kitaplık)

Bir kitaplık yapmak için, bir marangoz aşağıdaki parçalara gereksinim duyar:

4 uzun tahta levha,
6 kısa tahta levha,
12 çivi,



Marangozun deposunda 26 uzun tahta levha, 33 kısa tahta levha ve 200 çivi vardır.
Bu marangoz kaç tane kitaplık yapabilir?

Cevabınızı buraya yazınız __________________

Soru 8 (Kaykay)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Verilen problemi çözmek için gerekli olan bilgi nedir?

Rüzgarsız havada, düz yolda kaykayla 20 birim hızla gidiyorsunuz. Gittiğiniz yönde esen rüzgar hızınızı daha da arttırmaktadır. Buna göre rüzgarlı havada kaykayla kaç birim hız yaparsınız?

Gerekli olan bilgiyi buraya yazınız

Soru 9 (Akdeniz)

Yaz tatilinde ailenizle beraber 4 günlük bir Akdeniz turuna çıkmak istiyorsunuz. Tur şirketi size turla ilgili bilgileri ve hergün kaç kilometre yol yapacağınızı gösteren grafiği içeren broşür veriyor. Grafiği incelerken 4. gün kaç kilometre yol yapılacağının eklenmediğini görüyorsunuz. İlk gün 150 km. gideceğinizi ve toplam turun 1000 km olduğunu bildiğinize göre grafikte 4. günün sütunu kaç birimi göstermelidir?

a) 5
b) 6
c) 7
d) 8

Soru 10 (Hız)

"Saatte 75 km hız yapan bir otobüs ile, bulunduğunuz A şehrinden B şehrine 8 saatte gidiyorsunuz. ..."

Yukarıdaki boş bırakılan yere aşağıdaki ifadelerden hangisi yazıldığında oluşan problemin çözümü **yapılamaz**?

a) Bu otobüs, saatte 100 km hızla gitseydi, B şehrine kaç saat erken varırdınız?
b) Bu otobüs 2 saat önce yola çıksaydı, B şehrine saat kaçta varırdınız?
c) A şehrinden hareket eden bir başka otobüs, B şehrinden 200 km ilerideki C şehrine 8 saatte giderse, saatteki hızı kaç km olur?
d) Bir başka otobüs, A şehrinden B şehrine saatte 60 km hızla kaç saatte gider?

Soru 11 (Petşişe)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Aşağıda verilen sorulardan hangisi **problemde sorulan soruyla aynı anlama** gelmektedir?

Siz ve arkadaşınız çevre temizliği için pet şişe topluyorsunuz. Siz, arkadaşınızdan 3 tane daha fazla pet şişe topladınız. İkinizin topladığı toplam pet şişe sayısı 21 olduğuna göre arkadaşınız kaç tane pet şişe toplamıştır?

a) Arkadaşınızın toplam kaç pet şişesi vardır?
b) Arkadaşınız kaç tane pet şişe eksik toplamıştır?
c) Siz, arkadaşınızdan kaç tane fazla pet şişe topladınız?
d) Arkadaşınızın, sizin topladığınız kadar pet şişe toplaması için kaç tane daha pet şişe toplaması gereklidir?

Soru 12 (Basketbol)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Problemi çözmek için izlenecek **en uygun yöntem** hangisidir?

Berk 10 yaşındadır. Kendisi ve kendisinden küçük iki kardeşi için basketbol maçına bilet alacaktır. Biletler için ne kadar para ödeyecektir?

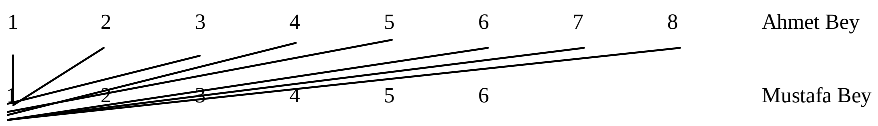
Biletler	
Yetişkin	6 YTL
12 yaşından küçük çocuklar	3 YTL

a) Şekil çizmek
b) Çıkarma yapmak
c) Çarpma yapmak
d) Bölme yapmak

Soru 13 (Çimbiçme)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Aşağıdaki çözümlerden hangisi verilen problemi doğru olarak çözmek için kullanılabilecek **en uygun yöntemdir**?

Ahmet Bey bahçesindeki çimleri biçerken komşusu Mustafa Bey'in de kendi bahçesindeki çimleri biçtiğini görüyor. Durup konuştuklarında, Ahmet Bey'in 8 günde bir, Mustafa Bey'in ise 6 günde bir çimleri biçtiğini öğreniyorlar. Buna göre Ahmet Bey ve Mustafa Bey kaç gün sonra ilk defa aynı anda çimleri biçerler?

a)


b) 6 + 8

c)

Ahmet Bey	8	16	24				
Mustafa Bey	6	12	18				

d)

		Ahmet							
M		1	2	3	4	5	6	7	8
u	1								
s	2								
t	3								
a	4								
f	5								
a	6								X

Soru 14 (Alp)

Aşağıda bir problem ve problem için bir cevap verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Aşağıda verilen ifadelerden hangisi problem için verilen cevabın **neden mantıklı olmadığını** en iyi şekilde açıklar?

Alp yeni bir bisiklet almak için harçlıklarından 7 ay boyunca para biriktirir. Yedinci ay sonunda 125 YTL para biriktirir. Alacağı bisiklet 95 YTL olduğuna göre bisikleti aldıktan sonra Alp'in elinde ne kadar para kalır?

Cevap: 220 YTL

a) Bisikletin fiyatı 95 YTL dir.
b) Eğer Alp'in 125 YTL si varsa, 95 YTL harcayacaktır.
c) Eğer Alp'in 125 YTL si varsa ve 95 YTL harcayacaksa, kalan miktar 125 YTL den az olmalıdır.
d) Eğer bisiklet 95 YTL ise, Alp bisiklet için gereken miktardan daha fazla para biriktirmiştir.

Soru 15 (Beden eğitimi)

Beden eğitimi öğretmeniniz sınıfınızdaki kız ve erkek öğrencilerin belirli bir mesafeyi ortalama olarak ne kadar sürede koştuğunu ve kız – erkek sayısını tablo haline getirmiştir. Buna göre bu tablo kullanılarak aşağıdaki sorulardan hangisine cevap **bulunamaz**?

KIZ		ERKEK	
Kişi sayısı	**Ortalama koşma süresi (dk)**	**Kişi sayısı**	**Ortalama koşma süresi (dk)**
15	8	20	6

a) Sınıfınızda toplam kaç öğrenci vardır?
b) Belirli mesafeyi koşmada sınıf ortalaması kaç dakikadır?
c) Belirli mesafeyi en hızlı ve en yavaş koşan arasında kaç dakika fark vardır?
d) Kızların ve erkeklerin ortalaması arasında kaç dakika fark vardır?

Yönerge: Soru 16, Soru 17 ve Soru 18 Telefon tarifeleri ile ilgilidir. Bu soruları cevaplamak Için Telefon tarifeleri ile ilgili verilen bilgileri kullanabilirsiniz.

İdil, Yiğit ve Didem yeni bir şehre taşınırlar. Her üçü de evlerine telefon hattı bağlatmak isterler ve bir telefon şirketinden iki farklı tarife öneren bilgiyi alırlar.

Her bir tarife için aylık sabit ücret ve konuştukları her dakika için farklı ücretler vardır. Bu ücretler konuşulan zamanın gündüz veya akşam olmasına göre ya da seçilen tarifeye göre değişmektedir. Her iki tarifenin de aylık ücretsiz konuşma süreleri vardır. İki tarifenin detayları aşağıdaki tabloda verilmiştir.

Tarife	**Aylık sabit ücret**	**Dakika başına ödenen ücret**		**Aylık ücretsiz konuşma süresi (dakika)**
		Gündüz (08:00 – 18:00)	**Gece (18:00 – 08:00)**	
A tarifesi	20 YTL	3 YTL	1 YTL	180 = 3 saat
B tarifesi	15 YTL	2 YTL	2 YTL	120 = 2 saat

Soru 16 (Telefon 1)

İdil her ay 2 saatten az konuşmaktadır. Hangi tarife onun için daha ucuz olacaktır?

Tarife _________

Cevabınızı aylık sabit ücrete ve aylık ücretsiz konuşma süresine göre açıklayın.

Soru 17 (Telefon 2)

Yiğit bir ayda geceleri 5 saat konuşmaktadır. Her iki tarife için ne kadar ücret ödeyecektir? Yaptığınız işlemleri gösterin.

Tarife A'ya ödeyeceği aylık ücret: ______________________________ YTL

Tarife B'ye ödeyeceği aylık ücret: ______________________________ YTL

Soru 18 (Telefon 3)

Didem Tarife B'yi seçmiştir ve aylık ödediği para 75 YTL dir. Didem 75 YTL ödediği ay kaç dakika konuşmuştur?

Yaptığınız işlemleri gösterin.

Konuşulan dakika ____________

Soru 19 (Dans)

Aşağıda bir problem verilmiştir. Sizden problemi çözmeniz **istenmemektedir**. Problemi çözmek için **ilk olarak bulunması gereken en uygun şey** nedir?

Dans gösterisi sergilenecek olan salonda ön koltukların her biri 8 YTL ve arka koltukların her biri 5 YTL dir. Derya 3 adet ön koltuk ve 6 adet arka koltuk ayırtmıştır. Derya'nın biletler için ne kadar para vermesi gereklidir?

a) Koltukların toplam sayısını bulmak
b) Ön koltukların biletlerinin toplam ücreti ve arka koltukların biletlerinin toplam ücretini bulmak
c) Biletlerin toplam ücretini bulmak
d) Biletlerin toplam sayısını bulmak ve biletlerin toplam ücretini bulmak

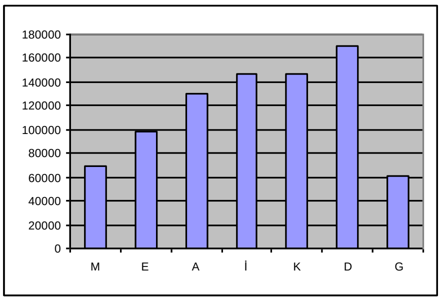
Soru 20 (Bölgeler)

Türkiye'nin coğrafi bölgelerini karşılaştırma dönem ödeviniz için ansiklopediden herbirinin yaklaşık yüzölçümünü tek tek çıkardınız ve aşağıdaki tabloyu oluşturdunuz.

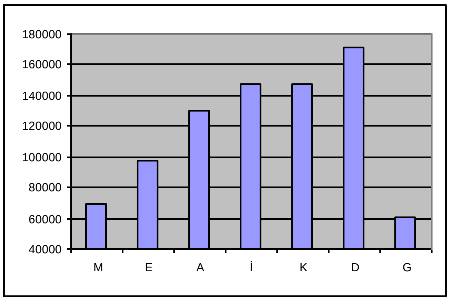
Bölgeler	**Tablodaki gösterimi**	**Yaklaşık Kilometrekare**
Marmara Bölgesi	M	69000
Ege Bölgesi	E	98000
Akdeniz Bölgesi	A	130000
İç Anadolu Bölgesi	İ	147000
Karadeniz Bölgesi	K	147000
Doğu Anadolu Bölgesi	D	171000
Güneydoğu Anadolu Bölgesi	G	61000

Bu tablodan yaralanarak verileri daha kolay yorumlamak için sütun grafiği çizmek istiyorsunuz. Verilerinizi kolay ve doğru yorumlayabilmek için hangi grafiği seçersiniz?

