A CROSS-CULTURAL COMPARISON OF THE IMPACT OF HUMAN AND PHYSICAL RESOURCE ALLOCATIONS ON STUDENTS' MATHEMATICAL LITERACY SKILLS IN THE PROGRAMME FOR INTERNATIONAL STUDENT ASSESSMENT (PISA) 2003

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ABSTRACT

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The purpose of the present study is to gain a more complete understanding of 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 through the Programme for International Student Assessment (PISA) 2003.

Hierarchical linear modeling (HLM) techniques were used separately for three different cultural settings using the database of Programme for International Student Assessment (PISA) 2003. The results indicated that students in Turkey, member and candidate countries of European Union who performed higher on the mathematical literacy assessment tended to have the following characteristics: (1)

enrolled at higher grade levels, (2) more educational resources at home, (3) higher levels of mathematics self-efficacy, (4) lower levels of mathematics anxiety, (5) more positive self-concept in mathematics, (6) less preferences for memorisation strategies, and (7) more positive disciplinary climate in mathematics lessons. As the performance of schools were considered, the higher average mathematics self-efficacy of students, the higher the mean school mathematical literacy performance.

The influence on mathematical literacy assessment varied from school to school with respect to grade level and disciplinary climate in mathematics lessons in Turkey and European Union countries, with respect to grade level, mathematics self-efficacy, and disciplinary climate in mathematics in European Union candidate countries. Moreover, school size and mathematics student-teacher ratio at school influenced the disciplinary climate in mathematics lessons in Turkey; academic selectivity of the school influenced the grade level and mathematics self-efficacy in the candidate countries of European Union.

Key Words: Programme for International Student Assessment (PISA), Mathematical Literacy, Hierarchical Linear Modeling (HLM), Student-Level Factors, School Level Factors, and Turkey, member and candidate countries of European Union.

ÖZ

ULUSLARARASI ÖĞRENCİ DEĞERLENDİRME PROGRAMI'NDA (PISA 2003) İNSAN VE FİZİKSEL KAYNAKLARIN ÖĞRENCİLERİN MATEMATİK OKUR YAZARLIĞINA OLAN ETKİSİNİN KÜLTÜRLER ARASI KARŞILAŞTIRILMASI

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Bu çalışmanın amacı, Türkiye, Avrupa Birliği üye ülkeleri ve Avrupa Birliği aday ülkeleri olmak üzere farklı kültürlerde, insan ve fiziksel kaynakların öğrencilerin Uluslararası Öğrenci Değerlendirme Programındaki (PISA 2003) matematik okur yazarlığına olan etkisinin incelenmesidir.

2003 Uluslararası Öğrenci Başarı Belirleme Programı'nda (PISA) farklı performans seviyeleri sergileyen üç farklı kültür için ayrı ayrı hiyerarşik lineer modelleme (HLM) analizi yürütülmüştür. Çalışmanın bulgularına göre, Türkiye ve Avrupa Birliği üye ve aday ülkelerinde, matematik okur yazarlığında başarılı olan öğrencilerde bulunan nitelikler şöyle sıralanabilir: (1) üst sınıflarda bulunan, (2) evlerinde daha fazla eğitim kaynağı bulunan, (3) matematikte kendini yeterli görme yeterlilikleri yüksek olan, (4) matematikte kaygı veya sıkıntı düzeyleri düşük olan, (5) matematikte özgüven düzeyleri yüksek olan, (6) ezberleme ve tekrar stratejilerini daha az tercih eden ve (7) matematik derslerinde daha pozitif sınıf ortamı bulunan öğrencilerdir. Ayrıca, matematikte kendini yeterli görme yeterliliklerinin ortalaması yüksek olan öğrencilerin bulunduğu okulların, matematik okur yazarlığında daha başarılı olduğu görülmektedir.

Türkiye ve Avrupa Birliği üye ülkelerinde, sınıf düzeyinin ve matematik derslerindeki sınıf ortamının, matematik okur yazarlığına etkileri okuldan okula değişmektedir. Avrupa Birliği aday ülkelerinde ise sınıf düzeyine ve matematik derslerindeki sınıf ortamına ek olarak matematikte kendini yeterli görme yeterliliğinin etkileri de okuldan okula değişmektedir. Bunlara ek olarak, Türkiye'de okul mevcudu ve okuldaki matematik öğrenci-öğretmen oranı, matematik derslerindeki sınıf ortamını etkilemekte; Avrupa Birliği aday ülkelerinde ise okulun akademik seçim ile ilgili özerkliği, sınıf düzeyini ve matematikte kendini yeterli görme yeterliliğini etkilemektedir.

Anahtar Kelimeler: Uluslararası Öğrenci Değerlendirme Programı (PISA), Matematik Okur Yazarlığı, Hiyerarşik Lineer Modelleme (HLM), Öğrenciye İlişkin Etkenler, Okula İlişkin Etkenler ve Türkiye, Avrupa Birliği üye ve aday ülkeleri.

To My Family

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I am very proud to have all of them as my family.

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LIST OF ABBREVIATIONS

OECD = Organisation for Economic Co-operation and Development

PISA = Programme for International Student Assessment

EU = European Union

Level-1 Variables = Student Level Variables

Level-2 Variables = School Level Variables

GRADE = Grade of the Students

GENDER = Gender of the Students

OCCUPAR = Highest Parental Occupational Status

EDUCPAR = Highest Educational Level of Parents

SES = Socio-Economic and Cultural Status

COMPHOME = Computer Facilities at Home

CULTURAL = Cultural Possessions of the Family

HOMEDUC = Home Educational Resources

ATTSCH = Attitudes towards School

RELATION = Student-Teacher Relations at School

BELONG = Sense of Belonging at School

INTEREST = Interest in Mathematics

MOTIVAT = Instrumental Motivation in Mathematics

SELFEFFI = Mathematics Self-Efficacy

ANXIETY = Mathematics Anxiety

SELFCON = Mathematics Self-Concept

CONTROL = Control Strategies

ELAB = Elaboration Strategies

MEMOR = Memorisation Strategies

COMPLRN = Competitive Learning

COOPLRN = Cooperative Learning

SUPPORT = Teacher Support in Mathematics Lessons

CLIMATE = Disciplinary Climate in Mathematics Lessons

MATHLIT = Mathematical Literacy

MEANEFFI = Average Mathematics Self-Efficacy

SCHTYPE = School Type

SCHSIZE = School Size

PFEMALE = Proportion of Females Enrolled at School

RATIO = Total Student-Teacher Ratio

MRATIO = Mathematics Student-Teacher Ratio

ASELECT = Academic Selectivity

ASSESS = Use of Assessments

ABGROUP = Ability Grouping between Mathematics Classes

EXCOURSE = Mathematics Extension Courses

MACTIV = Mathematics Activities

AUTRES = Resource Autonomy

AUTCURR = Curricular Autonomy

TSHORT = Teacher Shortage

PHYST = Quality of School’s Physical Infrastructure

EDUCRES = Quality of School’s Educational Resources

STMORALE = Student Morale and Commitment

TMORALE = Teacher Morale and Commitment

STFACTOR = Student-Related Factors Affecting School Climate

TFACTOR = Teacher-Related Factors Affecting School Climate

ACER = Australian Council for Educational Research

CITO = National Institute for Educational Measurement

NIER = National Institute for Educational Research

ETS = Educational Testing Service

PGB = PISA Governing Board

NPMs = National project Managers

SMEGs = Subject Matter Expert Groups

CFA = Confirmatory Factor Analysis

SEM = Structural Equation Modeling

HLM = Hierarchical Linear Modeling

CHAPTER I

INTRODUCTION

This study tries to examine students' characteristics and school characteristics across Turkey, European Union Countries and the candidate countries of European Union and to investigate the influences of student and school characteristics on mathematical literacy skills of 15-year-old students through the use of data from Programme for International Student Assessment (PISA) 2003 conducted by Organisation for Economic Co-operation and Development (OECD).

1.1 Organisation for Economic Co-operation and Development (OECD)

The Organisation for Economic Co-operation and Development (OECD) shall promote policies designed:

- to achieve the highest sustainable economic growth and employment and rising standard of living in Member countries, while maintaining financial stability, and thus to contribute to the development of the world economy;
- to contribute to sound economic expansion in Member as well as non-member countries in the process of economic development; and
- to contribute to the expansion of world trade on a multilateral, non-discriminatory basis in accordance with international obligations (OECD Publications, 2004, p. 2).

The original Member countries of the OECD are Austria, Belgium, Canada, Denmark, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, the Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, Turkey, the United Kingdom and the United States. The following countries became Members subsequently through accession at the dates indicated hereafter: Japan (28th April 1964), Finland (28th January 1969), Australia (7th June 1971), New Zealand (29th May 1973), Mexico (18th May 1994), the Czech Republic (21st December 1995), Hungary (7th May 1996), Poland (22nd November 1996), Korea (12th December 1996) and the Slovak Republic (14th December 2000) (OECD Publications, 2004, p. 2).

1.2 Programme for International Student Assessment (PISA)

The Organisation for Economic Co-operation and Development (OECD) launched the Programme for International Student Assessment (PISA) in 1997. PISA represents a commitment by governments to monitor the outcomes of education systems in terms of student achievement on a regular basis and within an internationally accepted common framework. It aims to provide a new basis for policy dialogue and for collaboration in defining and implementing educational goals, in innovative ways that reflect judgments about the skills that are relevant to adult life (OECD Publications, 2004, p. 3).

PISA seeks to measure how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies. The assessment is forward-looking, focusing on young people's ability to use their knowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered a specific school curriculum. This orientation reflects a change in the goals and objectives of curricula themselves, which are increasingly concerned with what students can do with what they learn at school, and not merely whether they can reproduce what they have learned (OECD Publications, 2004, p. 20).

Key features driving the development of PISA have been:

- its policy orientation, with design and reporting methods determined by the need of governments to draw policy lessons;
- the innovative "literacy" concept that is concerned with the capacity of students to apply knowledge and skills in key subject areas and to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations;

- its relevance to lifelong learning, which does not limit PISA to assessing students' curricular and cross-curricular competencies but also asks them to report on their own motivation to learn, their beliefs about themselves and their learning strategies;
- its regularity, which will enable countries to monitor their progress in meeting key learning objectives; and
- its breadth of geographical coverage and collaborative nature, with the 49 countries that have participated in a PISA assessment so far and the 11 additional countries that will join the PISA 2006 assessment representing a total of one third of the world population (OECD Publications, 2004, p. 20)

PISA is the most comprehensive and rigorous international programme to assess student performance and to collect data on student, family and institutional factors that can help to explain differences in performance (OECD Publications, 2004, p. 20). PISA is not a single cross-national assessment of the reading, mathematics and science skills of 15-year-olds. It is an on-going programme that, over the longer term, will lead to the development of a body of information for monitoring trends in the knowledge and skills of students in various countries as well as in different demographic sub-groups of each country (OECD Publications, 2003, p. 12). The first PISA survey was conducted in 2000 in 32 countries - including 28 OECD member countries - and repeated in 11 further partner countries in 2002. Two-thirds of the assessment focused on reading, with the other third giving a summary of performance in mathematics and science (OECD Publications, 2004, p. 22). A list of the participating countries in PISA 2000 can be found at the end of the dissertation, in Appendix A. PISA 2003 was conducted in 41 countries, including all 30 OECD countries. It included an in-depth assessment of mathematics and assessments with less detail in science, reading and problem solving (OECD Publications, 2004, p. 22). A list of the participating countries in PISA 2003 can also be found at the end of the dissertation, in Appendix A. In the next three-yearly survey, PISA 2006, the primary focus will be on science, and it will return to reading in 2009 (OECD Publications, 2004, p. 22). This will provide a thorough analysis of achievement in each area every nine years and a trend analysis every three (OECD Publications, 2003, p. 13).

Students cannot learn in school everything they will need to know in adult life. What they must acquire is the prerequisites for successful learning in the future. Students must be able to organize and regulate their own learning, to learn independently and in groups, and to overcome difficulties in the learning process. This requires them to be aware of their own thinking processes, learning strategies and methods. Moreover, further learning will increasingly occur in situations in which people work together and are dependent on one another. To assess these aspects, an instrument seeking information on self-regulated learning was included as an optional component of the PISA 2000 assessment and as a core component of PISA 2003 (OECD Publications, 2003, p. 12).

The PISA assessment provides three main types of outcomes:

- basic indicators providing a baseline profile of the knowledge and skills of the students;
- contextual indicators showing how such skills relate to important demographic, social, economic and educational variables;
- indicators on trends that emerge from the on-going nature of the data collection and that show changes in outcome levels and distributions, and in relationships between student-level and school-level background variables and outcomes (OECD Publications, 2003, p. 13).

Although PISA was originally crated by the OECD governments in response to their own needs, it has become a major policy tool for many other countries and economies as well. PISA is playing an increasing policy role in regions around the world (OECD Publications, 2004, p. 22). Across the world, policy makers use PISA findings to:

- gauge the literacy skills of students in their own country in comparison with those of the other participating countries;
- establish benchmarks for educational improvement, for example, in terms of the mean scores achieved by other countries or their capacity to provide high levels of equity in educational outcomes and opportunities; and
- understand relative strengths and weaknesses of their education system (OECD Publications, 2004, p. 22).

1.3 Literacy and PISA Literacy Concept

The PISA framework starts with the concept of "literacy", which is concerned with the capacity of students to apply knowledge and skills and to analyse, reason and communicate effectively as they pose, solve and interpret problems in a variety of situations (OECD Publications, 2004, p. 23). PISA literacy concept focuses on the knowledge, understanding and skills required for effective functioning in everyday life. Mastery of a body of basic knowledge and skills is required in literacy for effective participation in a modern society (OECD Publications, 2002a).

The concept of literacy used in PISA is much broader than the historical notion of the ability to read and write. It is measured on a continuum, not as something that an individual either does or does not have. It may be necessary or desirable for some purposes to define a point on a literacy continuum below which levels of competence are considered inadequate, but the underlying variability is important. A literate person has a range of competencies and there is no precise dividing line between a person who is fully literate and one who is not (OECD Publications, 2004, p. 23).

The acquisition of literacy is a lifelong process, taking place not just at school or through formal learning, but also through interactions with peers, colleagues and wider communities. Fifteen-year-olds cannot be expected to have learned everything they will need to know as adults, but they should have a solid foundation of knowledge in areas such as reading, mathematics and science. In order to continue learning in these subject areas and to apply their learning to the real world, they also need to understand fundamental processes and principles and to use these flexibly in different situations. It is for this reason that PISA assesses the ability to complete tasks relating to real life, depending on a broad understanding of key concepts, rather than limiting the assessment to the possession of subject-specific knowledge (OECD Publications, 2004, p. 23).

The assessment areas covered by PISA are defined in terms of:

➢ the content or structure of knowledge that students need to acquire in each assessment area (e.g., familiarity with mathematical concepts);

➢ the processes that need to be performed (e.g., pursuing a certain mathematical argument); and

- the situations in which students encounter mathematical problems and relevant knowledge and skills are applied (e.g., making decisions in relation to one's personal life, or understanding world affairs) (OECD Publications, 2004, p. 25).

In mathematics, being able to reason quantitatively and to represent relationships or dependencies is more apt than the ability to answer familiar textbook questions when it comes to deploying mathematical skills in everyday life. In reading, the capacity to develop interpretations of written material and to reflect on the content and qualities of text are central skills. In science, having specific knowledge, such as the names of plants and animals, is of less value than understanding broad topics such as energy consumption, biodiversity and human health in thinking about the issues under debate in the adult community. In problem solving, recognizing a problem, formulating its exact nature, using this knowledge to plan a strategy for solving it, adjusting the solution to better fit the original problem, and communicating the solution to others are seen as basic skills for future learning (OECD Publications, 2003, p. 12). Summary of the assessment areas in PISA 2003 is displayed at the end of the dissertation, in Appendix B.

1.4 Mathematical Literacy in PISA

PISA starts with a concept of mathematical literacy that is concerned with the capacity of students to analyse, reason and communicate effectively as they pose, solve and interpret mathematical problems in a variety of situations involving quantitative, spatial, probabilistic or other mathematical concepts (OECD Publications, 2004, p. 37). Mathematical literacy is defined as an individual's capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen (OECD Publications, 2003, p. 15).

PISA presents students with problems mainly set in real-world situations. These are crafted in such a way that aspects of mathematics would be a genuine benefit in solving the problem. The objective of the PISA assessment is to obtain measures of the extent to which students presented with these problems can activate their mathematical knowledge and competencies to solve such problems successfully

(OECD Publications, 2004, p. 37). The individual must translate the situation or problem into a form that exposes the relevance and usefulness of mathematics. If students are unpracticed at such a process, the potential power of mathematics to help deal with the situations and problems of their life may not be fully realized. The PISA approach to assessing mathematics was therefore designed to place the real-life use of mathematical knowledge and skills closer to the centre of a concept of mathematics learning. The intention is to encourage an approach to teaching and learning mathematics that gives strong emphasis to the processes associated with confronting problems in real-world contexts, making these problems amenable to mathematical treatment, using relevant mathematical knowledge to solve problems, and evaluating the solution in the original problem context (OECD Publications, 2004, p. 38).

1.5 The Present Study

Since the PISA project was first assessed in the year 2000 and repeated in the year 2003, not many researchers have conducted any research study about PISA. However, there were some studies directly related to PISA project. Some of these studies were basically conducted for the PISA 2000 project and descriptive in nature. Fredriksson (2001) conducted an informative study about the PISA project. In addition, the PISA data sets were used in order to compare the education in Britain with the educations in other countries. Taylor and Francis Group (2002) published an article explaining the properties of PISA and the report, Knowledge and Skills for Life-First Results from PISA 2000. The article also examines the first cycle of PISA project by using this report. McQuenn and Mendelovits (2003) discussed the steps taken to attain cultural relevance and appropriateness in the reading literacy construct and in the stimulus materials and items which operationalize it. Grisay (2003) described the procedures implemented by the PISA International Center for the development of national versions of the assessment instruments in all instruction languages used in the participating countries.

In the following years, Linnakylä, Malin and Taube (2004) conducted a comparative study which explores, compares and contrasts, by means of two-level logistic regression models, students' personal, socio-economic and cultural factors and their effects on low as opposed to average reading literacy achievement in Finland and Sweden although the Finnish and Swedish students are among the best readers in all OECD countries according to the results of PISA 2000. They found that the risk of being a low achiever is strongly determined by gender and by several socio-cultural factors as well as by students' personal characteristics, attitudes and activities both at and outside school. Leino, Linnakylä and Malin (2004) examined the Finnish students' multiliteracy profiles from the perspectives of both traditional printed reading and internet activities based on the data collected in PISA 2000 study. The multiliteracy profiles are described, first from the perspective of literacy activities and further examined in relation to students' gender, reading literacy performance, socio-economic background as well as access to books and computers. Kjærnsli and Lie (2004) searched for similarities and differences between the Nordic countries concerning patterns of competencies defined as scientific literacy in PISA 2000 study. Turmo (2004) examined the relationship between the cultural, social and economic capital of students from the Nordic countries and their level of scientific literacy based on the data from PISA 2000 study. It is found that the relationship between the home's economic capital and students' level of scientific literacy is relatively weak; however, the relationship between the cultural capital of the home and the level of scientific literacy is surprisingly strong in several of the Nordic countries. Hvistendahl and Roe (2004) presented the literacy achievement of Norwegian minority students, their habits, and their enjoyment of reading based on the PISA 2000 study. They found that the achievement gap between majority and minority students is larger in Denmark and Germany than in Norway and Sweden. Halinen, Sinko and Laukkanen (2005) discussed the literacy concept, the ways of promoting literacy and the factors affecting literacy with respect to the Finnish students who are the best readers in the world according to the PISA 2000 and 2003 survey results.