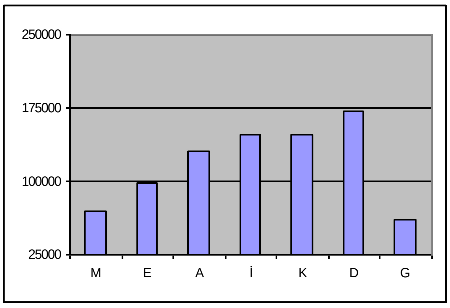
a)



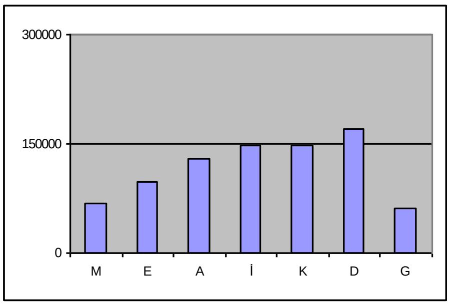
b)



c)



d)



APPENDIX F

SCORING GUIDES

Table F.1 Scoring guide 1

Sorunun ismi = Hesap makinesi	
Tam doğru cevap **Puan = 2**	36 x (a + b) a + b = 17 a ve b sayılarında "7" rakam kullanılmayacak
Kismi doğru cevap **Puan = 1**	36 x (a + b) a + b = 17 a ve b sayılarında "7" rakam kullanılmış
Yanlış cevap **Puan = 0**	Yanlış cevaplar (örneğin çizilmiş, silinmiş, okunaksız, anlamsız çiziktirmeler)
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

Table F.2 Scoring guide 2

Sorunun ismi = Canan	
Tam Doğru Cevap **Puan = 2**	Gençlik Dergisi. Her iki derginin hesaplamaları doğru (Gençlik Dergisi 60 YTL, Genç Haber 63 YTL) ve 3 YTL fark doğru
	Diğer doğru cevaplar (örneğin; Gençlik Dergisi. Bir derginin fiyatı doğru olarak hesaplanmış, diğeri gösterilmemiş ve fark 3 YTL)
Kısmi Doğru Cevap **Puan = 1**	Doğru hesaplama (60 ve 63 YTL), fakat yanlış dergi ismi verilmiş veya verilmemiş, veya aradaki fark verilmemiş
	Genç Haber için doğru hesaplama (63 YTL), fakat Gençlik Dergisi için yanlış hesaplama
	Gençlik Dergisi için doğru hesaplama (60 YTL), fakat Genç Haber için yanlış hesaplama
	Gençlik Dergisi, 3 YTL fark, hesaplamalar gösterilmemiş, fark özellikle belirtilecek –fark tek sayı arasındaki değil 24 sayı için olan fark olmalı
	Diğer kısmi doğru cevaplar (örneğin, doğru hesaplamalar fakat yanlış fark)
Yanlış Cevap **Puan = 0**	Yanlış cevaplar (örneğin, çizilmiş, silinmiş, okunaksız, anlamsız çiziktirmeler)
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

Table F.3 Scoring guide 3

Sorunun ismi = Kitaplık	
Doğru cevap **Puan = 1**	5
Yanlış cevap **Puan = 0**	Diğer cevaplar
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

Table F.4 Scoring guide 4

Sorunun ismi = Kaykay	
Doğru cevap **Puan = 1**	Rüzgarın hızı veya şiddeti, rüzgarın kaykayın hızını ne kadar arttırdığı ya da benzer cevaplar
Yanlış cevap **Puan = 0**	Diğer cevaplar (örneğin, hem saat hem rüzgar hızı, sizin ağırlığınız ve/veya kaykayın ağırlığı, hesaplamalar yapma)
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

Table F.5 Scoring guide 5

Sorunun ismi = Telefon 1	
Tam Doğru Cevap **Puan = 2**	Ücretsiz konuşma süresini ve Tarife B nin aylık sabit ücretinin daha düşük olduğunu belirten ifadeleri içeren Tarife B cevabı
Kısmi Doğru Cevap **Puan = 1**	Düşük aylık sabit ücreti içeren ve aylık ücretsiz konuşma süresini içermeyen Tarife B cevabı
Yanlış Cevap **Puan = 0**	Açıklama içermeyen veya yetersiz açıklama (sadece ücretsiz konuşma süresi) içeren Tarife B cevabı
	Açıklama içeren veya içermeyen Tarife A cevabı
	Yanlış cevaplar (örneğin, çizilmiş, silinmiş, okunaksız, anlamsız çiziktirmeler)
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

Table F.6 Scoring guide 6

Sorunun ismi = Telefon 2	
Tam Doğru Cevap **Puan = 2**	Tarife A = 140 YTL, Tarife B = 375 YTL ve hesaplamalar gösterilmiş
Kısmi Doğru Cevap **Puan = 1**	140 ve 375 YTL hesaplamalar gösterilmemiş
	Tarife A veya Tarife B için doğru cevap. Fakat sadece biri için hesaplamalar gösterilmiş
Yanlış Cevap **Puan = 0**	Yanlış cevaplar (örneğin, çizilmiş, silinmiş, okunaksız, anlamsız çiziktirmeler)
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

Table F.7 Scoring guide 7

Sorunun ismi = Telefon 3	
Tam Doğru Cevap **Puan = 2**	150 ve hesaplamalar gösterilmiş
Kısmi Doğru Cevap **Puan = 1**	150 ve hesaplamalar gösterilmemiş
	Doğru yöntem fakat hesaplama hatası yapılmış
	30 ve 30 cevabını veren hesaplamalar
Yanlış Cevap **Puan = 0**	Yanlış cevaplar (örneğin, çizilmiş, silinmiş, okunaksız, anlamsız çiziktirmeler)
Boş bırakılmış **Kod = 9**	Hiçbir şey yapılmamış

APPENDIX G

PROBLEM SOLVING PROCESSES, OBJECTIVES, AND CONTENT OF THE ITEMS

Table G.1 Problem solving process, objectives, and content of the items

Name of the item	Problem solving process	Related objective	Related content
Ela	Problemi anlama	Problem elemanları arasında ilişki kurar.	Doğru ve nokta
Dergi	Plan geliştirme	Uygun çözüm stratejisini seçer/ayırt eder.	Veri toplama
Hesap makinesi	Plan geliştirme	Uygun çözüm stratejisini oluşturur.	Toplama işleminin özellikleri
Halı	Problemi anlama	Eksik bilgi ile verilmiş bir veride çözüm için gerekli olanı seçer/ayırt eder.	Sayılar ile ilgili problemler
Canan	Çözümü kontrol etme/değerlendirme	Problemin çözümünü doğrulamak için kanıt gösterir.	Sayılar ile ilgili problemler
Televizyon	Problemi anlama	Problemi anlamada önemli olan anahtar ifadenin anlamını seçer/ayırt eder.	Sayılar ile ilgili problemler
Kitaplık	Planı uygulama	Problemi çözer.	Sayılar ile ilgili problemler
Kaykay	Problemi anlama	Eksik bilgi ile verilmiş bir veride çözüm için gerekli olanı bulur.	Sayılar ile ilgili problemler
Akdeniz	Planı uygulama	Problemi çözer.	Grafikler
Hız	Çözümü kontrol etme/değerlendirme	Verileri değerlendirerek problemin çözülebilirliğine karar verir.	Sayılar ile ilgili problemler
Petşişe	Problemi anlama	Problemde sorulan soruyla aynı anlama gelen soruyu seçer/ayırt eder.	Sayılar ile ilgili problemler
Basketbol	Plan geliştirme	Uygun çözüm stratejisini seçer/ayırt eder.	Sayılar ile ilgili problemler
Çimbiçme	Plan geliştirme	Uygun çözüm stratejisini seçer/ayırt eder.	Sayılar ile ilgili problemler
Alp	Çözümü kontrol etme/değerlendirme	Çözümün mantıklı olup/olmadığını belirten ifadeyi seçer/ayırt eder.	Sayılar ile ilgili problemler
Beden eğitimi	Çözümü kontrol etme/değerlendirme	Verileri değerlendirerek problemin çözülebilirliğine karar verir.	Sayılar ile ilgili problemler
Telefon 1	Çözümü kontrol etme/değerlendirme	Problemin çözümünü doğrulamak için kanıt gösterir.	Sayılar ile ilgili problemler
Telefon 2	Planı uygulama	Problemi çözer.	Sayılar ile ilgili problemler
Telefon 3	Planı uygulama	Problemi çözer.	Sayılar ile ilgili problemler
Dans	Plan geliştirme	Uygun çözüm stratejisini seçer/ayırt eder.	Sayılar ile ilgili problemler
Bölgeler	Planı uygulama	Problemde verilen veriye uygun durumu seçer/ayırt eder.	Grafikler

APPENDIX H

RESULTS OF THE PILOT STUDY

Table H.1 Results of the pilot study

Name of the item	Item difficulty	Item discrimination	Key	Format	Source
Ela	0.52	0.21	c	MC	Researcher
Dergi	0.54	0.28	b	MC	Researcher
Hesap makinesi	0.46	0.61	Scoring guide	FR	Researcher
Halı	0.56	0.32	c	MC	Researcher
Canan	0.44	0.46	Scoring guide	FR	Timss 1999
Televizyon	0.60	0.46	d	MC	Charles, Lester and O’Daffer (1987)
Kitaplık	0.40	0.60	Scoring guide	FR	PISA 2003
Kaykay	0.39	0.43	Scoring guide	FR	Charles, Lester and O’Daffer (1987)
Akdeniz	0.55	0.31	c	MC	Researcher
Hız	0.39	0.51	b	MC	National exam
Petşişe	0.60	0.40	a	MC	Charles, Lester and O’Daffer (1987)
Basketbol	0.60	0.40	c	MC	Charles, Lester and O’Daffer (1987)
Çimbiçme	0.44	0.33	c	MC	Charles, Lester and O’Daffer (1987)
Alp	0.45	0.44	c	MC	Charles, Lester and O’Daffer (1987)
Beden eğitimi	0.51	0.48	c	MC	Researcher
Telefon 1	0.34	0.44	Scoring guide	FR	Timss 2003
Telefon 2	0.36	0.32	Scoring guide	FR	Timss 2003
Telefon 3	0.33	0.31	scoring guide	FR	Timss 2003
Dans	0.57	0.44	b	MC	Charles, Lester and O’Daffer (1987)
Bölgeler	0.51	0.46	a	MC	Researcher

APPENDIX I

STUDENT QUESTIONNAIRE

I.1 Demographical Information Part

Genel Açıklamalar

Bu kitapçıkta kendiniz ile ilgili sorular bulacaksınız. Bazı sorular gerçekleri sorarken, diğer sorular sizin düşüncelerinizi sormaktadır. Her soruyu dikkatlice okuyunuz ve mümkün olduğunca doğru ve dikkatli bir şekilde cevap veriniz. Bir şeyi anlamadığınızda veya nasıl cevap verileceğinden emin olmadığınızda, yardım isteyebilirsiniz. Gerçek duygularınızı belirtmeniz ve mümkün olduğunca boş soru bırakmamanız çalışmanın sonuçları için büyük önem taşımaktadır. Cevaplarınız kesinlikle gizli tutulacaktır.

Katılımınız için teşekkür ederim. ODTÜ Eğitim Fakültesi Arş. Gör. Betül YAYAN

KİŞİSEL BİLGİLER

Açıklama : Bu bölümdeki soruları cevaplarken size uygun gelen seçeneği daire içine alınız.