Moreover, Iş Güzel and Berberoğlu (2003) conducted a research to investigate the factors affecting reading literacy and mathematical literacy skills of 15-year-old students in the Programme for International Student Assessment (PISA) 2000 data across different cultural settings such as Brazil, Japan and Norway. The results were discussed with reference to cultural context. Wirth and Klieme (2003) discussed the problem solving competence as a multidimensional construct. They emphasized that at least analytical and dynamic aspects of problem solving competence have to be distinguished if all aspects of problem solving are to be covered. They resulted that analytical aspects of problem solving competence are strongly correlated with reasoning, while dynamic problem solving reflects a specific dimension of self-regulated exploration and control that can be identified across computer-simulated domains. Lemke, Sen, Pahlke, Partelow, Miller, Williams, Kastberg and Jocelyn (2004) designed a report describing the performance of the U.S. students in mathematics literacy and problem solving skills. Bybee and Stage (2005) examined the content of the international assessments such as TIMSS and PISA, described TIMSS and PISA results in terms of U.S. students and discussed some important themes for gaining prominence in education in United States. Sen, Partelow and Miller (2005) designed another report describing how the U.S. education system compares with the education systems in the Group of Eight, or G8 countries which are among the world's most economically developed countries such as Canada, France, Germany, Italy, Japan, the Russian Federation, the United Kingdom and the United States.

The mathematical performance of the students is an essential factor in the field of mathematics education, because the mathematics performance symbolizes the success in the mathematics education. The performance of the students in mathematics is the main focus in most of the studies. Many researchers have studied the factors affecting the performance of the students in mathematics for a long time. The aim of these studies in this field is to investigate the factors in order to increase the students' performances in mathematics. On the basis of the findings of these studies, the educators are able to make the appropriate modifications in mathematics education.

It is widely believed that students' socio-economic backgrounds have a considerable impact in shaping opportunities for them which provide discriminatory educational experiences and this provides a significant potential effect on their academic achievement (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Boocock, 1980, as cited in Dowson & McInerney, 1998; Bos & Kuiper, 1999). Parental occupational status has a strong association and parent education has a positive influence with student performance on mathematical literacy (OECD Publications, 2004). Moreover, possessions and activities related to classical culture in the family home which is one of the aspects of students' socio-economic background also tend to be closely related to academic success (OECD Publications, 2004).

There is no evidence on the relationship between students' attitude to school and student performance. However, it has been shown to relate to other important outcomes relevant to learning for life. Among the school climate variables, poor student-teacher relations has a strong negative impact on mathematics performance. Furthermore, sense of belonging at school deserves to be treated alongside academic performance as an important outcome of schooling (OECD Publications, 2004).

Motivation has been found to be an important predictor for course selection, career choice, and performance (Eccles, 1994, as cited in OECD Publications, 2004, p. 123). A positive disposition towards mathematics remains an important educational goal in its own right for the interest in mathematics (OECD Publications, 2004). A number of studies have found that students' belief of their mathematical abilities is a powerful predictor of student success, course and career selection (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999). Self-efficacy is one of the strongest predictors of student performance. In fact, students' self-efficacy in mathematics is even more closely related to student performance on the PISA 2003 mathematics assessment than self-concept in mathematics (OECD Publications, 2004, p. 136). Anxiety is negatively related to student performance. Indeed, this association is not only strong at student levels as was the case with self-efficacy (OECD Publications, 2004). Students' academic self-concept is both an important outcome of education and a powerful predictor of student success (Marsh, 1986).

The relationship between reported use of control strategies and student performance in mathematics tends to be relatively weak. This is different from the case of reading in PISA 2000, where the use of control strategies was strongly related to reading performance. However, it is difficult to compare the values of memorization and elaboration strategies across countries and cultures because of the need for reference to the cultural and educational contexts and analyses (OECD Publications, 2004).

Individualistic competition has been shown to positively influence performance on high level skills (Okevukola & Ogunniyi, 1984, as cited in Al-Halal, 2001). On the other hand Ames and Ames (1984, as cited in Al-Halal, 2001) who compared different teaching instruction; competitive, individualistic, and cooperative reported that it is none of them was more effective than each other with respect to students' motivation and achievement. Actually, active learners use both strategies on different occasions, rather than limiting themselves to a single strategy that may not be best in a particular situation (OECD Publications, 2001, p. 115).

To the extent that teachers typically use more supportive practices for weaker students or classes attended by a majority of less able students, the correlations between support and performance would be expected to be negative. At the same time, to the extent that the encouragement offered is effective, one would expect that performance would be higher in classes that receive more support than in other classes. As might be anticipated from this, the relationship is mixed and generally weak (OECD Publications, 2004, p. 214). In terms of disciplinary climate, Bos and Kuiper (1999) found class climate did not show significant relationships with mathematics achievement in the most of the models of European countries. On the contrary, PISA 2000 results were supposed that the disciplinary climate have an influence on students' performance (OECD Publications, 2001). Therefore, it is hard to say something about the association between disciplinary climate in mathematics lessons and mathematics performance.

Factors that are influential on achievement level of students have been extensively studied. Among them, some particularly focused on mathematics achievement and school variables having impact on student performance. For instance, Lim (1995) conducted a research showing that school type had the most influence on the students' perceptions of classroom environment. Private schools have performance advantage, but once the socio-economic factors are taken into account, an advantage for public schools emerges. Therefore, it is realized that private schools have a significant part of their advantage due to their combined socio-economic intake (OECD Publications, 2004). The association between the school size and mathematics performance is found as negative (Edington & Martellaro, 1989). Lee and Bryk (1989) suggested that the schools with larger sizes and higher socio-economic status were less equitable in mathematics achievement. According to Lee, Smith, & Croninger (1997) the influence of larger schools on academic achievement was found as negative in high school mathematics and science. Moreover, school size tends to be positively related to school performance, all other things equal (OECD Publications, 2004). Student-teacher ratio is an indicator of the availability of teachers in relation to the number of students to be taught. Higher student-teacher ratio should be associated with lower levels of student attainment (Bidwell, & Kasarda, 1975).

The relationship of use of assessments with mathematics performance is quite different across the participating countries in PISA project such as positive and negative relationships (OECD Publications, 2004). Similarly, it is difficult to interpret relationships between schools' admittance policies and their performance. The ability grouping lessens the likelihood that students become discouraged by material that is too difficult for them or bored by material that is too easy (Hallinan, & Sørensen, 1987). The avoidance of ability grouping in mathematics classes has a positive effect on student mathematics performance. This positive effect reduces after accounting for the impact of socio-economic background (OECD Publications, 2004). Schools' offering of activities to promote student engagement with mathematics, such as mathematics competitions, mathematics clubs or computer clubs related to mathematics; tend to have a positive impact over and above all other factors. However, it is found that schools' offerings of activities to promote the engagement with mathematics depend highly on the socio-economic characteristics (OECD Publications, 2004). There is a weak association between the different aspects of school autonomy and the performance of students within a given country (OECD Publications, 2004).

It is found that students enrolled in schools where principals reported a high degree of teacher shortage tended to perform lower. However, this disadvantage is small once socio-economic factors are taken into account (OECD Publications, 2004). The association of quality of school's educational resources with school performance on mathematics tended to be slightly stronger than with regard to the quality of school's physical infrastructure, but remains weak (OECD Publications, 2004).

School principals' perceptions of students' morale and commitment tended to be lower than their perceptions of teachers' morale and commitment. Statistically significant positive effects of students' morale and commitment are found in some of the participating countries. However, negative effects are also observed in some of the other participating countries. The association between school principals' perceptions of teachers' morale and commitment and their students' scores in mathematics literacy tends to be weak (OECD Publications, 2004). The relationship between school principals' perceptions of student-related factors affecting school climate and student performance in mathematics tends to be positive similar with the association between teacher-related factors affecting school climate and student performance (OECD Publications, 2004).

In fact, factors related to student performance have also been extensively studied in modeling studies. The focus of the studies was the student performance and the factors affecting student understanding. For instance, academic and mathematics self-concepts (Marsh, 1986); social class, racial/ethnic, and academic background (Lee, & Bryk, 1989); mathematics ability perceptions, performance expectancies, value perceptions, and mathematics anxiety (Eccles, Meece, & Wigfield, 1990); home environment, motivation, mathematics attitude, and classroom environment (Reynolds, & Walberg, 1992); attitude towards mathematics on the basis of feeling of enjoyment, feeling of difficulty, and perceptions of mathematics (Ma, 1997); critical events, inattentiveness, student attitudes based on enjoyment of school, teacher responsiveness, and usefulness (Hill, & Rowe, 1998); antecedent variables, perceived importance of mathematics, and attitudes towards mathematics (Abu-Hilal, 2000); instructional and school organizational characteristics (D'Agostino, 2000); family context, learning experiences, self-efficacy, and interest (Ferry, Fouad, & Smith, 2000); student, school and education policy factors (Ryoo, 2001); teacher evaluation scores (Gallagher, 2004); instructional resource allocation and use (Lee, 2004); teacher empowerment (Park, 2003); student, teacher and school factors (Van den Broeck, Van Damme, & Opdenakker, 2005) are some of the variables considered as predictors of students' mathematics achievement performance. Furthermore, the database of the Third International Mathematics and Science Study (TIMSS) and the Programme for International Student Assessment (PISA) provided a comprehensive source to analyze the mathematics performance of students from different standpoints. Among them, some compared the countries with different levels of performances, some developed models to test previously developed path analytic models and some others examined student, teacher, and school level characteristics (Bos, & Kuiper, 1999;

Fullarton et al, 2003; Iş Güzel & Berberoğlu, 2005; Papanastasiou, C., 2000, 2002; Papanastasiou, E., 2002; Rodriguez, 2004; Schreiber, 2000, 2002; Stemler, 2001).

As known, schools need to provide appropriate and equitable opportunities for a diverse student body. The relative success with which they do this is an important criterion for judging the performance of education systems. Identifying the characteristics of poorly performing students and schools can also help educators and policy-makers determine priorities for policy. Similarly, identifying the characteristics of high performing students and schools can assist policy-makers in promoting high levels of overall performance.

The aforementioned studies about PISA project provide information apart from the learning achievement in mathematics. The PISA particularly gives further opportunities to understand mathematics related performances within the structure of literacy concept. It seems quite important to understand the literacy concept and mathematical literacy skills of the students with respect to various student and school characteristics in order to enhance school curricula in line with the content and activities which are crucial to foster necessary life skills to deal with the daily life problems which require higher order cognitive processes. These skills are not completely independent of school curricula; rather they depend on basic skills covered in mathematics classes within the context of a daily life situation.

Thus, in the present study, within the framework of hierarchical linear modeling, it was aimed to test a model to investigate the influences of student and school characteristics on mathematical literacy skills of 15-year-old students through the use PISA 2003 data.

1.5.1 Purpose of the Study

The focus of the education is people who include many constructs, feelings and emotions. Therefore, education is a complex phenomenon, which a single indicator is not able to provide information about it. Thus, all factors affecting performance should be examined at the same time. The investigation of each construct's association with performance and also the examination of the relationships among all the constructs allow not only to obtain a general picture of the education system, but also to compare the education systems across the different cultural settings.

Thus, the purpose of the present study was to investigate the ways in which the school level factors influence the student level characteristics and in turn affect the students' mathematical literacy performance in a multi-layered school system. The present study was conducted on modeling of the identified student and school level factors selected with respect to the previous studies that have important effects on the performance of the students in mathematical literacy after the mathematics self-efficacy levels of the students was taken into consideration. Furthermore, all the associations between student and school level factors and mathematical literacy performance of students were compared across Turkey, member countries of European Union and candidate countries of European Union.

In fact, Turkey represented a low performing country with an average mathematics score of 423 in the PISA 2003 study. The mathematics scores of the member and candidate countries of European Union were presented in Table 1.1.

Table 1.1 Mathematics Scores of Member and Candidate Countries of European Union in PISA 2003

	Mathematics Score (OECD Average ≅ 500)
European Union Countries	
Austria	506
Belgium	529
Denmark	514
Finland	544
Germany	503
Greece	445
Ireland	503
Italy	466
Luxembourg	493
Netherlands	538
Portugal	466
Spain	485
Sweden	509

Table 1.1 (Continued)

European Union Candidate Countries	
Czech Republic	516
Hungary	490
Poland	490
Slovak Republic	498
Latvia	483

* Information about United Kingdom was not reported.

As previously stated, student and school level factors were included in the present study. The included student level factors that were considered as the variables associated with mathematical literacy performance were grade, gender, highest parental occupational status, highest educational level of parents, socio-economic and cultural status, computer facilities at home, cultural possessions of the family, home educational resources, attitudes towards school, student-teacher relations, sense of belonging at school, interest in mathematics, instrumental motivation in mathematics, mathematics self-efficacy, mathematics anxiety, mathematics self-concept, control strategies, elaboration strategies, memorization strategies, competitive learning, cooperative learning, teacher support in mathematics lessons and disciplinary climate in mathematics lessons. The school level factors were school type, school size, proportion of females enrolled at school, total student-teacher ratio, mathematics student-teacher ratio, use of assessments, academic selectivity, ability grouping between mathematics classes, mathematics extension courses, mathematics activities, resource autonomy, curricular autonomy, teacher shortage, quality of school's physical infrastructure, quality of school's educational resources, student morale and commitment, teacher morale and commitment, student-related factors affecting school climate, teacher-related factors affecting school climate.

1.5.2 Definition of Terms

1.5.2.1 Student Level Factors

1. *Highest Parental Occupational Status*

Students were asked to report their mothers' and fathers' occupations, and to state whether each parent was in full-time paid work; part-time paid work; not working but looking for a paid job; or other The highest international socio-economic index of occupational status corresponds to the highest international socio-economic index of occupational status of either the father or the mother. International socio-economic index of occupational status was derived from students' responses on parental occupation (OECD Publications, 2004, p. 307).

2. *Highest Educational Level of Parents*

Students were asked to identify the highest level of education of their mother and father on the basis of national qualifications, which were then coded in accordance with the International Standard Classification of Education (ISCED 1997) in order to obtain internationally comparable categories of educational attainment (OECD Publications, 2004, p. 308).

3. *Economic, Social and Cultural Status*

The economic, social and cultural status captures wider aspects of a student's family and home background in addition to occupational status. In as much as it is important to take socio-economic and cultural background into account when comparing the performance of any group of students, a comparison of the outcomes of education systems needs to account for countries' social, economic and cultural circumstances and the resources that countries can devote to education (OECD Publications, 2004). Turkey is a country with below-average student performance in mathematics and an above-average impact of socio-economic background on performance (OECD Publications, 2004, p. 184).

4. *Computer Facilities at Home*

Computer facilities at home was derived from students' reports on the availability of a computer they can use for school, educational software, and a link to the internet (OECD Publications, 2004, p. 309).

5. Cultural Possessions of the Family

Possessions related to classical culture in the family was derived from students' reports on the availability of the classic literature, books of poetry, and works of art (OECD Publications, 2004, p. 309).

6. Home Educational Resources

The index of *Home Educational Resources* was derived from students' reports on the availability of a dictionary, a quiet place to study, a desk for study, a calculator, and books to help with school work (OECD Publications, 2004, p. 309).

7. Attitudes towards School

Students were asked to think about what they had learned at school in relation to how the school had prepared them for adult life, given them confidence to make decisions, taught them things that could be useful in their job or been a waste of time (OECD Publications, 2004, p. 115).

8. Student-Teacher Relations

Students were asked to indicate their ideas about the relationship between themselves and their teachers with respect to the statements: most teachers are interested in students' well-being, students who need extra help, will receive it from their teacher, most teachers treat students fairly, students get along well with most teachers, and most teachers really listen to what students have to say (OECD Publications, 2004, p. 309).

9. Sense of Belonging at School

Students were asked to express their perceptions about whether their school was a place where they felt like an outsider, made friends easily, felt like they belonged, felt awkward and out of place or felt lonely (OECD Publications, 2004, p. 115).

10. Interest in Mathematics

Students were asked about their interest in mathematics as a subject as well as their enjoyment of learning mathematics. Interest in and enjoyment of a subject is a relatively stable orientation that affects the intensity and continuity of engagement in learning situations, the selection of strategies and the depth of understanding (OECD Publications, 2004, p. 115).

11. Instrumental Motivation in Mathematics

Students were asked to what extent they are encouraged to learn by external rewards such as good job prospects. Longitudinal studies show that such motivation influences both study choices and performance (OECD Publications, 2004, p. 115).

12. Self-Efficacy in Mathematics

Students were asked to what extent they believe in their own ability to handle learning situations in mathematics effectively, overcoming difficulties. This affects students' willingness to take on challenging tasks and make an effort and persist in tackling them. It thus has a key impact on motivation (Bandura, 1994).

13. Anxiety in Mathematics

Students were asked to what extent they feel helpless and under emotional stress when dealing with mathematics. The effects of anxiety in mathematics are indirect, once self-related cognitions are taken into account (Eccles, Meece & Wigfield, 1990).

14. Self-Concept in Mathematics

Students were asked about their beliefs in their own mathematical competence. Belief in one's own abilities is highly relevant to successful learning (Marsh, 1986), as well as being a goal in its own right.

15. Learning Strategies: Control Strategies

Students were asked about their use of learning strategies for mathematics that involve checking what one has learned and working out what one still needs to learn, allowing learners to adapt their learning to the task at hand. These strategies are used to ensure that one's learning goals are reached and are at the heart of the approaches to learning measured by PISA (OECD Publications, 2004, p. 116).

16. Learning Strategies: Elaboration Strategies

Students were asked about their use of learning strategies for mathematics that involve connecting new material to prior learning. By exploring how knowledge learned in other contexts relates to new material students acquire greater understanding than through simple memorization (OECD Publications, 2004, p. 116).

17. Learning Strategies: Memorization Strategies

Students were asked about their use of learning strategies for mathematics that involve representations of knowledge and procedures stored in memory with little or no further processing (OECD Publications, 2004, p. 116).

18. Preference for Competitive and Cooperative Learning Situations

Learning in adult life occurs most frequently in circumstances in which people work together and depend on one another. In formal education, particularly at secondary and tertiary levels, learning occurs in isolation, in a context of preparation for competitive assessment. Although cooperative learning and competitive learning can be in conflict, both can lead to high performance (OECD Publications, 2001, p. 114).

19. Teacher Support

Students were asked to indicate the frequency with which teachers in their mathematics lessons show an interest in every student's learning, give students extra help when they need it, help students with their learning, continue to teach until students understand and give students an opportunity to express opinions (OECD Publications, 2004, p. 211).

20. Disciplinary Climate

The student context questionnaire included questions that allow for the identification and comparison of students' perceptions of factors that affect schools' climate for learning, as it related to attitudes and behavior of students (OECD Publications, 2004).

1.5.2.2 School Level Factors

1. School Type

Even in comprehensive school systems, there may be significant variation in performance levels between schools, due to the socio-economic and cultural characteristics of the communities that are served or to geographical differences. Finally, there may be differences between individual schools that are more difficult to quantify or describe, part of which could result from differences in the quality or effectiveness of the instruction that those schools deliver (OECD Publications, 2004, p. 161).

2. School Size

The school size contains the total enrolment at school based on the enrolment data provided by the school principal, summing the number of males and females at a school (OECD Publications, 2004, p. 314).

3. Proportion of Females Enrolled at School

The proportion of females enrolled at school provides the proportion of females at the school based on the enrolment data provided by the school principal, dividing the number of females by the total of males and females at school (OECD Publications, 2004, p. 314).

4. Total Student-Teacher Ratio

Total student-teacher ratio is obtained by dividing the school size by the total number of teachers. The number of part-time teachers contributes 0.5 and the number of full-time teachers contributes 1.0 to the total number of teachers (OECD Publications, 2004, p. 314).

5. Mathematics Student-Teacher Ratio

Mathematics student-teacher ratio is obtained by dividing the school size by the total number of mathematics teachers.

6. Academic Selectivity

School principals were asked about admittance policies at their school. Among these policies, principals were asked how much consideration was given to the given factors when students are admitted to the school (OECD Publications, 2004, p. 314):

7. Use of Assessments

School principals were asked to rate the frequency of the given assessments for 15-year-old students at school (OECD Publications, 2004, p. 314).

8. Ability Grouping between Mathematics Classes

To determine the extent of ability grouping within schools, school principals were asked to report the extent to which their school organizes instruction differently for students with different abilities (OECD Publications, 2004, p. 315).

9. Mathematics Extension Courses

School principals were asked to report on the occurrence of the given activities to promote engagement with mathematics at their school (OECD Publications, 2004, p. 315).

10. Mathematics Activities

School principals were asked to report on the occurrence of the given activities to promote engagement with mathematics at their school (OECD Publications, 2004, p. 315).

11. Resource Autonomy

School principals were asked to report whether teachers, department heads, the school principal, an appointed or elected board or education authorities at a higher level had the main responsibility for the given statements. It is the number of decisions that relate to school resources that are a school responsibility (OECD Publications, 2004, p. 315).

12. Curricular Autonomy

School principals were asked to report whether teachers, department heads, the school principal, an appointed or elected board or education authorities at a higher level had the main responsibility for the given statements. It is the number of decisions that relate to curriculum which are a school responsibility (OECD Publications, 2004, p. 315).

13. Quality of School's Physical Infrastructure and educational Resources

Ensuring the availability of a suitable physical infrastructure and an adequate supply of educational resources may not guarantee high performance, but the absence of such an environment could affect learning negatively. Buildings in good condition and adequate amounts of teaching space all contribute to a physical environment that is conducive to learning. Much the same can be said for schools with adequate educational resources, such as computers, library and teaching materials, including textbooks and multimedia resources for learning (OECD Publications, 2004, p. 248). Using principals' responses to a series of questions about the perceived extent to which material and educational resources hinder learning among 15-year-old students, two factors were created, one on the quality of the school's physical infrastructure and the other on the quality of educational resources (OECD Publications, 2004, p. 250).

14. Teacher Shortage

The PISA school questionnaire provides an opportunity to assess school principals' perspectives of the adequacy of teacher supply and to assess aspects such as perceptions about the quality and availability of teaching staff (OECD Publications, 2004, p. 245). Teacher shortage was derived from items measuring the school principal's perceptions of potential factors hindering instruction at school. These factors are a shortage or inadequacy of qualified mathematics teachers, qualified science teachers, qualified test language teachers, qualified foreign language teachers, and experienced teachers. (OECD Publications, 2004, p. 315).

15. Teachers' Morale and Commitment

School principals were asked to provide their views on teachers' morale and commitment. They were asked to indicate how strongly they agreed or disagreed with the following statements concerning the teachers in their schools such that teachers work with enthusiasm, teachers take pride in this school, the morale of teachers in this school is high and teachers value academic achievement (OECD Publications, 2004, p. 316).

16. Students' Morale and Commitment

School principals were asked to provide their views on students' morale and commitment indicating how strongly they agreed or disagreed with the following statements concerning the students in their schools such that students enjoy being in school, students work with enthusiasm, students take pride in this school, students value academic achievement, students are cooperative and respectful and students do their best to learn as much as possible (OECD Publications, 2004, p. 316).

17. Teacher-Related Factors Affecting the School Climate

Principals were asked to indicate the extent to which they perceived learning in their schools to be hindered by such factors as the teachers' low expectations of students, poor student-teacher relations, absenteeism among teachers, staff resistance to change, teachers not meeting individual students' needs, and students not being encouraged to achieve their full potential (OECD Publications, 2004, p. 219).

18. Student-Related Factors Affecting the School Climate for Mathematics

Principals were asked to indicate the extent to which learning is hindered by such factors as student absenteeism, the use of alcohol or illegal drugs and disruption of classes by students (OECD Publications, 2004, p. 214).

1.5.3 Significance of the Study

The PISA study is important because of being an international study. The international studies like TIMSS, PISA and PIRLS provide a base for both the international comparisons of the performance of education systems and the investigation of the assumptions about the quality of their own country's educational outcomes. In the international context, PISA provides strong, cross-culturally valid measures of competencies that are relevant to everyday life. Moreover, in the specific cultural context of a single country, PISA yields information to look closely at the factors associated with educational success.

The PISA study is also essential because of the assessment of the literacy domains. Generally the studies so far assessed the achievement in particular subjects. PISA project differs from these studies with respect to the assessed outcome in the study. As literacy concept is presented before, literacy is a lifelong learning in which new knowledge and skills necessary for successful adaptation to a changing world are continuously acquired throughout life. Thus, the PISA study assessed the ability of the students to complete tasks relating to real life depending on a broad understanding of key concepts rather than assessing the possession of specific knowledge.

As presented before, a few studies were conducted about the PISA project. In addition, these studies were generally informative studies about the PISA project. PISA being a new international project conducted first in the year 2000 and repeated in the year 2003 could be one of the reasons for the limited number of studies published. Consequently, the present study could be accepted as one of the first studies about the PISA 2003 project.

The present study tries to model the factors affecting mathematical literacy of 15-year-old students across different cultural settings through the use of the data sets from PISA 2003 project. Therefore, the purpose of the study was examine how the school level factors influence student level factors and in turn how the student level factors affect the students' mathematical literacy performance in a complex school system. Thus, a general pattern could be drawn about the impacts of human and physical resource allocations on students' mathematical literacy skills through PISA 2003 project across Turkey, member and candidate countries of European Union. On the basis of the general pattern, more information could be obtained on the ways to improve the performance levels of the students in mathematical literacy. Furthermore, since the PISA 2003 database is quite comprehensive to test different cultural settings, the findings about the effects of school and student level factors and the performance on mathematical literacy could be compared across Turkey, member and candidate countries of European Union. The results might provide comprehensive information about the Turkey education system and the education systems in the member and candidate countries of European Union that could be used by educators and policy makers to enhance the students' literacy experience across the different cultural settings.

CHAPTER II

LITERATURE REVIEW

This chapter of the dissertation is devoted to the presentation of the previous research in the literature related to the present study. Six main sections were included in this chapter: studies about Programme for International Student Assessment (PISA), studies about the relationship between student level factors and mathematical literacy or mathematics achievement performance, studies about the relationship between school level factors and mathematical literacy or mathematics achievement performance, related studies with the research content, related modeling studies using structural equation modeling, and lastly, related modeling studies using hierarchical linear modeling.

2.1 Studies about Programme for International Student Assessment (PISA)

An article was published examining the PISA project in some circumstances. These are the aim of PISA as the collection of the data on students' knowledge, skills and competencies in reading, mathematics and science for the OECD countries, the curriculum-focused and cross-curricular elements of PISA, and the assessment of PISA with respect to defined content areas not narrowly defined subject matter knowledge, the investigated subjects in PISA such as how well young people are prepared to meet the challenges of the future, whether they have the capacity to continue learning throughout life, whether some kinds of teaching and organization are more effective than others. In addition, the article used the PISA data in order to compare the education in Britain with the educations in other countries (Fredriksson, 2001).

Taylor and Francis Group (2002) published an article explaining the properties of PISA and the report, Knowledge and Skills for Life-First Results from PISA 2000. The article focused on the property of PISA as not being a one-off study, being a study to be repeated every three years in order to measure changes in pupils' achievements over time. The article also examined the domains to be measured in every three-year-period. In addition, the article looked over the first cycle by using the report, Knowledge and Skills for Life, which gives information about the first cycle of the PISA project.

Grisay (2003) described the procedures implemented by the PISA International Co-ordination Center for the development of national versions of the assessment instruments in all instruction languages used in the participating countries. Moreover, the article gave information in presenting data that provide some empirical information on the effectiveness of the procedures; developing two source versions, in English and French; producing two independent translations, one from the English and the other from the French source version, of the assessment material into the language of instruction in their country; reconciling them into a single national version; and checking the equivalence of all national versions against the source versions.

Iş Güzel and Berberoğlu (2003) conducted a research to investigate the factors affecting reading literacy and mathematical literacy skills of 15-year-old students in the Programme for International Student Assessment (PISA) 2000 data across different cultural settings such as Brazil, Japan and Norway. The results were discussed with reference to cultural context.

McQueen and Mendelovits (2003) discussed the steps taken to attain cultural relevance and appropriateness in the reading literacy construct and in the stimulus materials and items which operationalize it. The article explained the influence of multilingual considerations on the development of the reading literacy assessment instrument and noted some psychometric procedures used to maximize the validity of the instrument in an international context.

Wirth and Klieme (2003) discussed the problem solving competence as a multidimensional construct. They emphasized that at least analytical and dynamic aspects of problem solving competence have to be distinguished if all aspects of problem solving are to be covered. Analytical problem solving abilities are needed to structure, represent and integrate information. Dynamic problem solving includes aspects of self-regulated learning as well as the ability to adapt the problem solving process to a changing environment by continuously processing feedback information. The assessment of dynamic aspects of problem solving competence requires dynamic test environments. They resulted that analytical aspects of problem solving competence are strongly correlated with reasoning, while dynamic problem solving reflects a specific dimension of self-regulated exploration and control that can be identified across computer-simulated domains.

Hvistendahl and Roe (2004) presented the literacy achievement of Norwegian minority students, their habits, and their enjoyment of reading based on the PISA 2000 study. Aspects of their family background and attitudes towards school are related to literacy achievement results. A comparison between Denmark, Sweden, Norway and Germany shows that the achievement gap between majority and minority students is larger in Denmark and Germany than in Norway and Sweden. The minority students' responses to questions about socio-economic family background, reading habits, learning strategies and school motivation give a complex picture of their situation in Norwegian schools. The results indicate that there is some potential for equalizing differences between minority students and majority students.

Kjærnsli and Lie (2004) searched for similarities and differences between the Nordic countries concerning patterns of competencies defined as scientific literacy in PISA 2000 study. The first part focuses on gender differences concerning two types of competencies, understanding of scientific concepts versus skills in scientific reasoning, based on analyses of sum scores of groups of items. The second part focuses on differences and similarities between countries based on item-by-item analyses. In the last part cluster analysis has been used to see how countries establish clusters and whether these clusters represent meaningful groups in a geographical, cultural or political context.

Leino, Linnakylä and Malin (2004) examined the Finnish students' multiliteracy profiles from the perspectives of both traditional printed reading and internet activities in the light of the data collected as a national option integrated into the PISA 2000 study. Based on the responses to a survey questionnaire, students were grouped by cluster analysis into six distinct clusters according to the frequency with which they read diverse printed materials and were involved in various internet activities. The multiliteracy profiles are described, first from the perspective of literacy activities and further examined in relation to students' gender, reading literacy performance, socio-economic background as well as access to books and computers. Finally, some pedagogical suggestions are made with a view to different groups of student readers.

Linnakylä, Malin and Taube (2004) conducted a comparative study which explores, compares and contrasts, by means of two-level logistic regression models, students' personal, socio-economic and cultural factors and their effects on low as opposed to average reading literacy achievement in Finland and Sweden although the Finnish and Swedish students are among the best readers in all OECD countries according to the results of PISA 2000. They found that the risk of being a low achiever is strongly determined by gender and by several socio-cultural factors as well as by students' personal characteristics, attitudes and activities both at and outside school. The constructed model was relatively similar and predicted with approximately equal degrees of probability membership in the risk group in both countries. This lays a solid foundation for joint pedagogic developmental efforts.

Turmo (2004) examined the relationship between the cultural, social and economic capital of students from the Nordic countries and their level of scientific literacy based on the data from PISA 2000 study. It is found that the relationship between the home's economic capital and students' level of scientific literacy is relatively weak; however, the relationship between the cultural capital of the home and the level of scientific literacy is surprisingly strong in several of the Nordic countries. The results may be interpreted as a need in science education for a special focus on students from lower cultural backgrounds. To ensure that students from lower socio-economic backgrounds also achieve an adequate level of scientific literacy, it is argued that a cultural approach in science education is relevant and important.

Bybee and Stage (2005) examined the content of the international assessments such as TIMSS and PISA, described TIMSS and PISA results in terms of U.S. students and discussed some important themes for gaining prominence in education in United States. Halinen, Sinko and Laukkanen (2005) discussed the literacy concept, the ways of promoting literacy and the factors affecting literacy with respect to the Finnish students who are the best readers in the world according to the PISA 2000 and 2003 survey results.

Lemke, Sen, Pahlke, Partelow, Miller, Williams, Kastberg and Jocelyn (2004) designed a report describing the performance of the U.S. students in mathematics literacy and problem solving skills. Sen, Partelow and Miller (2005) designed another report describing how the U.S. education system compares with the education systems in the Group of Eight, or G8 countries which are among the world's most economically developed countries such as Canada, France, Germany, Italy, Japan, the Russian Federation, the United Kingdom and the United States.

2.2 Studies about the Relationships of the Student-Level Factors and Mathematical Literacy

It is widely believed that students' socio-economic backgrounds have a considerable impact in shaping opportunities for them which provide discriminatory educational experiences and this provides a significant potential effect on their academic achievement (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Boocock, 1980, as cited in Dowson & McInerney, 1998; Bos & Kuiper, 1999). The parental occupational status, the educational level of parents, computer facilities at home, cultural possessions of the family, and home educational resources are closely interrelated with socio-economic and cultural status. All of these factors about student background can be thought as important factors associated with the performance of students on mathematical literacy performance. Parental occupational status has a strong association with student performance (OECD Publications, 2004). Parent education may also be of significant educational benefit for children. The relationship between mothers' educational attainments and students' performance in mathematics is shown to be positive and significant in all participating countries in the PISA project. In addition to their own level of education, which is of course less amenable to policy, parents' support for their children's education is widely deemed to be an essential element of success at school. An important objective for public policy may therefore be to support parents, particularly those whose own educational attainment is limited, in order to facilitate their interactions both with their children and with their children's schools in ways that enhance their children's learning

(OECD Publications, 2004, p. 165, 166). Possessions and activities related to classical culture in the family home which is one of the aspects of students' socio-economic background also tend to be closely related to academic success (OECD Publications, 2004).

A relationship between students' attitude to school and student achievement is not evident. Nonetheless, the promotion of positive attitudes to school is worthwhile given that it has been shown to relate to other important outcomes relevant to learning for life (OECD Publications, 2004, p. 127). Among the school climate variables included, poor student-teacher relations has strong negative impact on mathematics performance (OECD Publications, 2004). Most students tend to have good relations with school staff and with other students, and they feel that they belong at school. However, some youths do not share this sense of belonging, and do not believe that academic success will have a strong bearing on their future. These feelings and attitudes may result in their becoming disaffected with school (Finn, 1989; Jenkins, 1995, as cited in OECD Publications, 2004, p. 127). Most studies about students' sense of belonging at school have been concerned with its relationship to academic performance. The sense of belonging at school can be, for some students, indicative of economic or educational success and long-term health and well-being. Thus, this perception deserves to be treated alongside academic performance as an important outcome of schooling (OECD Publications, 2004, p. 127).

The causal relationship between interest and enjoyment in mathematics and performance may well be complex and is difficult to discern. Interest in subject and performance may be mutually reinforcing and may also be affected by other factors, such as the social backgrounds of students and their schools. However, whatever the nature of this relationship, a positive disposition towards mathematics remains an important educational goal in its own right (OECD Publications, 2004, p. 120, 121). Motivation greatly influences the learning and performance of all students. This variable has been found to be an important predictor for course selection, career choice, and performance (Eccles, 1994, as cited in OECD Publications, 2004, p. 123). A number of studies have found that students' belief of their mathematical abilities is a powerful predictor of student success, course and career selection (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999). Self-efficacy is one of the strongest predictors of student performance. In fact, students' self-efficacy in mathematics is even more closely related to student performance on the PISA 2003 mathematics assessment than self-concept in mathematics (OECD Publications, 2004, p. 136). There is considerable cross-country variation in the degree to which students feel anxiety when dealing with mathematics, with students in Turkey reporting feeling most concerned. Anxiety in mathematics is negatively related to student performance. This means that students with an absence of anxiety about mathematics perform strongly in mathematics. The association between anxiety in mathematics and mathematics performance is not only strong at student levels as was the case with self-efficacy. In most countries, there is also a clear tendency for students in lower performing schools to report higher levels of anxiety in mathematics (OECD Publications, 2004, p. 140). Students' academic self-concept is both an important outcome of education and a powerful predictor of student success. Belief in one's own abilities is highly relevant to successful learning (Marsh, 1986). There is a moderately strong association between students' performance and their self-concept in mathematics. Moreover, this similar association is observed at school levels. Thus, schools in which the students tend to have a strong self-concept in mathematics tend to have high levels of mathematics performance. However, countries with high average self-concept in mathematics are not necessarily countries with high mean mathematics scores (OECD Publications, 2004).

The PISA 2003 study describes three constructs that are related to the control of learning strategies in general which is metacognitive strategies that involve planning, monitoring and regulation; memorization strategies such as learning key terms or repeated learning of material; and elaboration strategies such as making connections to related areas or thinking about alternative solutions (OECD Publications, 2004, p. 141). The relationship between reported use of control strategies and student performance in mathematics tends to be relatively weak. This is different from the case of reading in PISA 2000, where the use of control strategies was strongly related to reading performance. Students who are anxious about mathematics may use control strategies to help them more than those who are confident, so that while such strategies help individuals raise their performance, they are not on average used more by people who perform better. It is noteworthy that the relationship between the use of control strategies in mathematics and mathematics performance varies widely between countries (OECD Publications, 2004, p. 142). Students in PISA 2003 project were asked separate questions on their use of memorization and elaboration strategies in the field of mathematics. Memorisation strategies is an appropriate strategy when the students need to retrieve the information as presented. On the other hand, elaboration strategies are used to achieve understanding. However, it is difficult to compare the values of memorization and elaboration strategies across countries and cultures because of the need for reference to the cultural and educational contexts and analyses (OECD Publications, 2004).

Individualistic competition has been shown to positively influence performance on high level skills (Okevukola & Ogunniyi, 1984, as cited in Al-Halal, 2001). On the other hand Ames and Ames (1984, as cited in Al-Halal, 2001) who compared different teaching instruction; competitive, individualistic, and cooperative reported that it is none of them was more effective than each other with respect to students' motivation and achievement. They also added that each of them focuses on different ways of thinking. Students who like co-operative learning tend to perform better than those who do not. Those who like competitive learning also tend to perform better than those who do not. Behind this is a general tendency for those who like co-operative learning also to like competitive learning, and perhaps they have a positive disposition towards learning in general. This evidence suggests that active learners use both strategies on different occasions, rather than limiting themselves to a single strategy that may not be best in a particular situation (OECD Publications, 2001, p. 114, 115).

In some of the countries, there is important variation in students' perceptions of teacher support across schools. Indeed, males report particularly low levels of teacher support in their mathematics lessons in Turkey. To the extent that teachers typically use more supportive practices for weaker students or classes attended by a majority of less able students, the correlations between support and performance would be expected to be negative. At the same time, to the extent that the encouragement offered is effective, one would expect that performance would be higher in classes that receive more support than in other classes. As might be anticipated from this, the relationship is mixed and generally weak (OECD

Publications, 2004, p. 214). There is a tendency for participated counties in PISA 2003 project with more positive students' perceptions of disciplinary climate to perform better, but this relationship is not statistically significant (OECD Publications, 2004). Similarly Bos and Kuiper (1999) found class climate did not show significant relationships with mathematics achievement in the most of the models of European countries. On the contrary, PISA 2000 results were supposed that the disciplinary climate have an influence on students' performance (OECD Publications, 2001). Therefore, it is hard to say something about the association between disciplinary climate in mathematics lessons and mathematics performance.

2.3 Studies about the Relationships of the School-Level Factors and Mathematical Literacy

As previously stated, self-efficacy is one of the strongest factors associated with student performance in mathematics. In fact, the strongest relationship was observed between mathematics self-efficacy and mathematical literacy performance in the present study when the student level factors were considered. Thus, mathematics self-efficacy levels of students were decided to be controlled. Since the mathematics self-efficacy was considered as a controlling variable, the averages of mathematics self-efficacy levels of students were calculated separately for Turkey, European Union Countries and European Union Candidate Countries. Then, the average mathematics self-efficacy was examined as a controlling variable in the level-2 file in the hierarchical linear models. As there is a strong and positive association between mathematics self-efficacy and mathematics performance, the influence of average mathematics self-efficacy is expected as positive.