1. **Cinsiyetiniz nedir?**
   A. Kız
   B. Erkek

2. **Babanızın eğitim düzeyi nedir?**
   A. İlkokul terk veya hiç okula gitmedi
   B. İlkokulu bitirdi
   C. Ortaokul terk
   D. Ortaokulu bitirdi
   E. Lise terk
   F. Liseyi bitirdi
   G. Liseden sonra bir süre teknik eğitim aldı
   H. Üniversite terk
   I. Üniversiteyi bitirdi
   J. Bilmiyorum

3. **Annenizin eğitim düzeyi nedir?**
   A. İlkokul terk veya hiç okula gitmedi
   B. İlkokulu bitirdi
   C. Ortaokul terk
   D. Ortaokulu bitirdi
   E. Lise terk
   F. Liseyi bitirdi
   G. Liseden sonra bir süre teknik eğitim aldı
   H. Üniversite terk
   I. Üniversiteyi bitirdi
   J. Bilmiyorum

4. **Siz hariç kaç kardeşiniz var? (sizden büyük ve sizden küçük olanlar dahil)**
   A. Kardeşim yok B. 1 C. 2 D. 3 E. 4 ve üstü

5. **Evinizde yaklaşık kaç adet kitap var? (dergileri, gazeteleri ve okul kitaplarınızı hesaba katmayın)**
   A. Hiç ve çok az (0-10 kitap)
   B. Bir rafı doldurmaya yetecek kadar (11-25 kitap)
   C. Bir kitaplığı doldurmaya yetecek kadar (26-100 kitap)
   D. İki kitaplığı doldurmaya yetecek kadar (101-201 kitap)
   E. Üç veya daha fazla kitaplığı doldurmaya yetecek kadar (200'den fazla)

6. **Evinizde aşağıdakilerden herhangi biri var mı?**

		EVET	HAYIR
A	Hesap makinesi	a	b
B	**Bilgisayar**	a	b
C	Size ait çalışma masası	a	b
D	**Sözlük**	a	b
E	Bulaşık makinesi	a	b

7. **Bu öğretim yılında okulda aldığınız matematik dersinin dışında ek olarak ne sıklıkla matematik dersi aldınız?**
   A. Hergün
   B. Haftada bir veya iki kez
   C. Bazen
   D. Hiç

I.2 Mathematics Homework Scale

MATEMATİK ÖDEVLERİ ÖLÇEĞİ

Açıklama: Bu ölçek için, lütfen sadece **Matematik ödevlerini** düşününüz. Belirtilen ifadelerin ne sıklıkla gerçekleştiğini ilgili seçeneği daire içine alarak belirtiniz.

1. **Matematik öğretmeniniz ne sıklıkla matematik ödevi veriyor?**
   A. Hiç
   B. Haftada bir kere
   C. Her ders saatinde

2. **Eğer matematik öğretmeniniz ev ödevi veriyorsa, verdiği ödevlerin yapılması yaklaşık olarak ne kadar sürmektedir?**
   A. 15 dakikadan az
   B. 15-30 dakika arası
   C. 31-60 dakika arası
   D. 61-90 dakika arası
   E. 90 dakikadan fazla

3. **Eğer matematik öğretmeniniz ev ödevi veriyorsa, hangi sıklıkta ne tür ödevler vermektedir?**

		Hiç	Ara sıra	Oldukça sık	Hemen her zaman
A	Çalışma kağıtlarındaki alıştırmaları yapma	a	b	c	d
B	**Alıştırma kitabındaki alıştırmaları yapma**	a	b	c	d
C	Ders kitabındaki problemleri/soruları yapma	a	b	c	d
D	**Ders kitabını veya yardımcı materyalleri okuma**	a	b	c	d
E	Tanımları yazma	a	b	c	d
F	**Küçük araştırma(lar) yapma veya veri toplama**	a	b	c	d

G	Uzun süreli projeler üzerinde bireysel çalışma	a	b	c	d
H	**Uzun süreli projeler üzerinde küçük bir grup halinde çalışma**	a	b	c	d
I	Çalışılan konunun günlük hayatta kullanımını bulma	a	b	c	d
J	**Bireysel ve küçük bir grup halinde sözlü raporlar hazırlama**	a	b	c	d
K	Matematik günlüğü tutma	a	b	c	d

4. Eğer matematik öğretmeniniz yazılı matematik ödevi veriyorsa, aşağıdakileri ne sıklıkla yapılmaktadır?

		Hiç	Ara sıra	Oldukça sık	Hemen her zaman
A	Öğretmenimiz ev ödevinin yapılıp yapılmadığını kontrol eder	a	b	c	d
B	**Öğretmenimiz ödevleri toplar, düzeltir ve saklar.**	a	b	c	d
C	Öğretmenimiz ödevleri toplar, düzeltir ve geri verir.	a	b	c	d
D	**Öğretmenimiz sınıfa ev ödevleriyle ilgili açıklayıcı bilgiler verir.**	a	b	c	d
E	Öğretmenimiz ödevlerimizi düzeltmemizi sağlar.	a	b	c	d
F	**Öğretmenimiz ödevlerimizi birbirimizle değiştirerek düzeltmemizi sağlar.**	a	b	c	d
G	Öğretmenimiz ev ödevleriyle ilgili sınıf tartışması yaptırır.	a	b	c	d
H	**Ev ödevlerinden aldığımız notlar ders notlarımızı etkiler.**	a	b	c	d

I.3 Mathematics Classroom Practices Scale

MATEMATİK SINIF ORTAMI ÖLÇEĞİ

Açıklama: Bu ölçek için, lütfen sadece **Matematik dersinizi** düşününüz. Belirtilen ifadelerin, dersinizde ne sıklıkla gerçekleştiğini ilgili seçeneği daire içine alarak belirtiniz.

		Hiç	Ara sıra	Oldukça sık	Hemen her zaman
1	Öğretmen bize problemleri nasıl yapacağımızı gösterir.	a	b	c	d
2	**Tahtaya yazılanları defterimize yazarız.**	a	b	c	d
3	Kısa sınav veya test oluruz.	a	b	c	d
4	**Projeler üzerinde çalışırız.**	a	b	c	d
5	Kendi başımıza ders kitapları veya çalışma kağıtları üstünde çalışırız.	a	b	c	d
6	**Hesap makinesi kullanırız.**	a	b	c	d
7	Bilgisayar kullanırız.	a	b	c	d
8	**Problemleri çözerken günlük yaşamdan olayları kullanırız.**	a	b	c	d
9	İki kişi veya küçük gruplar halinde birlikte çalışırız.	a	b	c	d
10	**Öğretmen bize ev ödevi verir.**	a	b	c	d
11	Ev ödevimizi yapmaya sınıfta başlayabiliriz.	a	b	c	d
12	**Öğretmen ev ödevini kontrol eder.**	a	b	c	d

13	Birbirimizin ev ödevini kontrol ederiz.	a	b	c	d
14	**Tamamlanmış ev ödevlerimizi tartışırız.**	a	b	c	d
15	Öğretmen tahtayı kullanır.	a	b	c	d
16	**Öğretmen tepegöz kullanır.**	a	b	c	d
17	Biz tahtayı kullanırız.	a	b	c	d
18	**Biz tepegözü kullanırız.**	a	b	c	d
19	Öğretmen gelen mesajlar, ziyaretçiler vb. nedeniyle ara vermek durumunda kalır.	a	b	c	d
20	**Öğretmen matematik konularını göstermek için bilgisayar kullanır.**	a	b	c	d
21	Yeni bir konuya öğretmenin kuralları ve tanımları açıklamasıyla başlarız.	a	b	c	d
22	**Yeni bir konuya günlük yaşam ile ilgili bir pratik veya öykülü problemi tartışarak başlarız.**	a	b	c	d
23	Yeni bir konuya başladığımızda bir problem veya proje üzerinde küçük gruplar halinde birlikte çalışırız.	a	b	c	d
24	**Yeni bir konuya öğretmenin yeni konu ile ilgili ne bildiğimizi sormasıyla başlarız.**	a	b	c	d
25	Yeni bir konuya başladığımızda öğretmen yeni konu hakkında konuşurken ders kitabına bakarız.	a	b	c	d
26	**Yeni bir konuya başladığımızda yeni konu ile ilgili bir örneği çözmeye çalışırız.**	a	b	c	d
27	Öğretmen, bizim öğrenmemiz için çaba gösterir.	a	b	c	d
28	**Öğretmen, ihtiyacımız olduğunda bize yardım eder.**	a	b	c	d
29	Öğretmen biz anlayana kadar anlattıklarını tekrar eder.	a	b	c	d
30	**Öğretmen bize düşüncelerimizi açıklama fırsatı verir.**	a	b	c	d

I.4 Mathematics Self Concept Scale

MATEMATİK ÖZBENLİK ALGISI ÖLÇEĞİ

Açıklama: Matematikle ilgili düşüncelerinizi göz önüne aldığınızda belirtilen ifadelere ne derece katıldığınızı ya da katılmadığınızı ilgili seçeneği daire içine alarak belirtiniz.

		Hiç katılmıyorum	**Katılmıyorum**	**Katılıyorum**	**Tümüyle katılıyorum**
1	Matematikte çok iyi değilim.	a	b	c	d
2	**Matematikten iyi not alırım.**	a	b	c	d
3	Matematikte en zor problemleri bile anlarım.	a	b	c	d
4	**Matematiği çabuk öğrenirim.**	a	b	c	d
5	Matematiğin en iyi olduğum derslerden biri olduğuna inanıyorum.	a	b	c	d
6	**Bu kadar zor olmasaydı matematikten daha çok hoşlanırdım.**	a	b	c	d
7	Her ne kadar ben, elimden geleni yapsam da, sınıf arkadaşlarımın bir çoğuna kıyasla, benim için matematik daha zor.	a	b	c	d
8	**Hiç kimse her konuda iyi olamaz ve ben matematikte yetenekli değilim.**	a	b	c	d

9	Bazen matematikte ilk başta yeni bir konuyu anlamadığımda, bunu gerçekten hiç anlamayacağımı düşünürüm.	a	b	c	d
10	**Matematik benim güçlü yanlarımdan biri değildir.**	a	b	c	d

I.5 Mathematics Learning Situation Scale

MATEMATİK ÖĞRENME ORTAMI ÖLÇEĞİ

Açıklama: Matematikle ilgili düşüncelerinizi göz önüne aldığınızda belirtilen ifadelere ne derece katıldığınızı ya da katılmadığınızı ilgili seçeneği daire içine alarak belirtiniz.

		Hiç katılmıyorum	**Katılmıyorum**	**Katılıyorum**	**Tümüyle katılıyorum**
1	Matematikte sınıfın en iyisi olmayı isterim.	a	b	c	d
2	**Sınavlarda en yüksek notu almak için çaba harcarım.**	a	b	c	d
3	En iyilerden biri olmak istediğim için çok çabalarım.	a	b	c	d
4	**Derste diğerlerinden daha iyi olmaya çalışırım.**	a	b	c	d
5	Diğerlerinden daha iyi yapmaya çalıştığımda daha başarılı olurum.	a	b	c	d
6	**Derste diğer öğrencilerle grup halinde çalışmaktan hoşlanırım.**	a	b	c	d
7	Derste bir proje üzerinde çalışırken gruptaki tüm öğrencilerin fikirlerini birleştirmesi daha iyi öğrenmemizi sağlar.	a	b	c	d
8	**Derste diğer öğrencilerle birlikte çalıştığım zaman daha başarılı olurum.**	a	b	c	d
9	Derste grup olarak iyi çalışabilmek için diğerlerine yardım etmekten hoşlanırım.	a	b	c	d
10	**Derste diğer öğrencilerle birlikte çalıştığım zaman daha iyi öğreniyorum.**	a	b	c	d

I.6 Mathematics Learning Strategy Scale

MATEMATİK ÖĞRENME STRATEJİLERİ ÖLÇEĞİ

Açıklama: "**Matematik çalışmanın farklı yolları vardır**" sözünü düşündüğünüzde belirtilen ifadelere ne derece katıldığınızı ya da katılmadığınızı ilgili seçeneği daire içine alarak belirtiniz.

		Hiç katılmıyorum	**Katılmıyorum**	**Katılıyorum**	**Tümüyle katılıyorum**
1	Bazı problemleri o kadar sık tekrarlarım ki kendimi sanki onları gözüm kapalı çözebilecekmişim gibi hissederim.	a	b	c	d

2	**Çalışırken ezbere öğrenmeye çalışırım.**	a	b	c	d
3	Bir sorunun çözümü için gerekli yöntemleri anımsamak amacıyla örnekleri tekrar tekrar gözden geçiririm.	a	b	c	d
4	**Matematik öğrenmek için bir yöntemin tüm aşamalarını aklımda tutmaya çalışırım.**	a	b	c	d
5	Problemleri çözerken, yanıtı bulmak için genellikle yeni yollar düşünürüm.	a	b	c	d
6	**Öğrendiklerimin günlük hayatta nasıl kullanılabileceğini düşünürüm.**	a	b	c	d
7	Yeni kavramları önceden öğrendiğim şeylerle ilişkilendirerek anlamaya çalışırım.	a	b	c	d
8	**Bir soruyu çözerken, sonucun diğer sorulara nasıl uygulanabileceğini düşünürüm.**	a	b	c	d
9	Öğrenirken her öğrendiğimi daha önce öğrendiğim konularla ilişkilendirmeye çalışırım.	a	b	c	d
10	**Sınava hazırlanırken bilinmesi gereken en can alıcı noktaların ne olduğunu öğrenmeye çalışırım.**	a	b	c	d
11	Çalışırken, daha önce öğrendiklerimi hatırlayıp hatırlamadığımı konrol ederim.	a	b	c	d
12	**Çalışırken tam olarak anlayamadığım kavramları belirlemeye çalışırım.**	a	b	c	d
13	Bir şeyi anlamadığım zaman problemi belirginleştirmek için her zaman daha fazla bilgi araştırırım.	a	b	c	d
14	**Çalışırken önce öğrenmem gerekenleri tam olarak belirlerim.**	a	b	c	d
15	Matematik çalışırken çoktan seçmeli sorular çözerim.	a	b	c	d

I.7 Motivation and Anxiety Scale

MOTİVASYON VE ENDİŞE ÖLÇEĞİ

Açıklama: Matematikle ilgili düşüncelerinizi göz önüne aldığınızda belirtilen ifadelere ne derece katıldığınızı ya da katılmadığınızı ilgili seçeneği daire içine alarak belirtiniz.

		Hiç katılmıyorum	**Katılmıyorum**	**Katılıyorum**	**Tümüyle katılıyorum**
1	Matematik ile ilgili bir şeyler okumaktan hoşlanıyorum.	a	b	c	d
2	**Matematik derslerini dört gözle bekliyorum.**	a	b	c	d
3	Matematik çalışıyorum, çünkü matematiği seviyorum.	a	b	c	d
4	**Matematikte öğrendiğim konular ilgimi çekiyor.**	a	b	c	d
5	Matematik sıkıcıdır.	a	b	c	d
6	**Daha sonra yapmayı düşündüğüm işte bana yardımcı olacağından dolayı matematik için çaba harcamaya değer.**	a	b	c	d
7	Meslekte ilerlememi sağlayacağı için matematik öğrenmek önemlidir.	a	b	c	d
8	**Daha sonraki öğrenimimde matematiğe gereksinim duyacağımdan, matematik benim için önemlidir.**	a	b	c	d

9	Matematik dersinde, iş bulmama yardımcı olacak çok şey öğreneceğim.	a	b	c	d
10	**Matematik derslerinde genellikle zorluk çekerim diye kaygılanırım.**	a	b	c	d
11	Matematik ödevlerini yaparken çok gergin olurum.	a	b	c	d
12	**Matematik problemlerini çözerken çok sinirlenirim.**	a	b	c	d
13	Matematik sorularını çözerken çaresiz kaldığım duygusuna kapılırım.	a	b	c	d
14	**Matematikten kötü not alacağım diye endişelenirim.**	a	b	c	d

APPENDIX J

THE RESULTS OF FACTOR ANALYSIS OF STUDENT QUESTIONNAIRE

Table J.1 Results of factors analysis of student questionnaire

Factor 1 – Socioeconomic status (SES)	Loadings
Education of mother	.801
Education of father	.793
Number of books at home	.578
Dishwasher at home	.523
Number of siblings	-.449
Computer at home	.443
Factor 2 – Different types of homework (TYPEHOME)	
Working on long term projects by small groups	.717
Preparing oral presentations independently or by small groups	.694
Working on long term projects individually	.687
Conducting small research or collecting data	.648
Finding the use of math subjects in daily life	.595
Reading course book or other books	.498
Making exercises on the worksheets	.454
Factor 3 – Activities related with homework (ACTHOME)	
Teacher makes explanations about homework in class	.653
Teacher makes us correct our homework	.647
Teacher collects, corrects and keeps our homework	.577
Teacher collects, corrects and gives our homework back	.563
Teacher makes us discuss our homework in the class	.549
Teacher checks our homework	.522
Teacher makes us change our homework and correct them	.493
Factor 4 – Giving homework (GIVEHOME)	
Answering the problems or questions in the course book	.718
Frequency of homework	.554
Making exercises in the student exercise book	.553
Factor 5 – Teacher support (TCSUPP)	
Teacher helps us when we need help	.807
Teacher repeats what he/she told until we understand	.803
Teacher makes an effort for our learning	.799
Teacher gives us opportunity to explain our ideas	.737
Factor 6 – Projects, daily life examples and problems (PRODAILY)	
New topic – working in small groups on a problem or project	.725
We work on projects in pairs or small groups	.718
We work on projects	.636
We use daily life examples while solving problems	.564
New topic – discussing a practical or story problem	.541
Factor 7 – Use of technology (TECHNO)	
We use overhead projector	.845
Teacher uses overhead projector	.820
Teacher uses computer to show the mathematics topics	.689

Table J.1 (Continued)

Factor 8 – Mathematics self concept (MSCONCEPT)	Loadings
Although I do my best mathematics is more difficult for many of my classmates	.750
Nobody can be good in every subject, and I am just not talented in mathematics	.732
I would like mathematics much more if it were not so difficult	.694
Sometimes, when I do not understand a new topic in mathematics initially, I know that I will never really understand it	.688
Mathematics is not one of my strengths	.686
I am not good at mathematics	.585
Factor 9 – Preference for competitive learning situation (COMPE)	
I try very hard in mathematics because I want to do better in the exams than the others	.833
I make a real effort in mathematics because I want to be one of the best	.820
In mathematics I always try to do better than the other students in my class	.781
I would like to be the best in my class in mathematics	.706
I do my best work in mathematics when I try to do better than others	.620
Factor 10 – Preference for cooperative learning situation (COOPE)	
In mathematics I learn most when I work with other students in my class	.812
I do my best work in mathematics when I work with other students	.800
In mathematics I enjoy working with other students in groups.	.726
In mathematics, I enjoy helping others to work well in a group	.635
When we work on a project in mathematics, I think that it is a good idea to combine the ideas of all the students in a group.	.614
Factor 11 – Learning strategies – Use of control strategies (CONTROL)	
When I study mathematics, I try to figure out which concepts I still have not understood properly	.740
When I study for a mathematics test, I try to work out what are the most important parts to learn	.722
When I study mathematics, I start by working out exactly what I need to learn.	.698
When I study mathematics, I make myself check to see if I remember the work I have already done.	.697
When I cannot understand something in mathematics, I always search for more information to clarify the problem.	.490
Factor 12 – Learning strategies – Use of elaboration strategies (ELAB)	
I think how the mathematics I have learnt can be used in everyday life	.711
When I am solving a mathematics problem, I often think about how the solution might be applied to other interesting questions.	.655
When I am solving mathematics problems, I often think of new ways to get the answer	.649
When learning mathematics, I try to relate the work to things I have learnt in other subjects	.608
I try to understand new concepts in mathematics by relating them to things I already know	.587
Factor 13 – Math anxiety (ANXIETY)	
I feel helpless when doing a mathematics problem	.786
I get very tense when I have to do mathematics homework	.756
I often worry that it will be diffi cult for me in mathematics classes	.735
I get very nervous doing mathematics problems	.723
I worry that I will get poor marks in mathematics	.647
Factor 14 – Intrinsic motivation (INTMOT)	
I look forward to my mathematics lessons	.822
I do mathematics because I enjoy it	.771
I enjoy reading about mathematics	.749
I am interested in the things I learn in mathematics	.629
Factor 15 – Extrinsic motivation (EXTMOT)	
Learning mathematics is worthwhile for me because it will improve my career	.801
Mathematics is an important subject for me because I need it for what I want to study later on	.721
I will learn many things in mathematics that will help me get a job	.710
Making an effort in mathematics is worth it because it will help me in the work that I want to do later on	.634

APPENDIX K

TEACHER QUESTIONNAIRE

K.1 Demographic and Professional Information Part

Genel Açıklamalar

Bu kitapçıkta kendiniz ile ilgili sorular bulacaksınız. Bazı sorular gerçekleri sorarken, diğer sorular sizin düşüncelerinizi sormaktadır. Her soruyu dikkatlice okuyunuz ve mümkün olduğunca doğru ve dikkatli bir şekilde cevap veriniz. Bir şeyi anlamadığınızda veya nasıl cevap verileceğinden emin olmadığınızda, yardım isteyebilirsiniz. Gerçek duygularınızı belirtmeniz ve mümkün olduğunca boş soru bırakmamanız çalışmanın sonuçları için büyük önem taşımaktadır. Cevaplarınız kesinlikle gizli tutulacaktır.

Katılımınız için teşekkür ederim. ODTÜ Eğitim Fakültesi Arş. Gör. Betül YAYAN

KİŞİSEL VE MESLEKİ BİLGİLER

Açıklama : Bu bölümdeki soruları cevaplarken size uygun gelen seçeneği işaretleyiniz veya verilen boşluğa cevabınızı yazınız.

1. **Cinsiyetiniz nedir?**
   A. Kadın
   B. Erkek

---

2. **Bu ders yılının bitiminde toplam olarak kaç yıldır öğretmenlik yapıyor olacaksınız?_______________yıl**

3. **Hangi üniversiteden, fakülteden ve bölümden mezunsunuz?**
   Üniversite: ____
   Fakülte : ____
   Bölüm : ____

4. **Öğretmenlik eğitimini nerede aldınız?**

A Eğitim Fakültesi (Lütfen mezun olduğunuz bölümü işaretleyiniz)
Fen Bilimleri Eğitimi Bölümü / Matematik Öğretmenliği Programı
İlköğretim Matematik Öğretmenliği
Orta Öğretim Matematik Öğretmenliği
Diğer (Lütfen belirtiniz..)

B Pedagojik formasyon
Eğer pedagojik formasyon aldıysanız hangi resmi kurumdan aldınız?
____
Eğer pedagojik formasyon aldıysanız bu formasyon ne kadar sürmüştür?
____

C Diğer (Lütfen belirtiniz)
____

5. **Yüksek lisans ya da doktora dereceniz var mı?**

A Evet **B** Hayır

Cevabınız **evet** ise hangisi ya da hangileri olduğunu ve alanını belirtiniz lütfen

Yüksek lisans

Matematik eğitimi

Diğer (lütfen belirtiniz) ___________________________________

Doktora

Lisans sonrası doktora

Matematik eğitimi

Diğer (lütfen belirtiniz)___________________________

Yüksek lisans sonrası doktora

Matematik eğitimi

Diğer (lütfen belirtiniz)___________________________

6. Ders planınıza göre haftada kaç saat derse girmeniz gerekmektedir?

Matematik dersi : _____________ saat
Eğer giriyorsanız diğer branşlar: _____________ saat

7. Girdiğiniz sınıfların her birinde ortalama kaç öğrenci var? ___________________________

8. Öğretim faaliyetlerinizin tamamına haftada yaklaşık kaç saat harcamaktasınız? (okul içinde ve dışında harcanan zaman dahil) ______________________ saat

9. Diğer matematik öğretmenleriyle (zümre), müfredatı veya öğretim yaklaşımlarını tartışmak ve planlamak için ne sıklıkla bir araya gelirsiniz? (Sadece bir seçenek işaretleyiniz)

A Hiç
B Yılda bir veya iki kez
C İki ayda bir
D Ayda bir
E Haftada bir
F Haftada iki veya üç kez
G Hemen hergün

10. Matematik dersinizde, öğrencilerinizden aşağıdakileri ne sıklıkla yapmalarını istersiniz?

		Hiç veya hemen hemen hiç	**Bazı dersler**	**Çoğu dersler**	**Her ders**
A	Bir düşüncenin dayandığı mantığı açıklamak	a	b	c	d
B	**İlişkileri tablo, şema ve grafikler kullanarak ifade etmek ve analiz etmek**	a	b	c	d
C	Doğrudan belli bir çözüm yöntemi olmayan problemler üzerinde çalışmak	a	b	c	d
D	**Alıştırmaları ve problemleri çözmek için bilgisayar kullanmak**	a	b	c	d
F	Hesaplama becerileri için alıştırma yapmak	a	b	c	d

		EVET	**HAYIR**
11	Öğretmenlik, üniversiteye veya öğretmen eğitimi veren kuruma başladığınızda meslek olarak birinci tercihiniz miydi?	a	b
12	**Fırsatınız olsaydı başka bir mesleğe geçer miydiniz?**	a	b
13	Toplumun öğretmenlik mesleğini takdir ettiğini düşünüyor musunuz?	a	b
14	**Çalışmalarınızı öğrencilerinizin takdir ettiğini düşünüyor musunuz?**	a	b
15	Sınıfınıza matematik öğretirken bir ders kitabı kullanır mısınız?	a	b

Cevabınız **evet** ise, haftalık matematik öğretim sürenizin yaklaşık yüzde kaçı matematik ders kitabına dayalıdır? Uygun kutuyu işaretleyiniz.