When the school type is considered, private schools have performance advantage. But once the socio-economic factors are taken into account, an advantage for public schools emerges. Therefore, it is realized that private schools have a significant part of their advantage due to their combined socio-economic intake. This also allows private schools to create a learning environment which is more conducive to learning (OECD Publications, 2004). Lim (1995) also conducted a research showing that school type had the most influence on the students' perceptions of classroom environment. The association between the school size and mathematics performance is found as negative (Edington & Martellaro, 1989). Lee and Bryk (1989) suggested that the effect of social class differentiation on achievement was enhanced in larger schools. That is, the schools with larger sizes and higher socio-economic status were less equitable in mathematics achievement. According to Lee, Smith, & Croninger (1997) the influence of larger schools on academic achievement was found as negative in high school mathematics and science. The small school may facilitate social interactions and inhibit differentiated curriculum and teachers' specialization. They suggested that the school size should be small, with the optimal size between 600 and 900 students. Smaller classes are valued by parents and teachers because they may allow students to receive more individual attention from their teachers and reduce the disadvantage of managing large number of students and their work. However, the predominance of teacher costs in educational expenditure means that reducing class size leads to sharp increases in the costs of education (OECD Publications, 2004, p. 259). On the other hand, in many countries, there is a tendency for teachers and schools to put weaker students into smaller classes so that these students can receive the necessary attention. In such situations, smaller classes would tend to perform worse, even if reducing class size were conducive to improving performance, all other things being equal (OECD Publications, 2004, p. 259). As a result, school size tends to be positively related to school performance, all other things equal (OECD Publications, 2004).

Total student-teacher ratio is an indicator of the availability of teachers in relation to the number of students to be taught, whereas mathematics student-teacher ratio is the availability of mathematics teachers. When the teacher handles more students during a class session, his/her response to them will be less refined. Then, the teacher has less information to attend and less time to evaluate it for each student. Therefore, the aggregate level of achievement will be lower when the number of students per teacher is more. In the schools with large enrollments of students, teachers adjust their time in the classroom themselves. This adjustment of time in classroom is likely take the form of different treatment to students in the classroom such as disproportionate amounts of time devoted to each student. Thus, higher student-teacher ratio should be associated with lower levels of student attainment (Bidwell, & Kasarda, 1975).

It is difficult to relate the use of assessments to learning outcomes at the national level, not only because such assessments differ widely in nature and quality, but also because assessment policies and practices are often applied differentially across school and programme types. However, for the use of teacher-developed tests, there is a tendency for schools in which these assessments are applied more frequently to perform better. More frequent uses of assessments relate to monitoring schools' progress, making decisions about students' retention or to inform parents about their children's progress (OECD Publications, 2004, p. 231, 232). The relationship of use of assessments with mathematics performance is quite different across the participating countries in PISA project such as positive and negative relationships (OECD Publications, 2004). Similarly, it is difficult to interpret relationships between schools' admittance policies and their performance. More selective schools may perform better simply because they do not accept poorly performing students, and not necessarily because they provide better services. At the cross-country level, the prevalence of some of the attributes of academic selectivity, including the use of students' academic record or recommendations from feeder schools tend to be positively related to country performance, but only weakly and not statistically significantly (OECD Publications, 2004, p. 228). Lee and Bryk (1989) suggested that the academic background of students is positively related to mathematics achievement. When the students are grouped by their ability, teachers are able to gear the level and pace of instruction to the aptitudes of the students. This lessens the likelihood that students become discouraged by material that is too difficult for them or bored by material that is too easy. Students in small groups have the chance of receiving more individual attention from the teacher than students in larger groups during the period of the instruction (Hallinan, & Sørensen, 1987). However, the avoidance of ability grouping in mathematics classes has a positive effect on student mathematics performance. This positive effect reduces after accounting for the impact of socio-economic background. In many of the participating countries, ability grouping is not used. Therefore, the effect of ability grouping tends not to be statistically significant at the country level (OECD Publications, 2004). Schools' offering of activities to promote student engagement with mathematics, such as mathematics competitions, mathematics clubs or computer clubs related to mathematics, tend to have a positive impact over and above all other factors. Each additional activity that is offered by schools is associated with the mathematics performance. However, it is found that schools' offerings of activities to promote the engagement with mathematics depend highly on the socio-economic characteristics. There is a weak association between the different aspects of school autonomy and the performance of students within a given country. However, it is found that school involvement in various areas of decision-making tends to be positively related to mathematics performance at least at the cross-country level (OECD Publications, 2004).

The recruitment and retention of a highly qualified teaching force is a major policy concern in OECD countries. Ageing teacher populations and rising student participation rates continue to put pressure on the demand for teachers in many countries, but aspiring teachers in some countries find that teaching can be unduly stressful, that the profession is under-appreciated, and that salaries are low by comparison with salaries in professions with comparable qualifications (OECD Publications, 2004, p. 245). When the association is considered, it is seen that students enrolled in schools where principals reported a high degree of teacher shortage tended to perform lower. However, this disadvantage is small once socio-economic factors are taken into account. Actually, principals in Turkey were the one of the most likely to perceive that a shortage of inadequacy of teachers hindered learning in their schools (OECD Publications, 2004). Ensuring the availability of a suitable physical infrastructure and an adequate supply of educational resources may not guarantee high performance, but the absence of such an environment could affect learning negatively. Buildings in good condition and adequate amounts of teaching space all contribute to a physical environment that is conducive to learning. Much the same can be said for schools with adequate educational resources, such as computers, library and teaching materials, including textbooks and multimedia resources for learning (OECD Publications, 2004, p. 248). In Turkey, the school principals frequently reported that the quality of their school's physical infrastructure and their supply and quality of educational resources hindered learning. The association of quality of school's educational resources with school performance on mathematics tended to be slightly stronger than with regard to the quality of school's physical infrastructure, but remains weak (OECD Publications, 2004).

Principals' perceptions of students' morale and commitment has a small positive effect. Statistically significant positive effects are found in some of the participating countries. However, negative effects are also observed in some of the other participating countries. Therefore, it can be said that the pattern is mixed. School principals' perceptions of students' morale and commitment tended to be lower than their perceptions of teachers' morale and commitment. The association between school principals' perceptions of teachers' morale and commitment and their students' scores in mathematics literacy tends to be weak. However, there are countries where the association is stronger. Therefore, the relationship between principals' perception of teachers' morale and commitment and student performance on mathematics tends to be weak as well at the cross-country level. Besides, a stronger relationship is found between school's principals' perceptions of teachers' morale and commitment and students' morale and commitment (OECD Publications, 2004). The relationship between school principals' perceptions of student-related factors affecting school climate and student performance in mathematics tends to be positive. Similarly, the association between teacher-related factors affecting school climate and student performance is found as positive. That is, the greater the concern with teacher-related factors affecting school climate, the lower the student performance in mathematics. However, this influence is not found as very strong in some of the participating countries (OECD Publications, 2004).

2.4 Related Studies with the Research Content

The purpose of the study, conducted by Quinn and Jadav (1987), was to explore possible causal relationships between attitude and achievement in the subjects of mathematics and reading for elementary school children. Cross-lagged panel analysis was performed as a secondary analysis of data from studies of elementary grade students. The analysis was conducted on measures from a total of 1 758 elementary students from the second to sixth grades. For the subjects and grade levels studied, liking activities related to a topic does not appear to be causally related to doing well in that topic. As a conclusion, no significant and predominant causal relationship between attitude and achievement was indicated. Subsequently, it was concluded that producing changes in one variable would not necessarily lead to changes in the other.

Tocci and Engelhard (1991) performed a study; the purpose of the study was to investigate the relationships of attitude towards mathematics with mathematics achievement, parental support, and gender. A secondary analysis was conducted using nationally representative samples of 13-year-old students, 3 846 students in the United States, and 3 528 students in Thailand, which were collected as a part of the Second International Mathematics Study. A multivariate general model was used to analyze the data within each country. Four attitude scales which were Mathematics and Myself, Mathematics and Society, Mathematics as a Male Domain and Mathematics Anxiety were used as the criterion variables. The Mathematics and Myself scale was designed to assess students' personal views of themselves as learners of mathematics. The extent to which students enjoy studying mathematics, feel confidence in their ability as learners of mathematics, and want to achieve in mathematics was reflected in the scale. The Mathematics and Society scale was designed to measure students' views of the usefulness and importance of mathematics to society. A positive view indicated that mathematics was seen as useful in everyday life and important in preparing for an occupation. The Mathematics as a Male Domain scale examined the extent to which mathematics was viewed by students as a male domain. And the Mathematics and Anxiety scale was designed to measure the extent to which the students were anxious about mathematics. Mathematics achievement, parental support and gender were used as the predictor variables. The Parental Support for Mathematics scale contained nine items designed to measure the students' perceptions of parental behaviors, including enjoyment when encountering mathematics, interest and ability to help their child with mathematics homework and encouragement to study and do well in mathematics. The results in both countries confirmed earlier research indicating a positive relationship between mathematics achievement and two of the attitudes, students who have higher scores on mathematics tests tend to have more positive perceptions of their encounters with and reactions to the subject of mathematics, and the usefulness of mathematics in society. In the study, parental behaviors do appear to be related to student attitudes towards mathematics. Some of the more permanent and important effects of attitude may occur because of factors in the home environment that are central to their developing value system. As a conclusion, achievement and parental support are significant predictor of attitudes towards mathematics, in both countries.

The study, conducted by Entwisle and Alexander (1996), investigated the family type and children's growth in reading and mathematics over the primary grades. In a random sample of Baltimore school children over the first 2 years of school, there are no direct effects of parent configuration on marks or test score gains in reading and mathematics. However, the children whose parents have higher expectations for their school performance consistently outperform other children in reading and mathematics. Both kinds of parents' expectations have significant and strong total effects on test score gains. Just like the children's reading performance, expectations variables explain the effects of family configuration on children's mathematics performance. Parents' expectations probably impel children to perform because they reflect a whole set of parental attitudes about and views of the child, but they also proxy specific steps parents take to help children do well. For instance, parents who have high expectations are more likely to provide opportunities for the child to learn at home. Adding parent expectation variables to models predicting test scores at the start of first grade increases the explained variance from 13% to 23% for reading, and from 31% to 44% for mathematics. As a conclusion, the stripped down models showed parents' psychological supports are important for children's school performance and are largely independent of their economic resources.

Okpala, Okpala and Smith (2001) investigated the influence of parental involvement, socioeconomic status of the parents and instructional supplies expenditures on mathematics achievement scores of grade 4 students in a low-income country in North Carolina. An educational production function framework was used to analyze the influence of educational resources on mathematics achievement scores. In addition, pearson product-moment correlation and ordinary least squares regression were used to determine the overall strength of each relation and the variables with the greatest impact on mathematics achievement. Instructional supplies expenditures per pupil are not significant for explaining changes in mathematics scores. This result did not clear the inconsistencies that exist in the literature concerning the impact of expenditures per student. Furthermore, this result supported the finding of other studies that increased educational expenditures will not enhance students' achievement scores.

Papanastasiou, E. (2002) performed a study; the purpose of the study was twofold as to examine how the attitudinal and instructional variables differentiated 4^{th} grade students in Cyprus, Hong-Kong, and the USA and to determine how these variables were related to mathematics performance on the TIMSS test. The countries were chosen to represent high performing, average and low performing countries, correspondingly, on the TIMSS fourth-grade mathematics test. Hong-Kong represented a high performing country, the USA represented an average performing country and Cyprus represented a low performing country. A discriminant analysis was performed to examine how those variables differentiated the students in the three countries. Extremely positive attitudes towards mathematics are held by Cyprus-like students. These are the same students who had the highest mathematics scores within each country. The less the students use computers in their classrooms, the higher their mathematics scores are. It is interesting that the highest means generally belong to students who have never used computers. In addition, the lowest mathematics score average belongs to the students who used computers for most of their lessons. The US-like students who use computers for some of their lessons have higher performance than the US-like students who use computers for most, or none, of their lessons. As a conclusion, 4^{th} grade students who like mathematics and who have not been taught using computers tend to be better students. A more important conclusion that can be drawn from this study is that the same variables do not always have the same effects on different students. In reality, patterns of the same variables can have very different effects on the students, depending on the cultural context that the students are in.

2.5 Related Modeling Studies using Structural Equation Modeling (SEM)

The previous modeling studies using Linear Structural Relations Statistics Package Program (LISREL) were presented in this section of the dissertation. The presented studies here investigated the factors affecting mathematics achievement of the students. Modeling studies examining the performance of the students in mathematical literacy were not found. One explanation is that literacy is a new concept in education. Thus, the modeling studies found in the literature about the investigation of factors affecting the mathematics achievement were presented in this part.

The purpose of the study, conducted by Marsh (1986), was to examine empirical support for the internal/external (I/E) frame of reference model that describes the relation between verbal and mathematics self-concepts, and between these academic self-concepts and verbal and mathematics achievement. The empirical tests were based on all studies that have employed the Self Description Questionnaire. The model of the study is displayed in Figure 2.1.

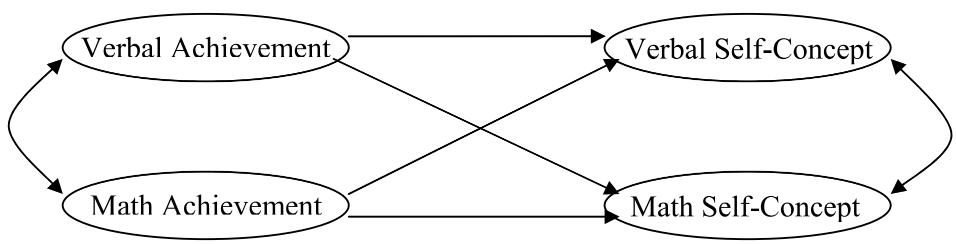

Figure 2.1 I/E Model of the Study (Marsh, 1986)

The I/E model was originally prompted by the observation that verbal and math self-concepts are relatively uncorrelated with each other, even though verbal and math achievement indicators are substantially correlated with each other and with the corresponding self-concepts. Despite high correlations between verbal and mathematics achievement indicators, and the significant correlation of each with the matching measure of academic self-concept, verbal and mathematics self-concepts are nearly uncorrelated with each other. Even though the mathematics and verbal self-concept correlation is significantly positive in some of these analyses, this correlation is substantially smaller than the mathematics and verbal achievement correlation. Furthermore, the direct effects of verbal achievement on mathematics self-concept, and the direct effect of mathematics achievement on verbal self-concept, are each significantly negative (Marsh, 1986).

Eccles, Meece and Wigfield (1990) used structural equation modeling procedures in order to assess the influence of past math grades, math ability perceptions, performance expectancies and value perceptions on the level of math anxiety in a sample of 250 students from 7th grade through 9th grade. A second set of analyses examined the relative influence of these performance, self-perception and affect variables on students' subsequent grades and course enrollment intentions in mathematics. Figure 2.2 presents the model of the study. The direct links between expectancies and Year 2 math grades are strong and positive, which indicates that students with higher performance expectancies in math have higher Year 2 grades. The results suggested that students' efficacy-related beliefs influence students' performances and academic choices in mathematics, as hypothesized. In addition, students' ability perceptions have strong direct effects on Year 2 performance expectancies, importance-ratings, but they have only indirect effects on Year 2 grades and intentions. As a conclusion, these results suggested that expectancy and importance ratings are stronger determinants of subsequent performance. The perceived value of mathematics may lead students to develop their mathematical skills and abilities, or students may come to value those skills and tasks they perform well.

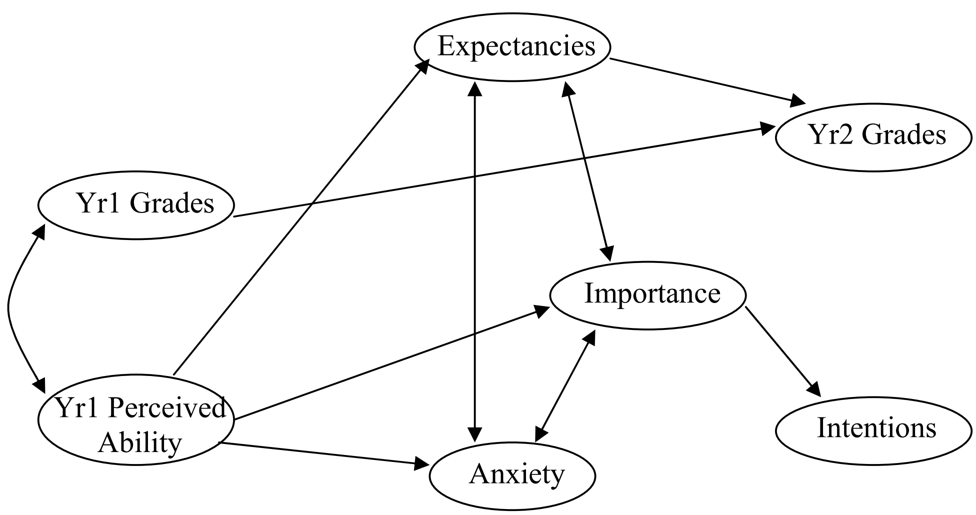

Figure 2.2 Model of the Study (Eccles, Meece and Wigfield, 1990)

Reynolds and Walberg (1992) conducted a study using a structural equation modeling with nine factors exert both indirect and direct effects on 7th grade mathematics achievement and attitude. A national probability sample of about 2 500 high school sophomore mathematics students were used in the further testing of the model. A three-wave longitudinal design incorporated data from students, teachers and parents. The structural model, evolved and cross-validated with the younger sample, significantly and substantially accounted for variance in mathematics achievement and attitudes toward mathematics. Figure 2.3 displays the model of the study.

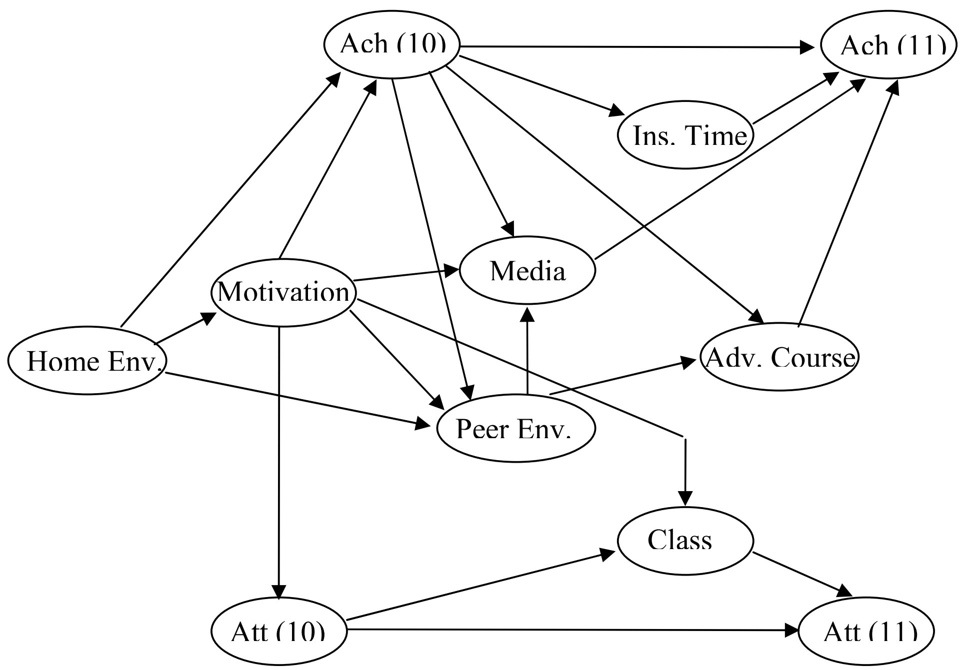

Figure 2.3 Model of the Study (Reynolds and Walberg, 1992)

Home environment has pervasive indirect effects on later achievement, and to a lesser degree, motivation. That result was expected, because children have been continuously exposed to the home environment since birth. Besides, prior attitude has small indirect effect on the achievement. On the other hand, the achievement-attitude relation suggested that the direction of the influence flows from achievement to attitude rather than the reverse. In addition, motivation and home environment have the greatest indirect effects on 11th grade mathematics attitudes, primarily through complex paths involving prior attitude. As a conclusion, home environment and previous achievement have the largest effects on achievement, perhaps because they cumulate during the preschool and elementary school years. Nonetheless, the other hypothesized factors, motivation, mathematics attitude, classroom environment also have significant effects on outcomes (Reynolds and Walberg, 1992).