☐ % 0-25 ☐ % 26-50 ☐ % 51-75 ☐ % 76-100

16. Aşağıda verilen etkinlikleri diğer matematik öğretmenleriyle ne sıklıkla gerçekleştirirsiniz?

		Hiç veya hemen hemen hiç	Ayda 2-3 kere	Haftada 1-3 kere	Hergün veya hemen hemen hergün
A	Belirli bir konunun nasıl öğretileceği konusunda tartışma	a	b	c	d
B	**Öğretim materyallerini hazırlama**	a	b	c	d
C	Diğer öğretmenlerin derslerini gözlemleme	a	b	c	d
D	**Sizin dersinizin diğer öğretmenler tarafından gözlemlenmesi**	a	b	c	d

17. Son 2 yılda aşağıda verilenlerle ilgili olarak herhangi bir hizmetiçi eğitime katıldınız mı?

		EVET	HAYIR
A	Matematik konuları	a	b
B	**Matematik öğretimi**	a	b
C	Matematik programı	a	b
D	**Bilgi teknolojilerinin matematik öğretiminde kullanımı**	a	b
E	Öğrencilerin eleştirel düşünme veya problem çözme becerilerinin geliştirilmesi	a	b
F	**Matematik derslerinin değerlendirilmesi ile ilgili yöntemler**	a	b

18. Bulunduğunuz okulda hangi statüde çalışıyorsunuz?

A Kadrolu öğretmen
B Sözleşmeli öğretmen
C Ücretli öğretmen
D Vekil öğretmen

K.2 Mathematics Homework Scale

MATEMATİK ÖDEVLERİ ÖLÇEĞİ

1. **Ne kadar sıklıkla ev ödevi verirsiniz?**
   A. Hiç
   B. Haftada bir kere
   C. Her ders saatinde

2. **Ev ödevi veriyorsanız, öğrencilerinize genellikle kaç dakikalık ev ödevi verirsiniz? (Sınıfınızdaki ortalama bir öğrencinin harcayacağı zamanı düşününüz)**
   a. 15 dakikadan az
   b. 15-30 dakika arası
   c. 31-60 dakika arası
   d. 61-90 dakika arası
   e. 90 dakikadan fazla

3. Ev ödevi veriyorsanız, aşağıdaki ödev çeşitlerinin her birini ne sıklıkla verirsiniz?

		Hiç	Ara sıra	Oldukça sık	Hemen her zaman
A	Çalışma kağıtlarındaki alıştırmaları yapma	a	b	c	d
B	**Alıştırma kitabındaki alıştırmaları yapma**	a	b	c	d
C	Ders kitabındaki problemleri/soruları yapma	a	b	c	d
D	**Ders kitabını veya yardımcı materyalleri okuma**	a	b	c	d
E	Tanımları yazma	a	b	c	d
F	**Küçük araştırma(lar) yapma veya veri toplama**	a	b	c	d
G	Uzun süreli projeler üzerinde bireysel çalışma	a	b	c	d
H	**Uzun süreli projeler üzerinde küçük bir grup halinde çalışma**	a	b	c	d
I	Çalışılan konunun günlük hayatta kullanımını bulma	a	b	c	d
J	**Bireysel olarak veya küçük gruplar halinde sözlü raporlar hazırlama**	a	b	c	d
K	Matematik günlüğü tutma	a	b	c	d

4. Ev ödevi veriyorsanız aşağıdakileri ne sıklıkla yaparsınız?

		Hiç	Ara sıra	Oldukça sık	Hemen her zaman
A	Ev ödevinin yapılıp yapılmadığını kontrol ederim.	a	b	c	d
B	**Ödevleri toplarım, düzeltirim ve saklarım.**	a	b	c	d
C	Ödevleri toplarım, düzeltirim ve geri veririm.	a	b	c	d
D	**Sınıfa ev ödevleri ile ilgili açıklayıcı bilgiler veririm.**	a	b	c	d
E	Öğrencilerin kendi ödevlerini düzeltmelerini sağlarım.	a	b	c	d
F	**Öğrencilerin, ödevlerini birbirleriyle değiştirerek düzeltmelerini sağlarım.**	a	b	c	d
G	Ev ödevleriyle ilgili sınıf tartışması yaptırırım.	a	b	c	d
H	**Öğrencilerin ev ödevlerinden aldıkları notları ders notu verirken dikkate alırım.**	a	b	c	d

K.3 Mathematics Classroom Practices Scale

MATEMATİK SINIF ORTAMI ÖLÇEĞİ

Açıklama: Belirtilen ifadelerin dersinizde ne sıklıkla gerçekleştiğini ilgili seçeneği daire içine alarak belirtiniz.

		Hiç	Ara sıra	Oldukça sık	Hemen her zaman
1	Öğrencilerime matematik problemlerini nasıl yapacaklarını gösteririm.	a	b	c	d
2	**Öğrenciler tahtaya yazılanları defterlerine yazarlar.**	a	b	c	d
3	Kısa sınav veya test uygularım.	a	b	c	d

4	**Öğrenciler projeler üzerinde çalışırlar.**	a	b	c	d
5	Öğrenciler bireysel olarak ders kitapları veya çalışma kağıtları üzerinde çalışırlar.	a	b	c	d
6	**Öğrenciler hesap makinesi kullanırlar.**	a	b	c	d
7	Öğrenciler bilgisayar kullanırlar.	a	b	c	d
8	**Problemleri çözerken günlük yaşamdan olayları kullanırız.**	a	b	c	d
9	Öğrenciler iki kişi veya küçük gruplar halinde çalışırlar.	a	b	c	d
10	**Öğrencilere ev ödevi veririm.**	a	b	c	d
11	Öğrenciler ev ödevlerini yapmaya sınıfta başlayabilirler.	a	b	c	d
12	**Verdiğim ev ödevlerini kontrol ederim.**	a	b	c	d
13	Öğrenciler birbirlerinin ev ödevini kontrol ederler.	a	b	c	d
14	**Tamamlanmış ev ödevlerini sınıfta tartışmalarını sağlarım.**	a	b	c	d
15	Tahtayı kullanırım.	a	b	c	d
16	**Tepegözü kullanırım.**	a	b	c	d
17	Öğrenciler tahtayı kullanır.	a	b	c	d
18	**Öğrenciler tepegözü kullanır.**	a	b	c	d
19	Gelen mesajlar, ziyaretçiler vb. nedeniyle ara vermek durumunda kalırım.	a	b	c	d
20	**Matematik konularını göstermek için bilgisayar kullanırım.**	a	b	c	d
21	Yeni bir konuya kuralları ve tanımları açıklayarak başlarım.	a	b	c	d
22	**Yeni bir konuya günlük yaşam ile ilgili bir problemi tartışarak başlarız.**	a	b	c	d
23	Yeni bir konuya başladığımda öğrenciler bir problem veya proje üzerinde küçük gruplar halinde çalışırlar.	a	b	c	d
24	**Yeni bir konuya öğrencilere konu ile ilgili ne bildiklerini sorarak başlarım.**	a	b	c	d
25	Yeni bir konuya başladığımda konu hakkında konuşurken öğrenciler ders kitabına bakarlar.	a	b	c	d
26	**Yeni bir konuya başladığımda öğrenciler konu ile ilgili bir örneği çözmeye çalışırlar.**	a	b	c	d
27	Her öğrencinin öğrenmesi için çaba gösteririm.	a	b	c	d
28	**Öğrenciler ihtiyaç duyduklarında onlara yardım ederim.**	a	b	c	d
29	Anlattıklarımı, öğrenciler anlayana kadar tekrar ederim.	a	b	c	d
30	**Öğrencilere düşüncelerini açıklama fırsatı veririm.**	a	b	c	d

K.4 Scale of Perceptions about Mathematics

MATEMATİKLE İLGİLİ ALGILAR ÖLÇEĞİ

1. **Öğrencilerin matematikte başarılı olabilmeleri için aşağıdakilerini yapmalarının ne kadar önemli olduğunu düşünüyorsunuz?**

		Önemli değil	Bir dereceye kadar önemli	Çok önemli
A	Formülleri ve işlemleri hatırlamak	a	b	c
B	**Sıralı ve işleme yönelik düşünmek**	a	b	c

C	Matematik kavramlarını, prensiplerini ve matematiksel yöntemleri anlamak	a	b	c
D	**Yaratıcı düşünebilmek**	a	b	c
E	Gerçek dünyada matematiğin nasıl kullanıldığını anlamak	a	b	c
F	**Sonuçları desteklemek için nedenler gösterebilmek**	a	b	c

2. Size göre, aşağıdakiler matematik dersinizi nasıl öğreteceğinizi ne derece kısıtlar?

		Çok fazla kısıtlar	Çok kısıtlar	Az kısıtlar	Hiç kısıtlamaz
A	Matematikte başarısız olan öğrenciler	a	b	c	d
B	**Farklı akademik yetenekleri olan öğrencilerin aynı sınıfta bulunması**	a	b	c	d
C	Matematiğe karşı ilgisiz öğrenciler	a	b	c	d
D	**Yaramaz öğrenciler**	a	b	c	d
E	Özel gereksinimi olan öğrenciler (örneğin; duyma, görme, konuşma özrü olan, fiziksel yetersizlikleri olan, akılla ilgili veya duygusal/ psikolojik bozuklukları olan)	a	b	c	d
F	**Çocuklarının öğrenmesine ve gelişmesine ilgi duymayan aileler**	a	b	c	d
G	Çocuklarının öğrenmesine ve gelişmesine ilgi duyan aileler	a	b	c	d
H	**Matematik konularıyla ilgili bilgisayar programlarının yetersiz sayıda olması**	a	b	c	d
I	Öğrencilerin derste bireysel veya küçük gruplar halinde kullanabilecekleri bilgisayar sayısının yetersiz sayıda olması	a	b	c	d
J	**Sizin kullanabileceğiniz matematiksel araç ve gereçlerinin (örneğin; onluk taban blokları, birim küpler, örüntü blokları v.s.) yetersiz sayıda olması**	a	b	c	d
K	Öğrencilerin kullanabileceği matematiksel araç ve gereçlerinin yetersiz sayıda olması	a	b	c	d
L	**Sınıf mevcudunun kalabalık olması**	a	b	c	d

3. Aşağıdaki ifadelerden her birine ne ölçüde katılıyorsunuz?

		Hiç katılmıyorum	Katılmıyorum	Katılıyorum	Tümüyle katılıyorum
A	Matematik soyut bir konudur.	a	b	c	d
B	**Matematik gerçek dünyayı göstermenin biçimsel bir yoludur.**	a	b	c	d
C	Matematik gerçek durumları göstermeye yönelik uygulamalı bir rehberdir.	a	b	c	d
D	**Eğer öğrenciler zorlanıyorsa, etkili bir yöntem, onlara ders esnasında kendi başlarına yapmaları için daha fazla alıştırma vermektir.**	a	b	c	d
E	Bazı öğrencilerin matematiğe karşı doğal yetenekleri vardır, bazılarının yoktur.	a	b	c	d
F	**Bir matematik konusunu öğretirken birden fazla gösterimden (resim, somut materyal, sembol kümesi, v.s.) yararlanmalıdır.**	a	b	c	d
G	Matematik algoritmalar veya kurallar kümesi olarak öğrenilmelidir.	a	b	c	d
H	**Öğretmenin temel dört işlem becerileri <u>ilköğretim</u> matematiğini öğretmek için yeterlidir.**	a	b	c	d
I	Matematik öğretimi için, öğretmenlerin öğrencileri sevmesi ve onları anlamaları esastır.	a	b	c	d

K.5 Mathematics Teaching Efficacy Beliefs Scale

MATEMATİK ÖĞRETİMİNE YÖNELİK YETERLİK ALGISI ÖLÇEĞİ

Açıklama: Belirtilen ifadelere ne derece katıldığınızı ilgili seçeneği daire içine alarak belirtiniz.