Ma (1997) suggested that mathematics educators have done little to investigate the reciprocal relationship between attitude towards mathematics and achievement in mathematics. In the study of Ma (1997), the reciprocal relationship was modeled, using data from a Dominican national evaluation of high school mathematics with a sample of 1 044 students. Three data sets that were used to examine a hypothesized causal model demonstrated relatively good results on model-data-fit. The model used in the study is presented in Figure 2.4.

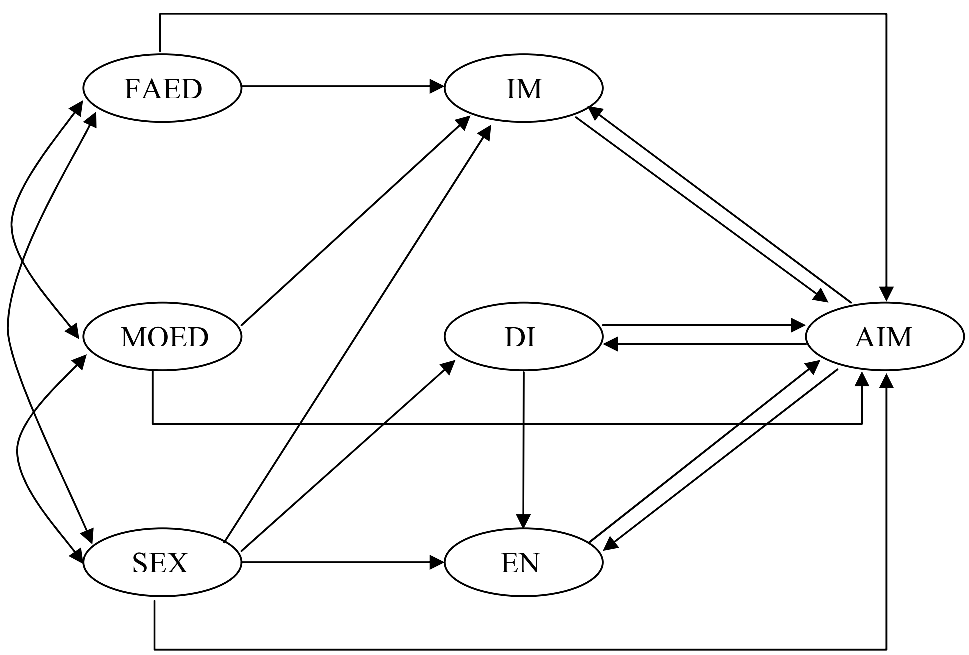

Figure 2.4 Structural Model of the Reciprocal Relationship (Ma, 1997)

A reciprocal relationship exists between every attitudinal measure and mathematics achievement. Moreover, the feeling of enjoyment, not the feeling of difficulty, directly affects mathematics achievement. On the other hand, the feeling of difficulty functions over the feeling of enjoyment to affect mathematics achievement. Furthermore, the perception of mathematics as important is independent of other attitudinal measures. As a conclusion, the findings suggested that the reciprocal or interactive nature between the attitude towards mathematics and achievement in mathematics can substantially modify their causal relationships. A unilateral relationship is likely to overestimate the causal effect between the attitude towards mathematics and achievement in mathematics (Ma, 1997).

Hill and Rowe (1998) suggested that long-standing and enduring problems in quantitative studies of educational effectiveness relate to fitting models that adequately reflect the complex inter-relationships among multivariate, multilevel factors affecting the students' educational progress, particularly among those that operate within classrooms. The article illustrated one approach to solving such difficulties by combining the analytic approaches of multilevel analysis and structural equation modeling in a two-stage process. The data used drawn from a longitudinal study of teacher and school effectiveness for three grade-level cohorts of 4 558 students clustered within 334 class or teacher groups in 52 elementary schools. The variables included in the model were critical events, inattentiveness, student attitudes such as enjoyment of school, teacher responsiveness, usefulness and two measures of student achievement in mathematics. The model of the study is given in the Figure 2.5. The results provided strong support for the proposition that it is the identity of the class or teacher groups to which students in elementary schools have been assigned that is the key determinant of their perceptions and experiences of schooling, as well as their academic achievement progress. In sum, teachers can and do make a difference. The importance of accounting for inter-relationships among factors operating within class or teacher groups affect the experiences of individual students and the classes to which they belong. As a conclusion, the finding that teacher responsiveness has strong effects on reducing their inattentiveness, together with the strong reciprocal effects between inattentiveness and mathematics progress, maximizes the progress of the students.

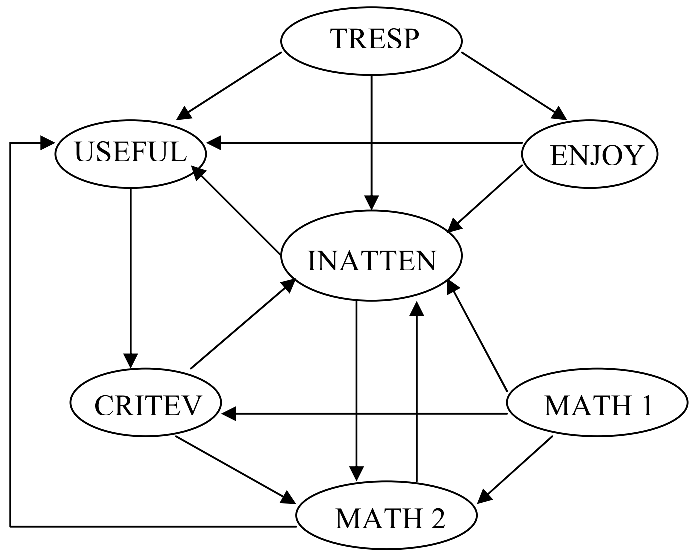

Figure 2.5 Schematic Multilevel, Structural Equation Model (Hill and Rowe, 1998)

Bos and Kuiper (1999) suggested that in international comparative studies like Third International Mathematics and Science Study (TIMSS), data analysis is aimed at differences and similarities among the education systems or the countries. In the study, the outcomes were presented of explorative path analysis on data collected with 8th grade students and classrooms in eight Western and two Central European education systems. For the 10 education systems, the resulting general path model explains 19% or less of the variance in achievement in mathematics. The model of the study is presented in Figure 2.6. The latent variables contained in the model were homework, teaching style, school climate, student's gender, maternal expectation, friends' expectation, success attribution mathematics, instructional formats, mathematics lesson climate, and attitude towards mathematics, home educational background, class size, effective learning time, assessment and out-of-school activities. In most of the 10 systems, attitude towards mathematics has a significant influence on achievement as a direct link. Attitude has a positive relation with achievement in 8 of the 10 systems, not in Germany and England. Class climate which was supposed to have a direct influence on achievement does not show a significant coefficient in the majority of the education systems, except for England with a significant path coefficient of 0.15. The percentage of the variance in class climate is explained by latent variables as homework, teaching style, school climate, friends' expectations and student's attitude.

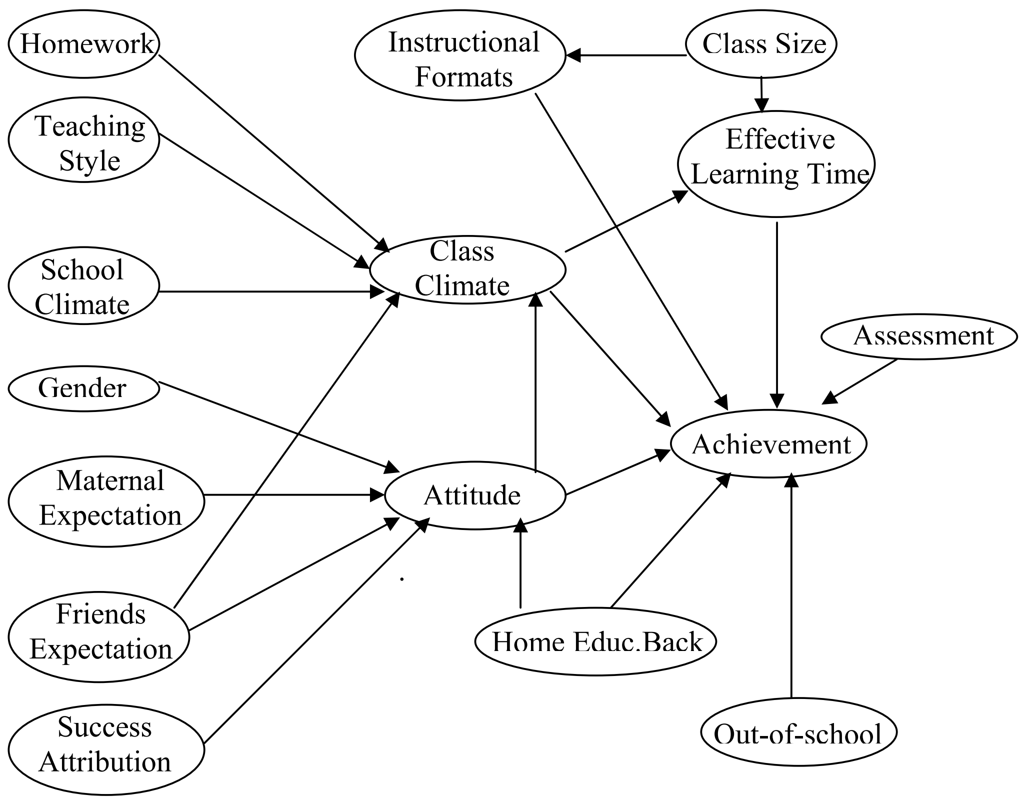

Figure 2.6 Recursive Student and Classroom Model (Bos and Kuiper, 1999)

Abu-Hilal (2000) conducted a study in order to test a model of mathematics achievement and its relations to antecedent and subsequent factors using structural equation modeling. A sample of 394 elementary school students in Al-Ain school district completed an Arabic version of the self-description. Students completed a questionnaire including their perception of the importance of mathematics, anxiety about it and the amount of effort they exerted in studying. Mathematics grades were obtained from the official school records. The model of the study is displayed in Figure 2.7. The study provided a result that mathematics importance or attitude towards mathematics relates positively to achievement in mathematics. In addition, importance of mathematics is positively, directly and indirectly related to self-concept. Moreover, students who attach more importance to and perform well in mathematics tend to develop positive perceptions of their abilities.

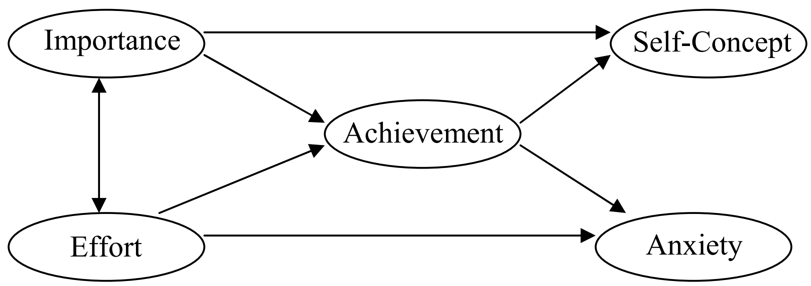

Figure 2.7 Structural Model of Mathematics Achievement (Abu-Hilal, 2000)

In the study of Ferry, Fouad and Smith (2000), the effects of family context and person input variables on learning experiences, self-efficacy, outcome expectancies, interests and goals were examined. Data on 791 undergraduate students enrolled in psychology classes at two universities were collected. Results based on a revised path model provided empirical validation of the Lent et al. (1994) model for this college student population. In the revised model, the included variables were age, gender, parental encouragement (enc), grades in mathematics and science classes (gms), math-science self-efficacy (msse), math-science outcome expectancies (msoe), math-science interests (msint), and math-science goals (msg). The model of the study is displayed in Figure 2.8. Parental encouragement in mathematics and science was found to significantly influence learning experiences. The magnitude of the path coefficient between encouragement and grades implies a causal link between encouragement and grades in mathematics and science. The more a parent is perceived as encouraging effort and experience in mathematics and science, the higher one's grades are in these areas. This result depicted the important influential role that parents' verbal suggestion, support, and domain-specific encouragement plays in their children's academic and career development. The significant indirect paths from encouragement to self-efficacy and outcome expectancies through grades was consistent with Lent and colleagues' (1994) hypothesis that contextual affordances inform learning experiences that predict self-efficacy and outcome expectancies. The relationships of mathematics and science grades to self-efficacy and outcome expectations illuminate the importance of performance accomplishments as a source of self-efficacy. Counselors can design, implement, and evaluate interventions that promote successful performance accomplishments and encourage students who have demonstrated prior achievement and aptitude in mathematics and science to participate in mathematics and science opportunities.

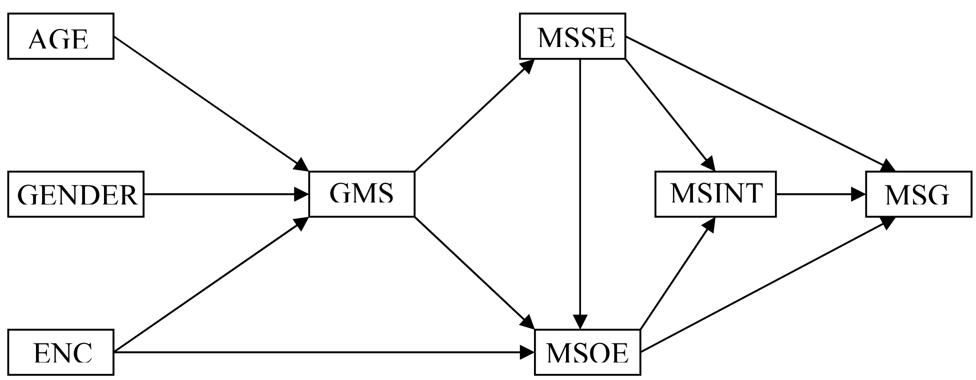

Figure 2.8 Revised Model of the Study (Ferry, Fouad and Smith, 2000)

Papanastasiou, C. (2002) investigated the mathematics achievement of 8th grade students in Cyprus enrolled the Third International Mathematics and Science Study (TIMSS) in the year 1994-1995, using a structural equation modeling. The model contained two exogenous constraints, the educational background of the family and the reinforcement from mother, friends and the individual himself; and five endogenous constructs, socioeconomic status, student attitudes towards mathematics, teaching, school climate and beliefs related to success in mathematics. The model of mathematics outcomes process of the study is displayed in Figure 2.9. The study demonstrated that although attitudes, teaching and beliefs have direct effect on mathematics outcomes, they are not statistically significant. Although the attitudes are positive for the majority of the students, achievements of the students in mathematics do not follow the same pattern. The findings of the study indicated that more should be undertaken to examine the influence of attitudes on mathematics outcome. He suggested that a positive relationship is often observed between mathematics achievement and the students' attitudes towards mathematics. That is, students who do well in mathematics generally have positive attitudes towards the subject, and those who have positive attitudes tend to perform better. Papanastasiou, C. (2000) was also conducted a study in which the same model was tested using the data from three countries, Cyprus, Japan and USA. In the study, the proposed model indicated that attitudes cannot be used to predict student outcomes in mathematics. As a conclusion, the attitudes towards mathematics are not found to be predictors of student achievement in mathematics in Cyprus, Japan and the US.

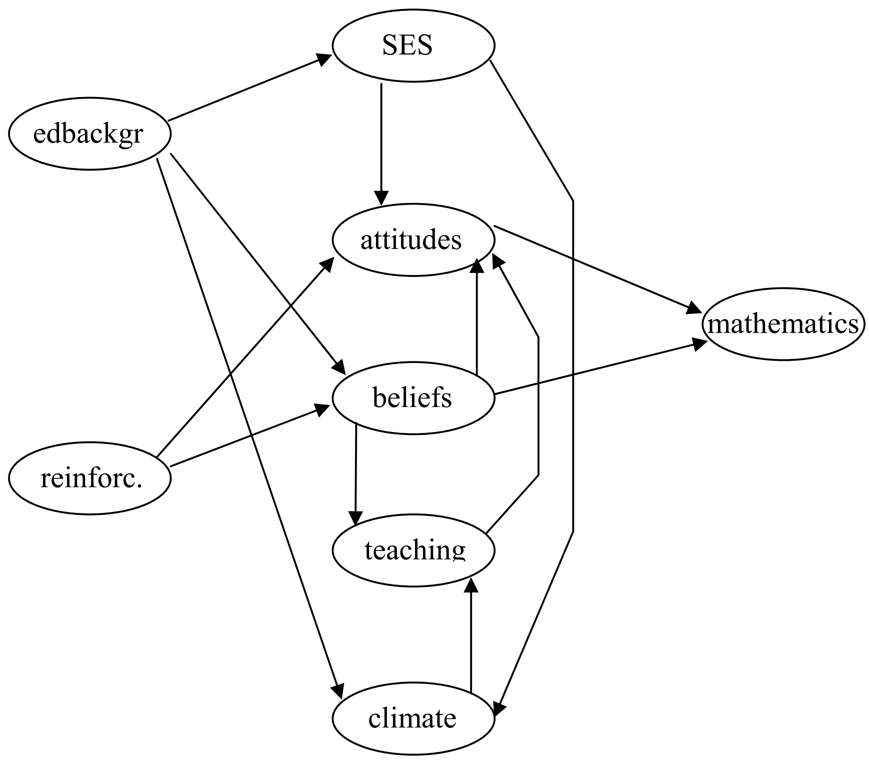

Figure 2.9 Model of Mathematics Outcomes Process (Papanastasiou, 2002)

Schreiber (2002) examined advanced mathematics achievement with 1 839 students from 162 schools. The data were obtained from the Third International

Mathematics and Science Study (TIMSS) 3rd population cohort. In order to examine the student-level and school-level factors, hierarchical or multilevel linear modeling was conducted. Figure 2.10 displays the model examined in this study. The results indicated a significant association between resources and mean advanced mathematics achievement. Overall, schools that have more resources have higher mean advanced mathematics achievement. The attitude-achievement slope coefficient indicated that, on average, student attitude towards mathematics is significantly and negatively related to advanced mathematics achievement. Because this item was reversely coded, the interpretation was that students with poor attitudes towards mathematics tend to perform lower on the test. This finding was important because it demonstrates that even the most advanced students' achievement is associated directly with their attitude towards mathematics. The analysis technique for the study was unidirectional. Although this analysis regressed achievement on attitude towards mathematics, this does not negate the possibility that attitude towards mathematics and achievement are bidirectional. Specially, the relationship could work in a bidirectional spiral pattern in which success increases attitude, which increases success, and so forth. In essence, attitude towards mathematics and mathematics achievement are simultaneously building on each other.

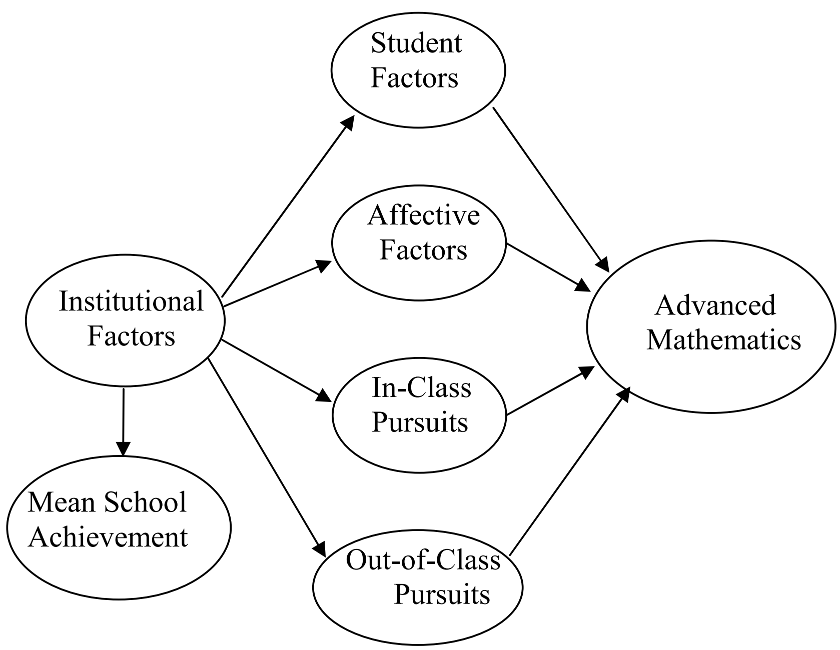

Figure 2.10 Model Examined (Schreiber, 2002)

Iş Güzel and Berberoğlu (2005) conducted a research to investigate the factors affecting reading literacy and mathematical literacy skills of 15-year-old students in the Programme for International Student Assessment (PISA) 2000 data across different cultural settings. Brazil, Japan and Norway were selected for the purpose of comparison on the basis of their rankings in the PISA project. The factors studied were attitudes towards reading, student-teacher relations, classroom climate, communication with parents, use of technology, attitudes towards mathematics, and reading literacy. The structural equation model examined in the study is presented in Figure 2.11.

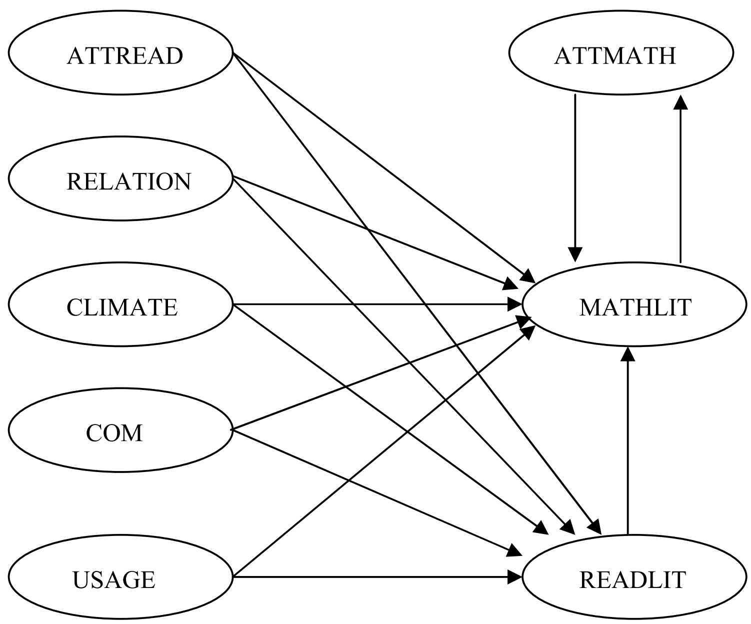

Figure 2.11 Structural Equation Model of the Study (Iş Güzel, and Berberoğlu, 2005)

The results indicated that the latent independent variable with the strongest effect on mathematical literacy is the use of technology in Brazil, communication with parents in Japan, and attitudes towards reading in Norway. In all the three countries, reading literacy had the strongest effect on mathematical literacy skills; mathematical literacy had a stronger relation to attitudes towards mathematics; attitudes towards reading was negatively related to mathematical literacy measures but positively related to reading literacy measures, and finally, communication with parents had a positive relation with reading literacy skills. A disciplined classroom environment fostered more success in PISA tests in Japan; on the other hand, in Brazil a reversed result was found for this particular variable. The use of technology had a strong influence on reading skills in Brazil; however, no and negative effects of this variable were observed in Norway and Japan respectively. These findings were discussed with reference to cultural context in the study (Iş Güzel, & Berberoğlu, 2005).

2.6 Related Modeling Studies using Hierarchical Linear Modeling (HLM)

Lee and Bryk (1989) identified some characteristics of secondary schools that encourage a high level of achievement and promote an equitable distribution of achievement across the diverse social class, racial/ethnic, and academic backgrounds of students. The data of the study consisted of a sub-sample of 10 187 students in 160 high schools from high school and beyond. Hierarchical linear modeling techniques were used to investigate the effect of the normative environment and academic organization of high schools on four social distribution parameters related to mathematics achievement. High average achievement is related to school social composition and to the school's academic emphasis. Although a smaller gap between the achievement of minority and white students is associated with an orderly school climate, less differentiation by social class and academic background are associated with smaller school size, less variability in course taking in mathematics, and a fair and effective disciplinary climate.

The purpose of the study, conducted by D'Agostino (2000), was to examine the effects of instructional and school organizational characteristics on the longitudinal mathematics and reading achievements of students from either a first-grade or third-grade cohort. Prospects, a data set on schools and students in the United States were collected during the early 1990s and this data was used in this study. Three schooling models were tested using hierarchical linear modeling (HLM) while controlling for parental socioeconomic status. The variables in the factor, school compositional effects were school size, days of school, urbanicity, poverty level, racial distribution, and student mobility. The variables in the factor, school organizational themes were stability and orderliness, social support and shared mission, and lastly decision-making, development and planning. The variables in the factor, instructional effects were basic-skill instruction, advanced-skill instruction, between-class grouping, in-class grouping, opportunity to learn, and homework. Factors and variables that represented instructional and school features were derived from teacher and principal responses to survey items. These features had direct and interactive effects on mathematics achievement, supporting both an environmental and interactive model of schooling. It is suggested that effective schools are successful at accumulating human resources, and they reach this state by fostering intragroup cohesion and morale. Good schools increase personnel commitment, and thus, motivate employees to achieve the organization's goals. As was evinced by the non-significance of the stability and orderliness composite, effective schools do not appear to focus on developing a formalized structure in order to create stability and predictability, as asserted by components of the continuity of the model. Perhaps, the greatest implication of these findings was that student achievement growth can be improved by modifying instructional practices and the school's organizational structure.

Schreiber (2000) conducted a study to gain a more complete understanding of the student and school level factors that influence advanced mathematics achievement in the United States. Using hierarchical linear modeling and the U.S. Population Three cohort from the TIMSS, the influence of student-level factors such as formal parent education, gender, after school employment, attitude towards mathematics, active responding and school-level factors such as resources, school size on advanced mathematics achievement were examined. The results indicated that students who performed better on the advanced mathematics test tended to have the following characteristics: enrolled in both advanced mathematics and physics, positive attitudes towards mathematics, parents with higher levels of formal education, perceived the classroom as active, believed that natural talent was the key to mathematics success, male, and spent less time engaged in non-academic activities. Additionally, the amount of time a student spent studying mathematics was not associated with achievement. The influence on advanced mathematics achievement varied from school to school with respect to formal parent education, gender, and attitudes towards mathematics. But, the average formal parent education of the school influenced the magnitude of a student's attitude towards mathematics.

The larger the faculty size, the fewer the resource shortages, and the higher the average formal education of the parents the higher the mean school advanced mathematics achievement. The severity of behavioral incidents did not significantly influence mean school achievement. Overall, the variables such as gender, parent education and attitude towards mathematics were observed to influence advanced mathematics achievement.

Ryoo (2001) conducted an analysis of education policies designed to increase levels of student achievement and to decrease differences of achievement across social groups. Social groups represented family socio-economic status and gender. The purpose of the study was to investigate to what degree student, school and education policy factors are related to improving student achievement and to reducing the school achievement gap. The determinants of the student achievement were student characteristics; family background and student effort; school characteristics; 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. The results indicated that a stratified school system has a positive effect on student academic achievement in mathematics, while it creates a bigger gap between students and schools. A composite variable indicating family background and socio-economic status has a significant and positive effect on achievement. Female students performed less well than male students. Regarding student time allocation, there is not a significant and positive relationship between television watching hours versus study hours and student achievement. With respect to school resources, a higher student-teacher ratio has a significant and negative effect on student achievement. The schools mean student socio-economic status is one of the strongest determinants of school achievement. Lastly, it was found that a national exam policy significantly increases student achievement.

Stemler (2001) explored school effectiveness in mathematics and science at the fourth grade using data from IEA's Third International Mathematics and Science Study (TIMSS). Exploratory models were developed using variables drawn from student, teacher, and school questionnaires. The variables were chosen to represent the domains of student involvement, instructional methods, classroom organization, school climate, and school structure. Six explanatory models for each subject were analyzed using two-level hierarchical linear modeling (HLM) and were compared to models using only school mean SES as an explanatory variable. In general, about one-quarter of the variability in mathematics and science achievement was found to lie between schools. The research findings revealed that after adjusting for differences in student backgrounds across schools, 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. In addition, more effective schools had students who reported less frequent use of computers and calculators in the classroom. These relationships were found to be stable across explanatory models, cultural contexts, and subject areas. This study has contributed a unique element to the literature by examining school effectiveness at the fourth grade across two subject areas and across 14 different countries.

Fullarton et al (2003) analyzed TIMSS data of Australia for the grades four and eight in both mathematics and science. Three-level hierarchical linear model was built to investigate the effects of student, teacher or classroom and school level factors. It was revealed that most of the variation in mathematics and science achievement arises from differences among students rather than their classrooms and schools. Verbal ability, socio-economic and socio-economic and socio-cultural background and attitude towards mathematics had significant effects on the performance of students. At the classroom level, class composition variables, namely, class mean of attitude towards mathematics and class mean of verbal ability test and at the school level, mean of socio-economic status were the only factors that had significant effects on mathematics achievement of students. The study did not identify any effects of teacher background such as age, gender, educational qualifications, teaching experience or approaches to teaching mathematics on the achievement measure. The reason of this was presented as the difficulty of capturing the details of what happens in the classroom.

Park (2003) examined the effects of teacher empowerment on teacher commitment and student achievement. Four teacher empowerment dimensions of formal authority, autonomy, collaboration, and trust based on the bureaucratic, professional and loose coupling perspectives were developed by a confirmatory factor analysis using the first and second follow-up data of National Educational Longitudinal Study of 1988. Utilizing the four dimensions of teacher empowerment, their relationships to the six environmental factors of teacher empowerment, their effects on teacher commitment, and their effects on student achievement were investigated. The results showed that differences in teacher empowerment existed at both teacher and school levels of the analyses. Gender, race, age, teaching experience, education level, and subjects taught were studied at the teacher level. The school background variables of sector, proportion of white students, size, and location and the six environmental factors were studied at the school level. Among the environmental factors, instructional materials, professional development opportunities, and principal leadership significantly affected the four dimensions while preparation time, rewards, and parent involvement did not significantly impact them. When both teacher-level and school-level variables were statistically controlled, teacher empowerment contributed to the variation in teacher commitment. Teachers empowered on the autonomy and trust dimensions were more committed to teaching activities. Female and non-white teachers were more committed than male and white teachers while mathematics teachers were less committed than history teachers. In the school-level analysis, public schools had more committed teachers and rewards and professional development were also positively related to teacher commitment.

Gallagher (2004) examined the validity of a performance-based, subject-specific teacher evaluation system by analyzing the relationship between teacher evaluation scores and student achievement. From a policy perspective, establishing validity was important because it is embedded in knowledge and skills based pay system, which attached high stakes to evaluation scores. In the first stage of the study, hierarchical linear modeling was used to estimate value-added teacher effects, which were then correlated with teacher evaluation scores in literacy, mathematics, language arts, and a composite measure of student achievement. Additionally, teacher evaluation scores were inserted into the hierarchical linear models as subject-specific predictors of student achievement. Results indicate a strong, positive, and statistically significant relationship between teacher evaluation scores and student achievement in reading and a composite measure of teacher and student performance and a positive, although not statistically significant, relationship in mathematics. In the second stage of the study, document analyses and interviews with teachers were used to explore factors affecting the relationship between teacher evaluation scores and student achievement across subjects. Findings suggest that the relationship is stronger in reading than mathematics because both teachers and evaluators have more pedagogical knowledge and better alignment to standards and assessments in reading than in mathematics.

Lee (2004) conducted a more systematic analysis of the 1992 NAEP teacher survey and student assessment data by constructing objective measures of key instructional resources and practices and investigating the ways in which the resources and practices affect student achievement in a multi-layered, complex school system. The study's objectives are to investigate the effectiveness of instructional resource allocation and use across the states and to explore the potentials and limitations of setting outcome-based standards of instructional resources and practices. It is found 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. Moreover, the availability of both human and physical resources was positively associated with the level of desirable instructional practices. Generally, the results showed that the effect of human resources was greater than the effect of physical resources.

Rodriguez (2004) investigated the relationship between assessment practices and achievement using U.S. TIMSS data. Several student level characteristics were important explanatory variables regarding variation in mathematics achievement, including mathematics self-efficacy, effort and level of uncontrollable attributions. At the classroom level, teacher assessment practices had significant relationships to classroom performance. In addition, cross-level interactions between student characteristics and teacher practices suggested that classroom assessment practices might uniquely interact with student characteristics in their role of motivating student effort and performance.

The purpose of the article published by Russell and Sibthorp (2004) is to provide examples of nested data structures and illustrate common approaches to dealing with this type of data often found in adventure education and therapy research. Data available from a study on the wilderness treatment outcomes are then analyzed using hierarchical linear modeling to illustrate how the process can increase interpretation of findings and inform future research. Results suggest that many of the variables of interest in research on adventure education and therapy, which might explain why outcomes vary for participants, may be missing from research designs due to nested data structures. It is also suggested to future researchers to consider hierarchical linear modeling approaches that may be appropriate for nested data structures common in studies on adventure education and therapy.

Van den Broeck, Van Damme and Opdenakker (2005) analyzed the effects of student, teacher and school level factors on students' achievement in Belgium (Flemish) data. Selecting two classes from each school made it possible to build three-level hierarchical linear model. As a national option, the extended versions of student, teacher and school questionnaires were used in addition to a parents' questionnaire and a numerical and spatial intelligence test. Questions on classroom climate and the constructivist learning environment were included in the extension of the teacher questionnaire in order to ascertain class characteristics. Through the international questionnaire, information referring to the age and the experience of he teacher were gathered. The average intelligence score of the class was calculated to make the group composition with respect to ability operational. By means of the null model, it was found that almost fifty-eight per cent of the total variance in mathematics scores is situated at the student level, twenty-eight per cent is due to the differences between classes and fourteen per cent is due to the differences between schools. Together with study oriented class and disruptive student factors, average intelligence score, which produced a very pronounced decline in deviance, explained more than ninety per cent of the variance at class level and more than one-third of the variance at the school level. After adding student level factors to the model, some of the class and school level factors were no longer significant. The researchers stated that more effort should be made to develop class and school level factors in the future TIMSS questionnaires.

2.7 The Present Study

In this chapter of the dissertation, theoretical framework of the study was explained and studies related to the study were reviewed. These findings indicated a general overview of the factors having impact on mathematics achievement. These summary results suggested that there is a need for further studies especially about PISA project in order to investigate influences of student level factors, school level factors and performance on mathematics literacy.

Actually, the PISA 2003 database is quite comprehensive to test different models explaining the associations between student level factors, school level factors and the mathematical literacy performance across different cultural settings. The study might provide many results that could be used by educators and policy makers to enhance student mathematical literacy performance in Turkey and to compare the results of Turkey, member countries of European Union and candidate countries of European Union.

CHAPTER III

METHODOLOGY

This chapter of the dissertation is devoted to the methodology of the present study. The methodology of the study was presented in six main sections. Population and sample, instruments, validity and reliability, procedure, data collection, data analyses were included as main sections in this chapter. All the sections are separately explained for Turkey, European Union Countries and European Union Candidate Countries.

3.1 Population and Sample

PISA needs to assess comparable target populations in order to achieve the comparability of the results. Differences between countries in nature and extent of pre-primary education and care, in the age of entry to formal schooling and in the structure of the education system do not allow school grades to be internationally comparable.

In order to provide the maximum coverage, the target population on the basis of the grade level is defined in some international assessments. The slight variation in the age distribution of the students across grade levels is a disadvantage of this grade-based target population. The variations in the distribution raise serious questions about the comparability of the results across the countries and within the countries. In addition, if the unrepresented students are enrolled in higher grade in one country and in lower grade in another country, this will exclude the students having higher levels of performance in the former country and the students having lower levels of performance in the latter country. Because of this, there may be serious bias in the results. As a consequence, PISA uses an age-based definition for its target population.

Students who are aged between 15 years 3 months and 16 years 2 months were covered in the assessment. The average age of the students was 15 years and 8 months across OECD countries. The grade or type of institution in which they are enrolled and of whether they are in full-time or part-time education was not regarded as a factor in the selection. Representing almost 23 million 15-year-old students enrolled in the schools of 41 participating countries were assessed in PISA 2003 (OECD Publications, 2004).

Countries in PISA were permitted to exclude up a total of 5 per cent of the population with respect to the sampling standards used. The bias resulting from these exclusions of 5 per cent is likely to remain in one standard error of sampling.

Exclusions were done at the school level or at the student level. The limits of the exclusions at the school level:

1. Geographically inaccessible schools or the schools believed that administration of PISA assessment was not feasible were excluded.
2. Schools where teaching was provided only for students in categories, for instance, for the blinds were excluded.

The percentage of the students in such schools had to be less than 2.5 per cent of nationally desired target population, 0.5% maximum for the first condition and 2% maximum for the second condition.

The limits of the exclusions at the student level:

1. Educable mentally retarded students decided by the opinion of school principal or qualified staff members and the students unable to follow the instructions at the assessment were excluded.
2. Permanently or physically disabled students, but the functionally disabled students able to respond were included in the assessment were excluded.
3. Non-native language speakers attended less than one year of instruction in the language of the assessment were excluded.

Students could not be excluded because of normal discipline problems. The percentage of the students excluded within schools had to be less than 2.5 per cent of nationally desired target population (OECD Publications, 2005).

At least 95 per cent of the target population was included in PISA 2003. As a consequence of the maximum coverage of students, the comparability of the results is achieved. Therefore, some statements can be made about the knowledge and skills of individuals born in the same year and still at school at 15 years of age, but having different educational experiences.

The present study was conducted through the three populations such as the population of Turkey, population of European Union Countries and population of European Union Candidate Countries. As the European Union Countries, the countries; Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom were selected. However, since the school questionnaire was not administered in France, this country was not included in the present study. On the other hand, the countries; Czech Republic, Hungary, Poland, Slovak Republic, and Latvia were selected as the European Union Candidate Countries. The total populations of 15-year-old students for each of the selected countries were presented in the Table 3.1 (OECD Publications, 2004).

Table 3.1 Total Populations of Students in the Participated Countries in PISA 2003

	Total Population of 15-Year-Old Students
Turkey	1 351 492
European Union Countries	
Austria	94 515
Belgium	120 802
Denmark	59 156
Finland	61 107
France*	809 053
Germany	951 800
Greece	111 286
Ireland	61 535
Italy	561 304
Luxembourg	4 204
Netherlands	194 216
Portugal	109 149
Spain	454 064
Sweden	109 482
United Kingdom	768 180

Table 3.1 (Continued)

	Total Population of 15-Year-Old Students
European Union Candidate Countries	
Czech Republic	130 679
Hungary	129 138
Poland	589 506
Slovak Republic	84 242
Latvia	37 544

* France was not included in the present study as the European Union Country since the school questionnaire was not administered in this country.

3.1.1 Sampling Procedures and Response Rates

Two-stage stratified sampling was used in most of the PISA samples. Firstly, individual schools where 15-year-old students were enrolled were selected. The selection of the schools was made systematically in the consideration of the probabilities proportional to size in order to include the estimated number of students. Although larger samples were required in national analyses, minimum 150 schools were selected in each country. After the schools were sampled, replacement schools were identified simultaneously. The identification of replacement schools was needed in case there was a problem in the participation of a sample school in PISA 2003. The sample selection process in each participating country was monitored by the experts from PISA Consortium. Minimum participation rates for the schools and the students were required by the data quality standards in PISA in order to minimize the response biases. By meeting the standards, any bias resulting from non-response will be smaller than the sampling error (OECD Publications, 2004).

For the initially selected schools, a minimum response rate of 85 per cent was required. When the initial response rate of schools was between 65 and 85 per cent, the required response rate was achieved by the usage of replacement schools. This procedure caused increased response biases. That's why; the participating countries were encouraged to persuade the participating schools in the original sample. The schools where student participation rate was between 25 and 50 per cent were not regarded as participating schools. The data collected from such schools were included in the database and various estimations were applied. The data collected from schools where student participation rate was less than 25 per cent were excluded from the database (OECD Publications, 2004).

A minimum participation rate of 80 per cent was required for the students within the participating schools. At the national level, not necessarily by each participating school, this minimum participation rate was required. If too few students participated in the original assessment sessions, follow-up sessions were applied in the schools. Student participation rates were calculated over all participating schools. The calculation was made regardless of the original sample or replacement schools. The participation of students in not only the original assessment but also the follow-up sessions was also regarded in the calculation (OECD Publications, 2004).