		Hiç katılmıyorum	Katılmıyorum	Kararsızım	Katılıyorum	Tümüyle katılıyorum
1	Eğer bir öğrenci matematikte her zamankinden daha iyi ise, bunun nedeni çoğunlukla öğretmeninin daha fazla çaba harcamasıdır.	a	b	c	d	e
2	**Matematik öğretmek için her zaman daha iyi yöntemler bulurum.**	a	b	c	d	e
3	Ne kadar çok çabalasam da matematiği öğretmede yeterince etkili <u>olamıyorum.</u>	a	b	c	d	e
4	**Öğrencilerin matematik notlarının iyiye gitmesi, genellikle öğretmenin daha etkili bir öğretim yöntemi bulmuş olmasının sonucudur.**	a	b	c	d	e
5	Matematik kavramlarını etkili bir şekilde nasıl öğreteceğimi biliyorum.	a	b	c	d	e
6	**Öğrencilerin sınıftaki matematik çalışmalarını takip etmede yeterince etkili <u>değilim.</u>**	a	b	c	d	e

7	Eğer öğrenciler matematikte başarısızlarsa, bunun nedeni büyük olasılıkla kötü matematik öğretimidir.	a	b	c	d	e
8	**Matematiği yeterince iyi öğretemiyorum.**	a	b	c	d	e
9	İyi bir öğretim yöntemi ile öğrencilerin matematik bilgilerindeki yetersizliklerin üstesinden gelinebilir.	a	b	c	d	e
10	**Matematikte başarısız olan bir öğrencinin başarısının yükselmesi, öğretmenin daha fazla ilgi göstermesi sonucunda olur.**	a	b	c	d	e
11	Matematik kavramlarını, etkili bir öğretim yapabilecek kadar iyi anlıyorum.	a	b	c	d	e
12	**Öğrencilerin matematikteki başarısından genellikle öğretmenleri sorumludur.**	a	b	c	d	e
13	Öğrencinin matematikteki başarısı, öğretmenin etkili matematik öğretimi ile doğrudan ilgilidir.	a	b	c	d	e
14	**Bir veli çocuğunun matematiğe karşı daha fazla ilgi duyduğunu belirtiyorsa, bunun nedeni büyük olasılıkla öğretmenin dersteki performansıdır.**	a	b	c	d	e
15	Matematik kavramlarını öğretirken gerçek hayat arasında bağlantı kurmada zorlanıyorum.	a	b	c	d	e
16	**Öğrencilerimin matematik ile ilgili sorularını cevaplayabiliyorum.**	a	b	c	d	e
17	Matematik öğretmek için gerekli becerilere sahip olduğumu hiç sanmıyorum.	a	b	c	d	e
18	**Eğer bir seçim hakkı verilseydi, müfettişleri beni değerlendirmeleri için derslerime davet etmezdim.**	a	b	c	d	e
19	Bir öğrencim matematiği anlamada güçlük çektiğinde ona yardım etmekte zorlanıyorum.	a	b	c	d	e
20	**Matematik öğretirken öğrencilerden gelen soruları her zaman hoş karşılıyorum.**	a	b	c	d	e
21	Öğrencilere matematiği sevdirmek için ne yapmam gerektiğini bilmiyorum.	a	b	c	d	e

APPENDIX L

THE RESULTS OF FACTOR ANALYSIS OF TEACHER QUESTIONNAIRE

Table L.1 Results of factors analysis of teacher questionnaire

Factor 1 – Personal teaching efficacy (PEREFFI)	**Loadings**
I am typically be able to answer students' mathematics questions	.818
I wonder if I have the necessary skills to teach mathematics	-.758
I generally teach mathematics ineffectively.	-.741
I understand mathematics concepts well enough to be effective in teaching mathematics	.640
I know the steps necessary to teach mathematics concepts effectively.	.573
I continually find better ways to teach mathematics.	.539
When teaching mathematics, I usually welcome student questions.	.518
I find it difficult to make connections between mathematics concepts and daily life.	-474
When a student has difficulty understanding a mathematics concept, I usually be at loss as how to help the student understand it better.	-.444
I do not know what to do to turn students on to mathematics.	-.429
Factor 2 – Outcome expectancy (OUTCOME)	
The teacher is generally responsible for the achievement of students in mathematics	.778
Students' achievement in mathematics is directly related to their teacher's effectiveness in mathematics teaching.	.777
When a low-achieving student progresses in mathematics, it is usually due to extra attention given by teacher.	.744
If parent comment that their child is showing more interest in mathematics at school, it is probably due to the performance of the child's teacher.	.690
If students are underachieving in mathematics, it is most likely due to ineffective mathematics teaching.	.635
When a student does better than usual in mathematics, it is often because the teacher exerted little extra effort.	.569
When the mathematics grades of students improve, it is often due to their teacher having found a more effective teaching approach.	.526
Factor 3 – Perceptions about being successful in mathematics (PERSUCC)	
Being able to provide reasons to support their solutions	.782
Understanding how mathematics is used in the real world	.777
Being able to think creatively	.559
Remembering formulas and procedures	-.496
Factor 4 – Perceptions about mathematics (PERMATH)	
Mathematics is primarily a practical and structured guide for addressing real situations	-.877
Mathematics is primarily a formal way of representing the real world	-.752
Mathematics should be learned as sets of algorithms or rules that cover all possibilities	.606
Basic computational skills on the part of the teacher are sufficient for teaching elementary mathematics	.528
Factor 5 – Perceptions about physical limitations (PHYLIM)	
Shortage of mathematics equipment for your use in demonstrations and other exercises	.879
Shortage of mathematics equipment for students' use	.786
Shortage of computer software about mathematics	.706
Crowded classes	.559
Shortage of computer for students' use	.512
Factor 6 – Perceptions about limitations aroused from students (LIMSTU)	
Uninterested students in mathematics	.704
Unsuccessful student in mathematics	.668
Students with special needs, (e.g., hearing, vision, speech impairment, physical disabilities, mental or emotional/psychological impairment)	.626
Students with different academic abilities in the same classroom	.515

APPENDIX M

LETTER OF PERMISSION

T.C.
ANKARA VALİLİĞİ
Milli Eğitim Müdürlüğü

ÖĞRENCİ İŞLERİ
DAİRESİ BAŞKANLIĞI
Ev. Arş. Md. Saat :

Bölüm : Strateji Geliştirme
Sayı : B B.08.4.MEM.4.06.00.04–312/ 25781
Konu : Araştırma İzni (Betül YAYAN)

14/3/2008

ORTA DOĞU TEKNİK ÜNİVERSİTESİ
Öğrenci İşleri Dairesi Başkanlığına

İlgi : a) 14.02.2008 tarih ve 400/994/1966 sayılı yazınız.
b) 10.03.2008 tarih ve 312/23886 sayılı Valilik Oluru.

Üniversiteniz, Eğitim Fakültesi, Ortaöğretim Fen ve Matematik Alanları Eğitimi Anabilim Dalı Doktora Programı öğrencisi Betül YAYAN'ın, **"6. Sınıf Öğrencilerinin Problem Çözme Becerilerini Etkileyen Etmenler"** konulu tez çalışması kapsamında; ekli listede belirlenen okullarda uygulama yapma isteği ilgi (b) Valilik Oluru ile uygun görülmüş olup, konu hakkında çalışmanın yapılacağı İlçe Milli Eğitim Müdürlüklerine bilgi verilmiştir.

Mühürlü anket örneği (14 Bölümden oluşan) yazımız ekinde gönderilmiş olup, uygulama yapılacak sayıda çoğaltılması ve çalışmanın bitiminde iki örneğinin (CD/disket) Müdürlüğümüz Strateji Geliştirme Bölümüne gönderilmesi hususunda bilgilerinizi ve gereğini rica ederim.

Murat Bey BALTA
Vali a.
Milli Eğitim Müdürü

EKLER :
1. Öğrenci Anketi -Soru Kitapçığı (8 Bölüm)
2. Öğretmen Anketi-Soru Kitapçığı (6 bölüm)
3. Okul Listesi (1 Sayfa)
4. Valilik Onayı (1 Sayfa)

APPENDIX N

DESCRIPTIVE SUMMARY OF STUDENT AND TEACHER LEVEL INSTRUMENTS

Table N.1 Mathematics homework scale

			1	2	3	4	5
Items	*M*	*SD*	%	%	%	%	%
1	2.60	0.56	3.60	32.0	61.7	-	-
2	2.68	0.97	7.20	38.6	33.8	11.0	5.6
3A	2.18	0.98	25.2	40.2	15.2	13.5	
3B	2.95	0.96	7.60	23.5	30.2	33.6	
3C	3.25	0.85	3.00	16.5	29.8	45.7	
3D	2.36	1.03	21.2	33.7	20.1	16.9	
3E	2.56	1.09	19.1	27.8	22.4	24.7	
3F	2.30	0.89	15.1	47.2	19.5	12.1	
3G	2.23	0.90	18.7	46.1	17.3	11.2	
3H	2.15	0.92	23.0	42.2	17.4	9.90	
3I	2.30	0.99	22.0	34.5	21.7	13.9	
3J	1.96	0.96	36.2	33.1	15.2	8.40	
3K	1.39	0.87	75.2	7.60	4.60	6.60	
4A	2.68	1.03	11.9	34.0	21.4	27.6	
4B	1.90	1.02	43.3	26.2	13.2	10.4	
4C	2.04	1.06	37.2	27.0	15.2	13.1	
4D	3.04	0.97	7.80	18.6	28.6	37.5	
4E	2.91	1.03	11.0	19.8	27.3	34.1	
4F	1.75	1.01	52.3	20.2	11.2	8.90	
4G	2.21	1.06	29.9	29.0	19.8	14.9	
4H	2.84	1.10	14.6	20.9	22.6	34.8	

Table N.2 Mathematics self concept scale

Items	*M*	*SD*	1	2	3	4
			%	%	%	%
1*	2.73	0.64	9.00	34.1	27.2	25.8
2	2.75	0.67	8.60	26.4	39.6	20.1
3	2.39	0.63	15.5	38.6	30.1	11.2

Table N.2 (Continued)

Items	*M*	*SD*	1	2	3	4
			%	%	%	%
4	2.87	0.66	7.10	23.6	37.7	25.6
5	2.77	0.71	11.9	26.9	27.4	28.6
6*	2.43	0.62	25.0	26.8	21.0	22.2
7*	2.72	0.68	12.1	27.8	30.3	25.1
8*	2.82	0.75	10.9	24.1	31.8	28.8
9*	2.73	0.58	13.2	25.4	30.1	26.2
10*	2.81	0.72	12.1	23.1	31.4	29.1