As previously stated, the present study was conducted as three parts including Turkey, European Union Countries and European Union Candidate Countries. The numbers of 15-year-old students assessed in the PISA 2003 project for each of selected countries were presented in the Table 3.2 (OECD Publications, 2004).

Table 3.2 Numbers of Students Assessed in the PISA 2003 for Participated Countries

	Number of Students Assessed in PISA 2003
Turkey	4 855
European Union Countries	
Austria	4 597
Belgium	8 796
Denmark	4 218
Finland	5 796
France*	4 300
Germany	4 660
Greece	4 627
Ireland	3 880
Italy	11 639
Luxembourg	3 923
Netherlands	3 992
Portugal	4 608
Spain	10 791
Sweden	4 624
United Kingdom	9 535

Table 3.2 (Continued)

	Number of Students Assessed in PISA 2003
European Union Candidate Countries	
Czech Republic	6 320
Hungary	4 765
Poland	4 383
Slovak Republic	7 346
Latvia	4 627

* France was not included in the present study as the European Union Country since the school questionnaire was not administered in this country.

3.1.2 Subjects of the Present Study

As the Turkey sample, all the Turkish students assessed in PISA 2003 project were included in the present study. 4 855 students who were participated and 159 principals who answered the school questionnaire in PISA 2003 project were included as the Turkey sample.

As the European Union Countries sample, all of the fourteen samples including the samples of Austria, Belgium, Denmark, Finland, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, and United Kingdom were included in the present study. Unfortunately, the sample of France was not selected as the European Union Country because the school principals in France did not answer the school questionnaire. When the samples of the fourteen countries were added up, 85 686 students and 3 098 school principals were included as the European Union Countries sample. However, the sample of the European Union Countries was very large when compared with the Turkey sample. This inequality in the samples could lead some biased results in the comparison of the results. Therefore, it was decided to select a random sample of European Union Countries whose size was almost the same as Turkey sample. Correspondingly, a random sample of 6% was selected from the whole European Union Countries sample. In the 6% random sample, 5 129 students and 189 school principals were included as the European Union Countries sample. The numbers of students and school principals selected for each country in the European Union Countries sample were displayed in the Table 3.3.

Table 3.3 Number of Students and School Principals Selected for Each Country in the European Union Countries Sample

	Number of Students	Number of School Principals
European Union Countries		
Austria	489	19
Belgium	709	23
Denmark	152	9
Finland	241	9
Germany	329	15
Greece	74	9
Ireland	234	9
Italy	628	22
Luxembourg	437	4
Netherlands	163	6
Portugal	185	7
Spain	651	23
Sweden	282	11
United Kingdom	555	23
Total	5 129	189

Lastly, all of the five samples including the samples of Czech Republic, Hungary, Poland, Slovak Republic, and Latvia were included as the European Union Candidate Countries sample in the present study. When the samples of the five countries were added up, 27 441 students and 1 117 school principals were included as the European Union Candidate Countries sample. Again, the sample of the European Union Candidate Countries was very large when compared with the Turkey sample. This inequality in the samples could also lead some biased results in the comparison of the results. Similarly, it was decided to select a random sample of European Union Candidate Countries whose size was almost the same as Turkey sample. Correspondingly, a random sample of 16% was selected from the whole European Union Candidate Countries sample. In the 16% random sample, 4 419 students and 185 school principals were included as the European Union Candidate Countries sample. The numbers of students and school principals selected for each country in the European Union Candidate Countries sample were given in the Table 3.4.

Table 3.4 Number of Students and School Principals Selected for Each Country in the European Union Candidate Countries Sample

	Number of Students	Number of School Principals
European Union Candidate Countries		
Czech Republic	1 058	45
Hungary	711	37
Poland	867	29
Slovak Republic	782	30
Latvia	1 001	44
Total	4 419	185

In Table 3.5, the distributions of the gender of the students in Turkey, European Union Countries and European Union Candidate Countries were presented. As can be seen from Table 3.5, there were 2 090 female and 2 765 male students in Turkey; 2 531 female and 2 597 male students in European Union Countries; and 2 225 female and 2 194 male students in European Union Candidate Countries.

Table 3.5 Distributions of Gender of the Subjects in Turkey, European Union Countries and European Union Candidate Countries

	Turkey	EU Countries	EU Candidate Countries
Female	2 090	2 531	2 225
Percent of Female (%)	43.0	49.3	50.4
Male	2 765	2 597	2 194
Percent of Male (%)	57.0	50.6	49.6
Missing	-	1	-
Percent of Missing (%)	-	0.1	-
Total	4 855	5 129	4 419

The distribution of the grades of the students in Turkey, European Union Countries and European Union Candidate Countries is given in Table 3.6. From the Table 3.6, there was a range in the grades. The grades of the students ranged from 7th

grade to 12th grade in Turkey and European Union Countries. In European Union Candidate Countries, the grades were ranged from 7th grade to 11th grade.

Table 3.6 Distribution of Grades of Subjects in Turkey, European Union Countries and European Union Candidate Countries

	Turkey	EU Countries	EU Candidate Countries
7th Grade	27	32	32
Percent of 7th Grade	0.6	0.6	0.7
8th Grade	92	264	228
Percent of 8th Grade	1.9	5.1	5.2
9th Grade	191	2 058	2 830
Percent of 9th Grade	3.9	40.1	64.0
10th Grade	2 863	2 199	1 299
Percent of 10th Grade	59.0	42.9	29.4
11th Grade	1 670	392	18
Percent of 11th Grade	34.4	7.6	0.4
12th Grade	12	184	-
Percent of 12th Grade	0.2	3.6	-
Missing	-	-	12
Percent of Missing	-	-	0.3
Total	4 855	5 129	4 419

3.2 Instruments

Four domains were examined in PISA 2003. These four literacy domains were reading literacy, mathematical literacy, science literacy and problem solving skills. But, mathematical literacy was included in the present study. The concept of literacy used in PISA has a meaning more than the ability to read and write. Literacy is continuous which is not something either to have or not have. Between a fully literate person and an individual that is not literate, there is not a clear dividing line (OECD Publications, 2004).

The literacy takes place not only at school or through formal learning, but also through interactions with peers, colleagues and wider communities. That’s why, literacy is a lifelong process. Although the 15-year-old students cannot be expected to know everything as adults, they should have the knowledge and skills in areas such as reading, mathematics and science (OECD Publications, 2004). In addition, to apply their learning to the real world, they should know some elementary processes and principles. Because of this, the ability to complete tasks related with real life is assessed in PISA.

A comprehensive assessment of how well a country is performing in education must look at the cognitive, affective and attitudinal aspects in addition to academic performance. To this end, PISA 2003 establishes a broader profile of what students are like as learners at age 15, one that includes students' learning strategies and some of non-cognitive outcomes of schooling that are important for lifelong learning: their motivation, their engagement and their beliefs about their own capacities. Since the focus of PISA 2003 was on mathematics, most of these issues were analyzed in the context of mathematics as well (OECD Publications, 2004, p. 110).

The assessment areas covered by PISA are defined in terms of:

1. The content or structure of knowledge

The students need to acquire in each assessment area, e.g., familiarity with mathematical concepts).

2. The processes

The students need to perform the processes, e.g., pursuing a certain mathematical argument)

3. The situations

The students encounter mathematical problems and relevant knowledge and skills that are applied in situations, e.g., making decisions in relation to one's personal life, or understanding world affairs (OECD Publications, 2004, p. 25).

In addition to literacy in mathematics domain, the background questionnaires completed by students and school principals provide essential information. The characteristics and attitudes of students as learners in mathematics were categorized as motivational factors and general attitudes towards school including interest in and enjoyment in mathematics, instrumental motivation in mathematics, attitudes towards school and sense of belonging at school; self-related beliefs in mathematics including self-efficacy in mathematics and self-concept in mathematics; emotional factors in mathematics including anxiety in mathematics; and student learning strategies in mathematics including memorization/rehearsal strategies, elaboration strategies and control strategies (OECD Publications, 2004).

On the other hand, the school factors that were examined in PISA were selected on the basis of three strands of research: studies on effective teaching and instruction, which tend to focus on classroom management and teaching strategies, such as students' opportunity to learn, time on task, monitoring performance at classroom levels, approaches to teaching and differentiation practices; school effectiveness studies, which focus on organizational and managerial characteristics of schools, such as school and classroom climate, achievement orientation, school autonomy and educational leadership, evaluation strategies and practices, parental involvement and staff development; studies of economic factors relating to production functions, which focus on resource inputs, such as school size, student/teaching staff ratios, the quality of schools' physical infrastructures and of their educational resources, teacher experience, training and compensation, and how these translate into educational outcomes (OECD Publications, 2004, p. 208).

3.2.1 Mathematical Literacy Assessment

Mathematical literacy in PISA was defined as the following (OECD Publications, 2004):

> *Mathematical literacy is the capacity to identify, understand the role that mathematics plays in the world, to make well-founded judgments and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen (p.26).*

Students' mathematical knowledge and skills were assessed according to three dimensions relating to:

1. the mathematical content to which different problems and questions relate;
2. the processes that need to be activated in order to connect observed phenomena with mathematics and then solve the respective problems; and
3. the situations and contexts that are used as sources of stimulus materials and in which problems are posed (OECD Publications, 2004, p. 38).

These three components are presented in visual form in Figure 3.1. These three components of mathematics domain will be explained in detail later on this chapter of the dissertation.

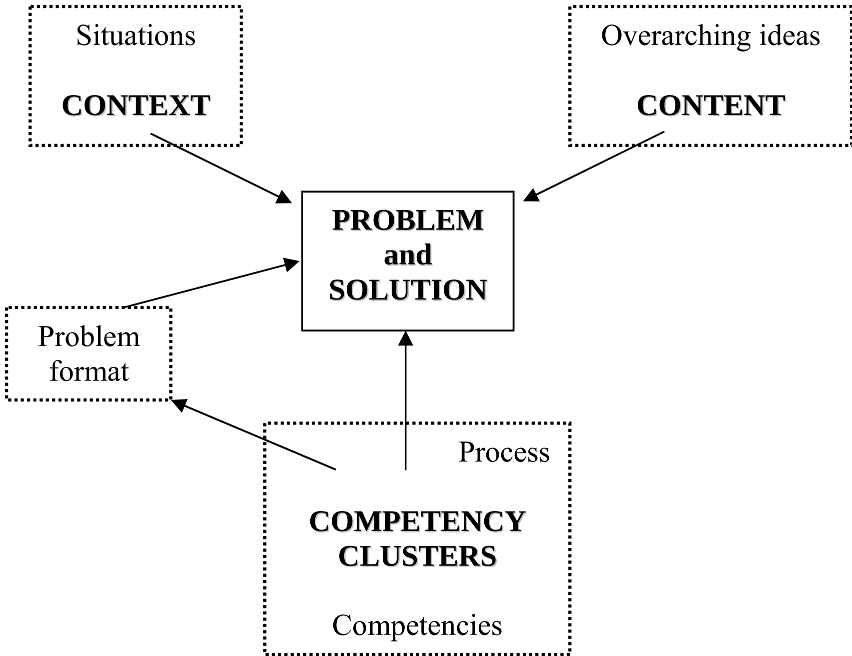

Figure 3.1 Components of the Mathematics Domain
(OECD Publications, 2003, p. 30)

In mathematical literacy assessment, a combination of question types was used. A problem or situation was represented on each task and a set of questions was asked depending on the problem or situation. The questions were grouped as units according to the context. On each unit, diagrams and written information were given with a range of questions. Examples for the questions in the mathematical literacy assessment can be found at the end of the dissertation, in Appendix C.

Valuable information about the students' ideas and thinking could be provided from the students' responses, either correct or incorrect. The marking guides for mathematics included a system of two-digit coding for marking. Therefore, the frequency of various kinds of correct and incorrect responses could be recorded. The first digit was the actual score, whereas the second digit was used to categorize the different types of responses. The categorization was based on the strategies used by the student to answer the item. The usage of double-digit coding has two main advantages. Firstly, more information can be collected about students' misconceptions, common errors and different approaches in solving problems. Secondly, a more structured way of presenting the codes, indicating the hierarchical levels of groups of codes, is allowed by double-digit coding (OECD Publications, 2004).

At the end of the dissertation, in Appendix D, scale reliabilities estimates for inter-coder reliability for Turkey, European Union Countries and European Union Candidate Countries were indicated. It is obvious that high percentage of consistent agreements was observed for all of the countries. The international verifier or the adjudicator agreed with the national marks in about 70 per cent to 90 per cent of cases, when inter-coder reliabilities were examined.

3.2.1.1 Content

The mathematical literacy assessment was established around four content areas:

- Space and Shape:

It relates to spatial and geometric phenomena and relationships, often drawing on curricular discipline of geometry. It requires looking for similarities and differences when analyzing the components of shapes and recognizing shapes in different representations and different dimensions, as well as understanding the properties of objects and their relative positions.

- Change and Relationships:

It involves mathematical manifestations of change as well as functional relationships and dependency among variables. This content area relates most closely to algebra. Mathematical relationships are often expressed as equations or inequalities, but relationships of a more general nature (e.g., equivalence, divisibility and inclusion, to mention but a few) are relevant as well. Relationships are given a variety of different representations, including symbolic, algebraic, graphic, tabular and geometric representations. Since different representations may serve different purposes and have different properties, translation between representations is often of key importance in dealing with situations and tasks.

- Quantity:

It involves numeric phenomena as well as quantitative relationships and patterns. It relates to the understanding of relative size, the recognition of numerical patterns, and the use of numbers to represent quantities and quantifiable attributes of real-world objects (counts and measures). Furthermore, quantity deals with the processing and understanding of numbers that are represented in various ways. An important aspect of dealing with quantity is quantitative reasoning, which involves number sense, representing numbers, understanding the meaning of operations, mental arithmetic and estimating. The most common curricular branch of mathematics with which quantitative reasoning is associated is arithmetic.

- Uncertainty:

It involves probabilistic and statistical phenomena and relationships that become increasingly relevant in the information society. These phenomena are the subject of mathematical study in statistics and probability (OECD Publications, 2004, p. 38, 39).

The Appendix E at the end of the dissertation shows the breakdown by mathematical content area of the 85 test items used in the PISA 2003 assessment.

3.2.1.2 Process

The PISA mathematics assessment requires students to confront mathematical problems that are based on some real-world context, where the students are required to identify features of the problem situation that might be amenable to mathematical investigation, and to activate the relevant mathematical competencies to solve the problem (OECD Publications, 2004, p. 40). In order to do so they need to engage in a multi-step process of “mathematisation”: (1) starting with a problem situated in reality; (2) organizing it according to mathematical concepts and identifying the relevant mathematics; (3) gradually trimming away the reality through processes such as making assumptions, generalizing and formalizing, which promote the mathematical features of the situation and transform the real-world problem into a mathematical problem that faithfully represents the situation; (4) solving the mathematical problem; and (5) making sense of the mathematical solution in terms of the real situation, including identifying the limitations of the solution (OECD Publications, 2003, p. 38). The Figure 1.2 outlines a five-step description of mathematisation of the theoretical basis for the PISA mathematics framework with the steps of mathematisation.

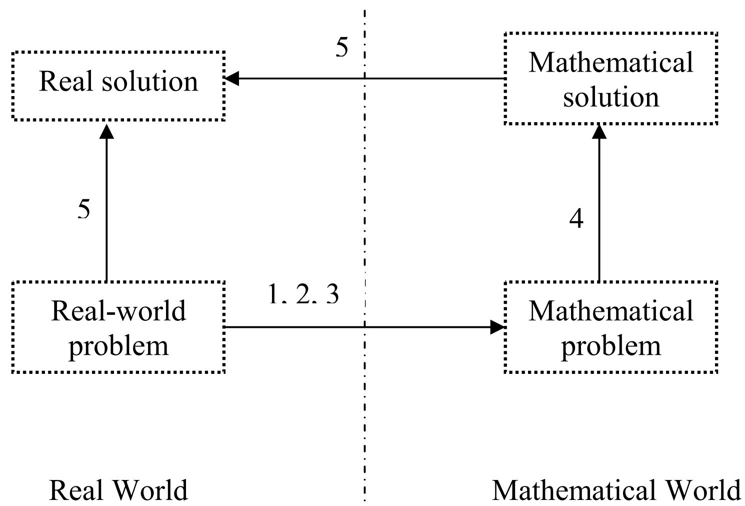

Figure 3.2 Mathematisation Cycle (OECD Publications, 2003, p. 38)

Various competencies are required for mathematisation to be employed. These include: thinking and reasoning; argumentation; communication; modeling; problem posing and solving; representation; and using symbolic, formal and technical language and operations. While it is generally true that these competencies operate together, and there is some overlap in their definitions, PISA mathematics tasks were often constructed to call particularly on one or more of these competencies. The cognitive activities were organized in PISA within three competency clusters that are labeled: the reproduction cluster, the connections cluster, and the reflective cluster (OECD Publications, 2004, p. 40).

- The reproduction cluster:

It is called into play in those items that are relatively familiar, and that essentially require the reproduction of practiced knowledge, such as knowledge of facts and of common problem representations, recognition of equivalents, recollection of familiar mathematical objects and properties, performance of routine procedures, application of standard algorithms and technical skills, manipulation of expressions containing symbols and formulae in a familiar and standard form, and carrying out straight-forward computations.

- The connections cluster:

It builds on reproduction to solve problems that are not simply routine, but that still involve somewhat familiar settings or extend and develop beyond the familiar to a relatively minor degree. Problems typically involve greater interpretation demands, and require making links between different representations of the situation, or linking different aspects of the problem situation in order to develop a solution.

- The reflection cluster:

It builds further on the connections cluster. These competencies are required in tasks that demand some insight and reflection on the part of the student, as well as creativity in identifying relevant mathematical concepts or in linking relevant knowledge to create solutions. The problems addressed using the competencies in this cluster involve more elements than others, and additional demands typically arise for students to generalize and to explain or justify their results (OECD Publications, 2004, p. 40, 41).

The Appendix E at the end of the dissertation shows the breakdown by competency cluster of the 85 test items used in the PISA 2003 assessment.

3.2.1.3 Situation

The stimulus material represented a situation that students could conceivably confront, and for which activation of their mathematical knowledge, understanding or skill might be required or might be helpful in order to analyze or deal with the situation. There were of four sorts of situations: personal, educational or occupational, public and scientific (OECD Publications, 2004, p. 41).

- Personal situations:

They directly relate to students' personal day-to-day activities. These have at their core the way in which a mathematical problem immediately affects the individual and the way the individual perceives the context of the problem. Such situations tend to require a high degree of interpretation before the problem can be solved.

- Educational or occupational situations:

They appear in a students' life at school, or in a work setting. These have at their core the way in which the school or work setting might require a student or employee to confront some particular problem that requires a mathematical solution.

- Public situations relating to the local and broader community:

They require students to observe some aspect of their broader surroundings. These are generally situations located in the community that have at their core the way in which students understand relationships among elements of their surroundings. They require the students to activate their mathematical understanding, knowledge and skills to evaluate aspects of an external situation that might have some relevant consequences for public life.

- Scientific situations:

They are more abstract and might involve understanding a technological process, theoretical situation or explicitly mathematical problem. The PISA mathematics framework includes in this category relatively abstract mathematical situations with which students are frequently confronted in a mathematics classroom, consisting entirely of explicit mathematical elements and where no attempt is made to place the problem in some broader context. These are sometimes referred to as "intra-mathematical" contexts (OECD Publications, 2004, p. 41, 42).

The Appendix E at the end of the dissertation shows the breakdown by situation type of the 85 test items used in the PISA 2003 assessment.

These four situation types vary in two important aspects. The first is in terms of the distance between the student and the situation, the degree of immediacy and directness of the problem's impact on the student. Personal situations are closest to students, being characterized by the direct perceptions involved. Educational and occupational situations typically involve some implications for the individual through their daily activities. Situations relating to the local and broader community typically involve a slightly more removed observation of external events in the community. Finally, scientific situations tend to be the most abstract and therefore involve the greatest separation between the student and the situation. The PISA assessment assumes that students need to be able to handle a range of situations, both close to and distant from their immediate lives (OECD Publications, 2004, p. 42).