* Reversed items

Table N.3 Mathematics classroom practices scale

			1	2	3	4
Items	*M*	*SD*	%	%	%	%
1	3.45	0.79	3.1	9.4	25.8	59.3
2	3.63	0.63	1.1	4.6	23.4	67.5
3	2.32	1.00	21.9	37.3	20.3	16.0
4	2.29	1.01	23.8	33.4	21.3	14.5
5	2.44	1.06	22.0	29.1	24.7	19.4
6	1.40	0.78	71.5	15.3	5.40	4.10
7	1.42	0.84	72.7	12.3	5.50	5.60
8	2.52	0.99	15.8	33.6	26.9	19.4
9	2.10	0.98	30.4	36.5	17.4	11.4
10	3.36	0.84	3.30	12.7	25.8	53.4
11	2.09	1.01	32.0	35.0	15.4	12.7
12	2.65	1.05	14.6	31.5	21.6	27.3
13	2.18	1.16	37.7	21.7	17.1	18.9
14	2.26	1.07	28.6	28.2	20.9	16.0
15	3.60	0.70	2.30	5.20	20.7	67.0
16	1.44	0.87	69.8	11.0	6.00	6.00
17	3.21	0.90	4.80	15.9	27.7	45.5
18	1.37	0.82	72.1	8.20	5.20	4.80
19	1.92	0.94	36.8	39.3	11.0	9.20
20	1.35	0.81	77.3	8.00	5.60	4.80
21	3.22	0.93	6.00	15.5	26.6	48.2
22	2.30	1.03	24.6	32.4	22.3	15.5
23	2.00	0.99	35.4	33.8	15.1	10.3
24	2.65	0.99	12.3	31.5	27.2	23.3
25	2.63	1.06	16.5	27.9	25.8	25.6
26	3.05	0.94	7.00	18.9	32.7	37.3
27	3.58	0.74	2.70	6.20	19.4	67.3
28	3.45	0.80	3.10	8.90	25.0	57.3
29	3.40	0.84	4.00	10.0	26.0	56.0
30	3.24	0.91	5.20	15.3	27.0	48.7

Table N.4 Mathematics learning situation scale

First part - competitive learning preferences						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
1	3.58	0.74	3.40	4.50	21.4	66.4
2	3.46	0.72	2.00	6.80	32.0	54.5
3	3.37	0.78	2.80	9.40	32.6	50.5
4	3.36	0.76	2.70	8.70	35.3	47.4
5	3.11	0.85	4.40	16.0	38.6	35.0
Second part - co-operative learning preferences						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
6	2.89	1.04	13.5	16.4	31.2	32.9
7	3.20	0.91	6.09	10.7	33.5	43.4
8	2.89	0.98	11.0	18.0	35.8	29.5
9	3.11	0.87	6.60	12.6	38.8	36.4
10	2.92	1.00	11.6	16.6	34.7	32.4

Table N.5 Mathematics learning strategy scale

First part – memorization strategy						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
1	2.70	0.97	12.6	25.0	34.5	22.4
2	2.37	1.00	21.9	28.6	28.0	13.8
3	3.11	0.83	4.70	13.0	42.4	32.9
4	3.16	0.83	4.80	11.4	41.2	36.0
Second part –elaboration strategy						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
5	2.99	0.88	5.90	18.4	39.6	29.2
6	2.93	0.88	6.80	18.0	41.1	25.3
7	3.01	0.85	5.50	16.1	42.8	28.3
8	2.95	0.86	5.90	18.7	42.3	25.8
9	2.95	0.87	6.40	17.8	42.5	26.3
Third part – control strategy						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
10	3.23	0.84	4.20	12.2	34.5	42.3
11	3.19	0.82	4.20	11.6	39.0	37.7
12	3.17	0.81	3.70	12.2	39.4	35.2
13	2.92	0.88	6.30	21.2	39.6	26.1
14	3.19	0.81	3.40	12.8	38.8	37.4
Solving multiple choice questions						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
15	3.09	0.90	6.20	15.2	36.0	35.9

Table N.6 Motivation and anxiety scale

First part – intrinsic motivation						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
1	2.92	0.95	10.3	16.6	39.5	29.9
2	2.88	0.96	9.80	20.9	35.9	29.1
3	3.04	0.92	6.80	18.1	35.4	35.2
4	3.16	0.85	5.00	12.5	39.8	37.3
5*	3.17	1.00	8.90	12.5	25.9	46.6
Second part – instrumental motivation						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
6	3.20	0.85	5.30	10.7	39.0	40.2
7	3.43	0.79	3.50	7.80	28.6	56.0
8	3.36	0.81	3.50	9.50	31.3	50.7
9	3.19	0.86	5.70	11.0	38.2	40.2
Third part – mathematics anxiety						
Items	*M*	*SD*	1	2	3	4
			%	%	%	%
10*	2.48	1.04	18.1	33.1	21.2	21.0
11*	2.83	1.05	13.4	20.5	28.6	31.5
12*	2.97	1.05	12.1	17.1	26.3	38.4
13*	2.75	1.08	15.1	25.1	23.9	31.2
14*	2.00	1.05	39.3	30.1	13.2	13.1

* Reversed items

Table N.7 Scale of perceptions about mathematics

First part						
			1	2	3	
Items	*M*	*SD*	%	%	%	
1A*	1.56	0.54	46.0	52.0	2.00	
1B*	1.29	0.50	72.0	24.0	2.00	
1C	2.84	0.37	0.00	16.0	84.0	
1D	2.82	0.39	0.00	18.0	82.0	
1E	2.74	0.49	2.00	22.0	76.0	
1F	2.60	0.61	6.00	28.0	66.0	
Second part						
			1	2	3	4
Items	*M*	*SD*	%	%	%	%
2A	2.50	0.77	10.0	36.0	46.0	6.00
2B	2.42	0.76	8.00	50.0	34.0	8.00
2C	2.20	0.83	22.0	40.0	34.0	4.00
2D	2.63	0.86	12.0	24.0	50.0	12.0
2E	2.36	0.83	20.0	26.0	52.0	2.00
2F	2.18	0.85	20.0	50.0	22.0	8.00
2G	3.62	0.60	0.00	6.00	26.0	68.0

Table N.7 (Continued)

Items	*M*	*SD*	1 %	2 %	3 %	4 %
2H	3.04	0.84	6.00	14.0	48.0	30.0
2I	3.00	0.82	4.00	20.0	46.0	28.0
2J	2.52	0.79	12.0	30.0	52.0	6.00
2K	2.26	0.75	18.0	38.0	44.0	0.00
2L	1.68	0.77	48.0	38.0	12.0	2.00
Third part						
			1	2	3	4
Items	*M*	*SD*	%	%	%	%
3A*	2.58	0.77	6.00	38.0	42.0	10.0
3B	3.34	0.52	0.00	2.00	62.0	36.0
3C	3.19	0.53	0.00	6.00	66.0	24.0
3D*	2.25	0.73	10.0	58.0	22.0	6.00
3E*	1.82	0.66	32.0	54.0	14.0	0.00
3F	3.44	0.58	0.00	4.00	48.0	48.0
3G*	2.57	0.74	4.00	44.0	40.0	10.0
3H*	2.78	0.90	8.00	28.0	40.0	22.0

* Reversed items

Table N.8 Mathematics teaching self efficacy beliefs scale

First dimension - Personal teaching efficacy beliefs							
Item	*M*	*SD*	1 %	2 %	3 %	4 %	5 %
2	4.10	0.62	0.00	2.00	8.00	66.0	22.0
3*	4.12	0.75	0.00	6.00	4.00	60.0	28.0
5	4.14	0.61	0.00	2.00	6.00	66.0	24.0
6*	3.92	0.86	0.00	10.0	10.0	56.0	22.0
8*	4.50	0.55	0.00	0.00	2.00	44.0	50.0
11	4.27	0.49	0.00	0.00	2.00	68.0	28.0
15*	4.00	0.96	0.00	12.0	8.00	46.0	32.0
16	4.61	0.49	0.00	0.00	0.00	38.0	60.0
17*	4.63	0.49	0.00	0.00	0.00	36.0	62.0
19*	4.29	0.71	0.00	4.00	2.00	54.0	38.0
20	4.50	0.74	2.00	0.00	2.00	36.0	56.0
21*	4.18	1.01	4.00	4.00	6.00	40.0	44.0
Second dimension - Mathematics teaching outcome expectancy							
Item	*M*	*SD*	1 %	2 %	3 %	4 %	5 %
1	3.71	0.92	2.00	12.0	10.0	60.0	12.0
4	3.78	0.92	4.00	6.00	12.0	62.0	14.0
7	2.90	1.03	2.00	44.0	20.0	26.0	6.00
9	4.00	0.84	0.00	8.00	10.0	54.0	26.0
10	3.79	0.85	0.00	10.0	16.0	54.0	16.0

Table N.8 (Continued)

Item	*M*	*SD*	1	2	3	4	5
			%	%	%	%	%
12	2.88	0.95	4.00	36.0	28.0	28.0	2.00
13	3.79	1.01	2.00	12.0	12.0	48.0	22.0
14	3.90	0.87	0.00	8.00	18.0	48.0	24.0

* Reversed items

Table N.9 Two dimensions of mathematics teaching self efficacy beliefs scale

Dimensions	Possible scores		Min.	Max.	*M*	*SD*
	Min.	Max.				
Personal mathematics teaching efficacy	12	60	41	60	51.3	4.64
Mathematics teaching outcome expectancy	8	40	16	39	28.7	4.87

APPENDIX O

ASSUMPTIONS UNDERLYING HIERARCHICAL LINEAR MODELING

O.1 The Homogenetity of Variance Assumption

The homogeneity of level-1 variance was tested using *H* statistics. The *H* statistics was not significant ($\chi2$ = 61.62, df = 49, p-value = 0.107) which indicated that the variances across teachers were equal to each other.

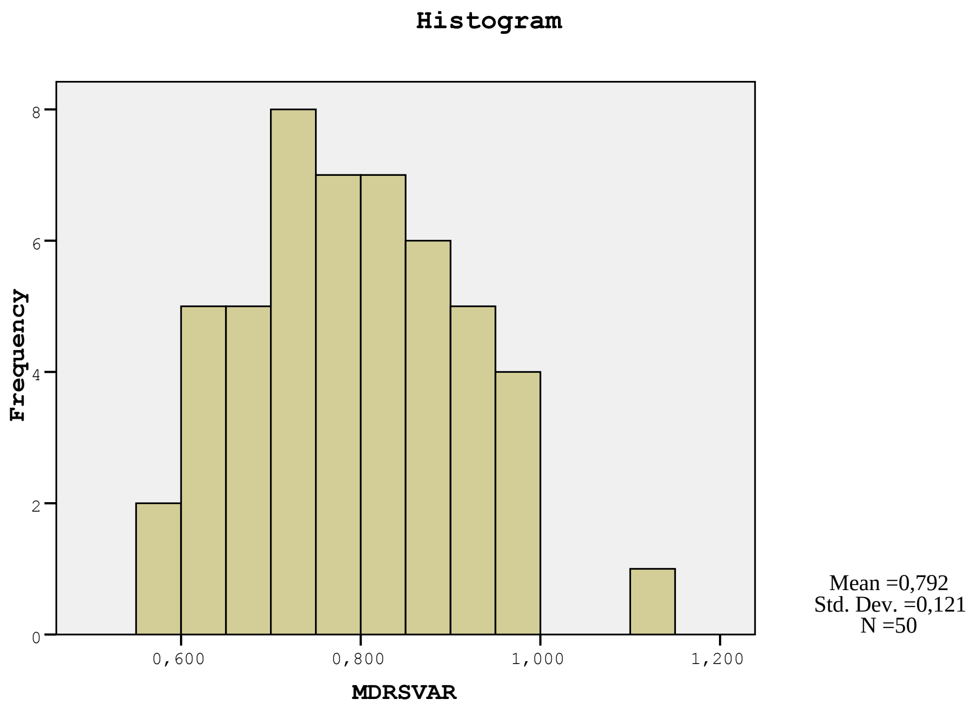


Figure O.1.1 Histogram of MDRSVAR

O.2 Normality Assumption of Random Coefficients

In the table given below, the Skewness and Kurtosis values of empirical bayes (EB) residuals of the slope *teacher support* (EBTCSUPP) are presented. As it is seen the values are within acceptable range to claim that the distribution is normal. Moreover, the histogram of the random coefficients EB estimates is displayed in the following.

Table O.2.1 Skewness and Kurtosis Values of the EB Estimates of Random Coefficients

	Skewness	Kurtosis
EBTCSUPP	0.263	0.357

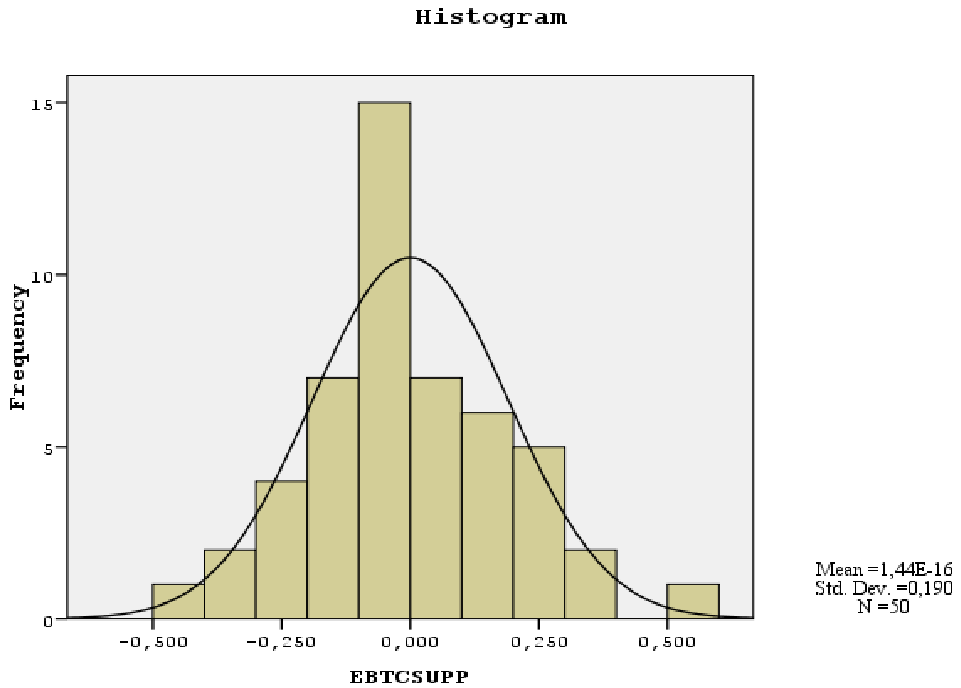


Figure O.2.1 Histogram of EB Residuals of the slope for *teacher support*

O.3 Normality Assumption of Level-2 Residuals

The CHIPCT and MDIST are the two variables in level-2 residual file. For checking the normality assumption the Q-Q plot of MDIST and CHIPCT is investigated. If the Q-Q plot of MDIST against CHIPCT resembles a 45 degree line, there is evidence that the random effects are distributed *v*-variate normal (Raudenbush et al., 2001, p. 44). Figure C.3 represent Q-Q plot of MDIST versus CHIPCT approximating a 45 degree line, and that the assumption is tenable.

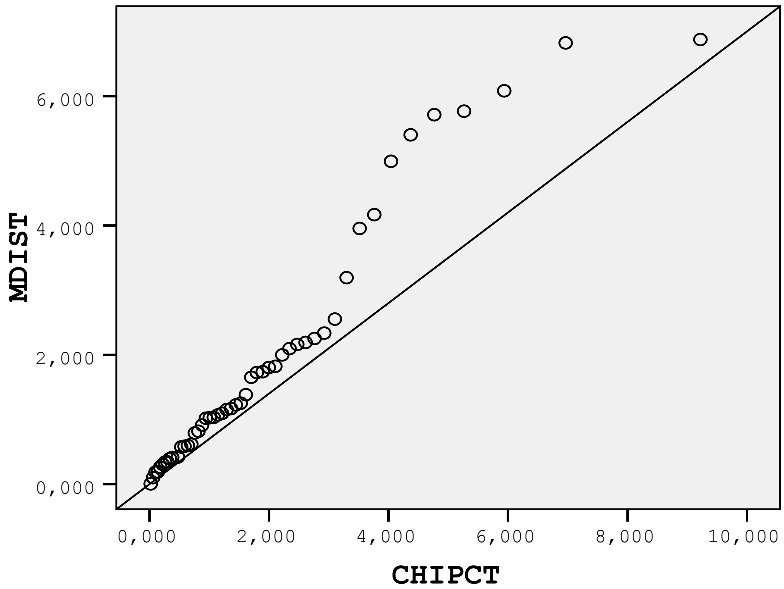


Figure O.3.1 Plot of MDIST versus CHIPCT

O.4 Assumption of Normal Distribution of Level-1 Errors

The Q-Q plot of the level-1 residuals based on the final fitted model is displayed in the figure given below. It can be cliamed that the plot is approximately linear, suggesting that there is not a serious departure from a normal distribution.

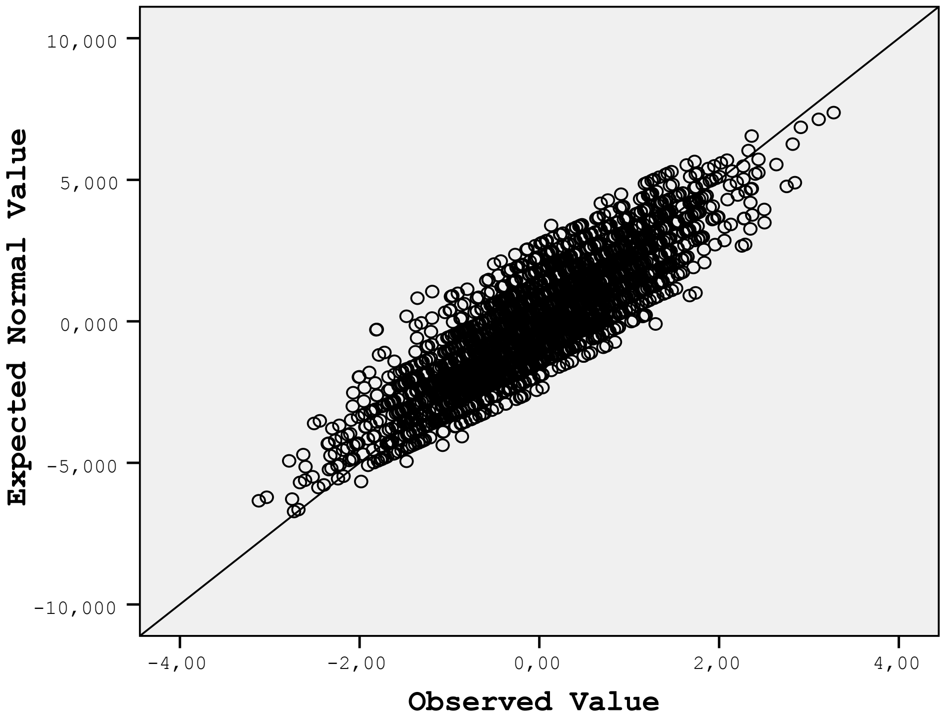


Figure O.4.1 Q-Q Plot of the Level-1 Residuals

O.5 Assumption of Linear Relationship between Level-2 Predictors and an Outcome

The plots of EB residuals for *teacher support* slope against *average mathematics self concept*, *average socioeconomic status*, and *perceptions about limitations aroused from students* are displayed in the figures given in the following. The plots suggest that the residuals randomly distributed around zero line with respect to values of level-2 predictors.

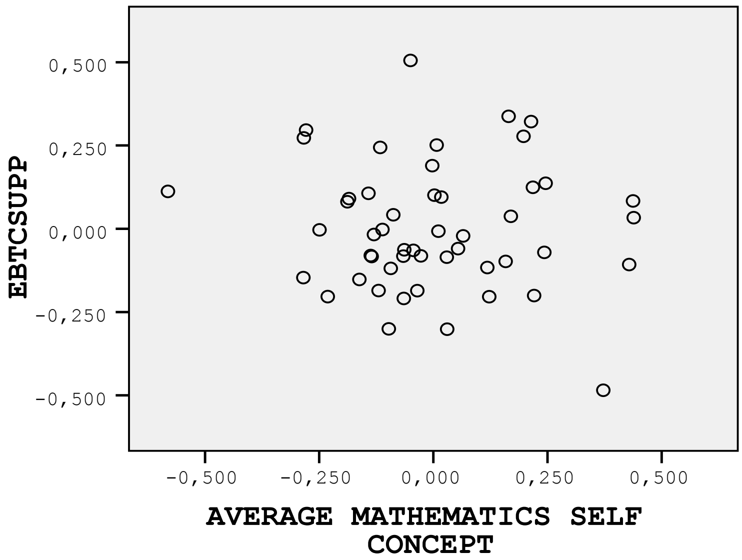


Figure O.5.1 EB residuals for Teacher Support Slope against Average Mathematics Self Concept

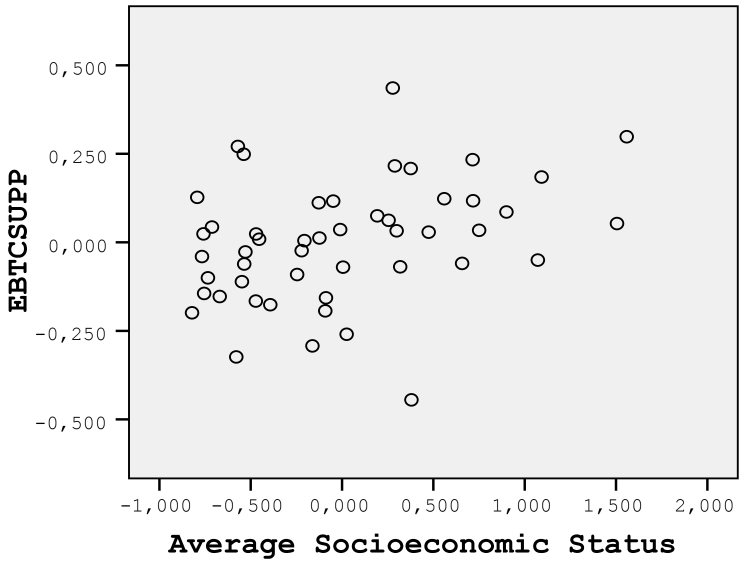


Figure O.5.2 EB residuals for Teacher Support Slope against Average Socioeconomic Status

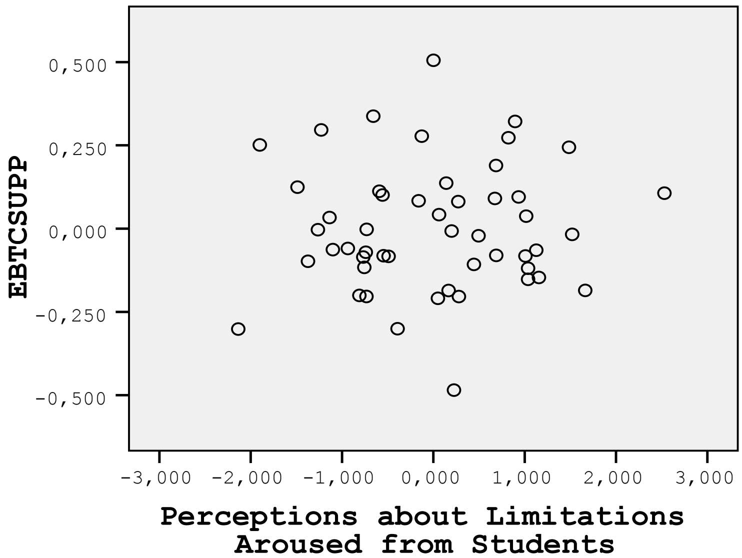


Figure O.5.3 EB residuals for Teacher Support Slope against Perceptions about Limitations Aroused from Students

VITA

PERSONAL INFORMATION

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EDUCATION

Degree	Institution	Year of Graduate
MS	METU, SSME	1999
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WORK EXPERINCE

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2001-Present	METU, Department of Secondary Science and Mathematics Education	Research Assistant
2000-2001	Anadolu University, Department of Elementary Education	Research Assistant
1999-2000	Ministry of National Education	Mathematics Teacher

PUBLICATIONS

Presentations

Eryılmaz, A., Gülnar, N., Serin, G., Hardal, Ö., Can, H., Aşcı, Z., & **Yayan, B.** (2004). 1994-2003 yılları arasında Hacettepe Üniversitesi Eğitim Bilimleri Dergisi'nde Fen Bilimleri Eğitimi alanında yayımlanan makalelerin içerik analizi. *VI. Ulusal Fen Bilimleri ve Matematik Eğitimi Kongresi poster sunumu, 9-11 Eylül, 2004*.

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