There are also differences in the extent to which the mathematical nature of a situation is apparent. A few of the tasks refer only to mathematical objects, symbols or structures, and make no reference to matters outside the mathematical world. However, PISA also encompasses problems that students are likely to encounter in their lives in which the mathematical elements are not stated explicitly. The assessment thus tests the extent to which students can identify mathematical features of a problem when it is presented in a non-mathematical context and the extent to which they can activate their mathematical knowledge to explore and solve the problem and to make sense of the solution in the context or situation in which the problem arose (OECD Publications, 2004, p. 42).

3.2.2 Student Questionnaire

In addition to literacy in mathematics domain, the background questionnaires completed by students provide essential information. The characteristics and attitudes of students as learners in mathematics were categorized as motivational factors and general attitudes towards school including interest in and enjoyment in mathematics, instrumental motivation in mathematics, attitudes towards school and sense of belonging at school; self-related beliefs in mathematics including self-efficacy in mathematics and self-concept in mathematics; emotional factors in mathematics including anxiety in mathematics; and student learning strategies in mathematics including memorization/rehearsal strategies, elaboration strategies and control strategies (OECD Publications, 2004).

In the present study, student characteristic variables such as grade and gender of the students; student background variables such as highest parental occupational status, highest educational level of parents, socio-economic and cultural status, computer facilities at home, cultural possessions of the family, and home educational resources; school climate variables such as attitudes towards school, student-teacher relations at school, and sense of belonging at school; variables about self-related cognitions in mathematics such as interest in mathematics, instrumental motivation in mathematics, mathematics self-efficacy, mathematics anxiety, and mathematics self-concept; learning and instruction variables such as control strategies, elaboration strategies, memorization strategies, competitive learning, and cooperative learning; classroom climate variables such as teacher support and disciplinary climate in mathematics lessons were selected as the student level factors.

3.2.2.1 Student Level Factors: Highest Parental Occupational Status

Students were asked to report their mothers' and fathers' occupations, and to state whether each parent was in full-time paid work; part-time paid work; not working but looking for a paid job; or other (OECD Publications, 2004, p. 307).

Parental occupational status was derived from students' responses on parental occupation. The index captured the attributes of occupations that convert parents' education into income. The index was derived by the optimal scaling of occupation groups to maximize the indirect effect of education on income through occupation and to minimize the direct effect of education on income, net of occupation. *The Highest Parental Occupational Status* corresponds to the highest occupational status of either the father or the mother (OECD Publications, 2004, p. 307).

3.2.2.2 Student Level Factors: Highest Educational Level of Parents

Parental education is a family background variable that is often used in the analysis of educational outcomes. Indices were constructed using information on the educational level of the father, the educational level of the mother, and the highest level of education between the two parents, referred to as the *Highest Educational Level of Parents* (OECD Publications, 2004, p. 307).

Students were asked to identify the highest level of education of their mother and father on the basis of national qualifications, which were then coded in accordance with the International Standard Classification of Education (ISCED 1997) in order to obtain internationally comparable categories of educational attainment. The resulting categories were (OECD Publications, 2004, p. 308):

(0) for no education

(1) for the completion of <ISCED Level 1> (primary education)

(2) for the completion of <ISCED Level 2> (lower secondary education)

(3) for the completion of <ISCED Level 3B or 3C> (vocational / pre-vocational upper secondary education, aimed in most countries at providing direct entry into the labor market)
(4) for the completion of <ISCED Level 3A> (upper secondary education, aimed in most countries at gaining entry into tertiary-type A[university level] education) and / or <ISCED Level 4> (non-tertiary post-secondary)
(5) for qualifications in <ISCED Level 5B> (vocational tertiary)
(6) for the completion of <ISCED Level 5A, 6> (tertiary-type A and advanced research programmes)

3.2.2.3 Student Level Factors: Socio-Economic and Cultural Status

The index of *Economic, Social and Cultural Status* was created to capture wider aspects of a student's family and home background in addition to occupational status. It was derived from the following variables (OECD Publications, 2004, p. 307):

(1) The highest international socio-economic index of occupational status of the father or mother
(2) The highest level of education of the father or mother converted into years of schooling
(3) The number of books at home as well as access to home educational and cultural resources, obtained by asking students whether they had at their home: a desk to study at, a room of their own, a quiet place to study, a computer they can use for school work, educational software, a link to the internet, their own calculator, classic literature, books of poetry, works of art (e.g., paintings), books to help with their school work, and a dictionary

The rationale for the choice of these variables was that socio-economic status is usually seen as being determined by occupational status, education and wealth. As no direct measure on parental wealth was available from PISA, access to relevant household items was used as a proxy. The student scores on the index are factor scores derived from a Principal Component Analysis which are standardized to have an OECD mean of zero and a standard deviation of one (OECD Publications, 2004, p. 307).

3.2.2.4 Student Level Factors: Computer Facilities at Home

The index of *Computer Facilities at Home* was derived from students' reports on the availability of the following items in their home (OECD Publications, 2004, p. 309):

(1) A computer they can use for school
(2) Educational software
(3) A link to the internet

Scale construction was done using Item Response Theory (IRT) scaling and positive values indicate higher levels of computer facilities at home (OECD Publications, 2004, p. 309).

3.2.2.5 Student Level Factors: Cultural Possessions of the Family

The index of *Possessions Related to Classical Culture in the Family* was derived from students' reports on the availability of the following items in their home (OECD Publications, 2004, p. 309):

(1) Classic literature
(2) Books of poetry
(3) Works of art

Scale construction was performed through IRT scaling and positive values indicate higher levels of cultural possessions (OECD Publications, 2004, p. 309).

3.2.2.6 Student Level Factors: Home Educational Resources

The index of *Home Educational Resources* was derived from students' reports on the availability of the following items in their home (OECD Publications, 2004, p. 309):

(1) A dictionary
(2) A quiet place to study
(3) A desk for study
(4) A calculator
(5) Books to help with school work

Scale construction was done using Item Response Theory (IRT) scaling and positive values indicate higher levels of home educational resources (OECD Publications, 2004, p. 309).

3.2.2.7 Student Level Factors: Attitudes towards School

The index of *Attitudes towards School* was derived from students' reported agreement with the following statements (OECD Publications, 2004, p. 309):

(1) School has done little to prepare me for adult life when I leave school
(2) School has been a waste of time
(3) School helped give me confidence to make decisions
(4) School has taught me things which could be useful in a job

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. As items 3 and 4 were inverted for scaling, positive values on this index indicate positive attitudes towards school. Scale construction was done using IRT scaling (OECD Publications, 2004, p. 309).

3.2.2.8 Student Level Factors: Student-Teacher Relations at School

The index of *Student-Teacher Relations* was derived from students' reported agreement with the following statements (OECD Publications, 2004, p. 309):

(1) Most teachers are interested in students' well-being
(2) Students who need extra help, will receive it from their teacher
(3) Most teachers treat students fairly
(4) Students get along well with most teachers
(5) Most teachers really listen to what students have to say

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. All the items were inverted for scaling and positive scores on this index indicate good student-teacher relations at school. This index was constructed using IRT scaling (OECD Publications, 2004, p. 309).

3.2.2.9 Student Level Factors: Sense of Belonging at School

The index of *Sense of Belonging at School* was derived from students' reported agreement that school is a place where (OECD Publications, 2004, p. 309):

(1) I feel like an outsider (or left out of things)

(2) I make friends easily

(3) I feel like I belong

(4) I feel awkward and out of place

(5) Other students seem to like me

(6) I feel lonely

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. Items 2,3, and 5 were inverted for scaling and positive values indicate positive feelings about the students' school. This index was constructed using IRT scaling (OECD Publications, 2004, p. 309).

3.2.2.10 Student Level Factors: Interest in Mathematics

The index of *Interest in Mathematics* was derived from students' reported agreement with the following statements (OECD Publications, 2004, p. 310):

(1) I enjoy reading about mathematics

(2) I look forward to my mathematics lessons

(3) I do mathematics because I enjoy it

(4) I am interested in the things I learn in mathematics

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. All the items were inverted for IRT scaling and positive values on this index indicate higher levels of interest in mathematics. This index was constructed using IRT scaling (OECD Publications, 2004, p. 310).

3.2.2.11 Student Level Factors: Instrumental Motivation in Mathematics

The index of *Instrumental Motivation in Mathematics* was derived from students' reported agreement with the following statements (OECD Publications, 2004, p. 310):

(1) Making an effort in mathematics is worth it because it will help me in the work that I want to do later on
(2) Learning mathematics is worthwhile for me because it will help me with the subjects that I want to study further on in school
(3) Mathematics is an important subject for me because I need it for what I want to study later on
(4) I will learn many things in Mathematics that will help me get a job

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. All the items were inverted for scaling and positive values on this index indicate higher levels of instrumental motivation to learn mathematics. This index was constructed using IRT scaling (OECD Publications, 2004, p. 310).

3.2.2.12 Student Level Factors: Mathematics Self-Efficacy

The index of *Mathematics Self-Efficacy* was derived from students' reported level of confidence with the following calculations (OECD Publications, 2004, p. 310):

(1) Using a train timetable, how long it would take to get from Zedville to Zedtown
(2) Calculating how much cheaper a TV would be after a 30 per cent discount
(3) Calculating how many square meters of tiles you need to cover a floor
(4) Understanding graphs presented in newspapers
(5) Solving an equation like $3x + 5 = 17$
(6) Finding the actual distance between two places on a map with a 1:10,000 scale
(7) Solving an equation like $2(x + 3) = (x + 3)(x – 3)$
(8) Calculating the petrol consumption rate of a car

A four-point scale with the response categories “very confident”(=1), “confident”(=2), “not very confident”(=3), “not at all confident”(=4) was used. All the items were inverted for scaling and positive values on this index indicate higher levels of self-efficacy in mathematics. This index was constructed using IRT scaling (OECD Publications, 2004, p. 310).

3.2.2.13 Student Level Factors: Mathematics Anxiety

The index of *Anxiety in Mathematics* was derived from students’ reported agreement with the following statements (OECD Publications, 2004, p. 310):

(1) I often worry that it will be difficult for me in Mathematics classes
(2) I get very tense when I have to do Mathematics homework
(3) I get very nervous doing Mathematics problems
(4) I feel helpless when doing a Mathematics problem
(5) I worry that I will get poormarks in Mathematics

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and positive values on this index indicate higher levels of mathematics anxiety. This index was constructed using IRT scaling (OECD Publications, 2004, p. 310).

3.2.2.14 Student Level Factors: Mathematics Self-Concept

The index of *Self-Concept in Mathematics* was derived from students’ level of agreement with the following statements (OECD Publications, 2004, p. 310):

(1) I am just not good at mathematics
(2) I get good marks in mathematics
(3) I learn mathematics quickly
(4) I have always believed that mathematics is one of my best subjects
(5) In my mathematics class, I understand even the most difficult work

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. Items 2, 3, 4, and 5 were inverted for scaling and positive values on this index indicate a positive self-concept in mathematics. This index was constructed using IRT scaling (OECD Publications, 2004, p. 310).

3.2.2.15 Student Level Factors: Control Strategies

The index of *Control Strategies* was derived from students' reported agreement with the following statements (OECD Publications, 2004, p. 313):

(1) When I study for a mathematics test, I try to work out what are the most important parts to learn

(2) When I study mathematics, I make myself check to see if I remember the work I have already done

(3) When I study mathematics, I try to figure out which concepts I still have not understood properly

(4) When I cannot understand something in mathematics, I always search for more information to clarify the problem

(5) When I study mathematics, I start by working out exactly what I need to learn

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. All the items were inverted for scaling and positive values indicate preferences for this learning strategy. This index was constructed using IRT scaling (OECD Publications, 2004, p. 313).

3.2.2.16 Student Level Factors: Elaboration Strategies

The index of *Elaboration Strategies* was derived from students' reported agreement with the following statements (OECD Publications, 2004, p. 313):

(1) When I am solving mathematics problems, I often think of new ways to get the answer

(2) I think how the mathematics I have I have learnt can be used in everyday life

(3) I try to understand new concepts in mathematics by relating them to things I already know

(4) When I am solving a mathematics problem, I often think about how the solution might be applied to other interesting questions

(5) When learning a mathematics problem, I try to relate the work to things I have learnt in other subjects

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and positive values indicate preferences for this learning strategy. This index was constructed using IRT scaling (OECD Publications, 2004, p. 313).

3.2.2.17 Student Level Factors: Memorisation Strategies

The index of *Memorisation Strategies* was derived from students’ level of agreement with the following statements (OECD Publications, 2004, p. 312):

(1) I go over some problems in mathematics so often that I feel as if I could solve them in my sleep

(2) When I study mathematics, I try to learn the answers to problems off by heart

(3) In order to remember the method for solving a mathematics problem, I go through examples again and again

(4) To learn mathematics, I try to remember every step in a procedure

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and positive values indicate preferences for this learning strategy. This index was constructed using IRT scaling (OECD Publications, 2004, p. 313).

3.2.2.18 Student Level Factors: Competitive Learning

The index of *Competitive Learning* was derived from students’ reported agreement with the following statements (OECD Publications, 2004, p. 313):

(1) I would like to be best in my class in mathematics

(2) I try very hard in mathematics because I want to do better in the exams than the others

(3) I make a real effort in mathematics because I want to be one of the best

(4) In mathematics I always try to do better than other students in my class

(5) I do my best work in mathematics when I try to do better than others

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and positive values indicate preferences for competitive learning situations. This index was constructed using IRT scaling (OECD Publications, 2004, p. 313).

3.2.2.19 Student Level Factors: Cooperative Learning

The index of *Cooperative Learning* was derived from students’ reported agreement with the following statements (OECD Publications, 2004, p. 313):

(1) In mathematics I enjoy working with other students in groups

(2) 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

(3) I do my best work in mathematics when I work with other students

(4) In mathematics, I enjoy helping others to work well in a group

(5) In mathematics I learn most when I work with other students in my class

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and positive values indicate preferences for cooperative learning situations. This index was constructed using IRT scaling (OECD Publications, 2004, p. 313).

3.2.2.20 Student Level Factors: Teacher Support in Mathematics Lessons

The index of *Teacher Support* was derived from students’ reports on the frequency with which (OECD Publications, 2004, p. 313):

(1) The teacher shows an interest in every students’ learning

(2) The teacher gives extra help when students need it

(3) The teacher helps students with their learning

(4) The teacher continues teaching until the students understand

(5) The teacher gives students an opportunity to express opinions

A four-point scale with the response categories “every lesson”(=1), “most lessons”(=2), “some lessons”(=3), “never or hardly ever”(=4) was used. All the items were inverted for scaling and positive values indicate perceptions of higher levels of teacher support. This index was constructed using IRT scaling (OECD Publications, 2004, p. 313).

3.2.2.21 Student Level Factors: Disciplinary Climate in Mathematics Lessons

The index of *Disciplinary Climate* was derived from students’ reports on the frequency with which, in their lessons (OECD Publications, 2004, p. 313):

(1) Students don’t listen to what the teacher says
(2) There is noise and disorder
(3) The teacher has to wait a long time for students to quieten down
(4) Students cannot work well
(5) Students don’t start working for a long time after the lesson begins

A four-point scale with the response categories “every lesson”(=1), “most lessons”(=2), “some lessons”(=3), “never or hardly ever”(=4) was used. Positive values indicate perceptions of a more positive disciplinary climate whereas low values indicate a more negative disciplinary climate. This index was constructed using IRT scaling (OECD Publications, 2004, p. 314).

3.2.3 School Questionnaire

In addition to literacy in mathematics domain, the background questionnaires completed by school principals provide essential information. The school factors that were examined in PISA were selected on the basis of three strands of research: studies on effective teaching and instruction, which tend to focus on classroom management and teaching strategies, such as students’ opportunity to learn, time on task, monitoring performance at classroom levels, approaches to teaching and differentiation practices; school effectiveness studies, which focus on organizational and managerial characteristics of schools, such as school and classroom climate, achievement orientation, school autonomy and educational leadership, evaluation strategies and practices, parental involvement and staff development; studies of economic factors relating to production functions, which focus on resource inputs, such as school size, student/teaching staff ratios, the quality of schools' physical infrastructures and of their educational resources, teacher experience, training and compensation, and how these translate into educational outcomes (OECD Publications, 2004, p. 208).

In the present study, school characteristic variables such as school type, school size, and proportion of females enrolled at school; variables about the indicators of school resources such as total student-teacher ratio and mathematics student-teacher ratio; variables about admittance policies and instructional context such as academic selectivity, use of assessments, ability grouping between mathematics classes, mathematics extension courses, mathematics activities, resource autonomy, and curricular autonomy; school resources variables such as quality of the school's physical infrastructure, quality of the school's educational resources, and teacher shortage; school climate variables such as teacher morale and commitment, student morale and commitment, teacher-related factors affecting school climate, and student-related factors affecting school climate were selected as the school level factors.

3.2.3.1 School Level Factors: School Type

Schools were classified as either public or private according to whether a private entity or a public agency has the ultimate power to make decisions concerning its affairs (OECD Publications, 2004, p. 314).

3.2.3.2 School Level Factors: School Size

The *School Size* index contains the total enrolment at school based on the enrolment data provided by the school principal, summing the number of males and females at a school (OECD Publications, 2004, p. 314).

3.2.3.3 School Level Factors: Proportion of Females Enrolled at School

The index of *Proportion of Females Enrolled at School* provides the proportion of females at the school based on the enrolment data provided by the school principal, dividing the number of females by the total of males and females at school (OECD Publications, 2004, p. 314).

3.2.3.4 School Level Factors: Total Student-Teacher Ratio

School principals reported the number of full-time and part-time teachers in total, of full-time and part-time teachers fully certified by <the appropriate authority>, of full-time and part-time teachers with an <ISCED 5A> qualification in <pedagogy> (OECD Publications, 2004, p. 314).

From this, an index of *Total Student-Teacher Ratio* is obtained by dividing the school size by the total number of teachers. The number of part-time teachers contributes 0.5 and the number of full-time teachers contributes 1.0 to the total number of teachers (OECD Publications, 2004, p. 314).

3.2.3.5 School Level Factors: Mathematics Student-Teacher Ratio

School principals reported the number of full-time and part-time mathematics teachers in total, of full-time and part-time mathematics teachers fully certified by <the appropriate authority>, of full-time and part-time mathematics teachers with an <ISCED 5A> qualification in <pedagogy>. From this, an index of *Mathematics Student-Teacher Ratio* is obtained by dividing the school size by the total number of mathematics teachers.

3.2.3.6 School Level Factors: Academic Selectivity

School principals were asked about admittance policies at their school. Among these policies, principals were asked how much consideration was given to the following factors when students are admitted to the school based on a scale from not considered, considered, high priority or prerequisite (OECD Publications, 2004, p. 314):

(1) Students' academic record (including placement tests)
(2) Recommendation of feeder schools
(3) Parents' endorsement of the instructional or religious philosophy of the school
(4) Student need or desire for a special programme
(5) Attendance of other family members at the school (past or present)
(6) Country specific factors

A school was considered to have selective admittance policies if students' academic record or recommendation from a feeder school was a high priority or a prerequisite for admittance. It was considered a school with non-selective admittance if both factors were not considered for admittance (OECD Publications, 2004, p. 314).

3.2.3.7 School Level Factors: Use of Assessments

School principals were asked to rate the frequency of the following assessments for 15-year-old students at school (OECD Publications, 2004, p. 314):

(1) Standardized tests
(2) Teacher-developed tests
(3) Teachers' judgmental ratings
(4) Student portfolios
(5) Student assignments / projects / homework

All five items are recoded into numerical values, which approximately reflect frequency of assessments per year ("never" = 0, "1-2 times a year" = 1.5, "3-5 times a year" = 4, "monthly" = 8, "more than once a month" = 12). The index of *Use of Assessments* is calculated as the sum of these recoded items and then divided into three categories (OECD Publications, 2004, p. 314):

(1) Less than 20 times a year
(2) 20-39 times a year
(3) More than 40 times a year

3.2.3.8 School Level Factors: Ability Grouping between Mathematics Classes

To determine the extent of ability grouping within schools, school principals were asked to report the extent to which their school organizes instruction differently for students with different abilities as (OECD Publications, 2004, p. 315):

(1) Mathematics classes studying similar content, but at different levels of difficulty
(2) Different classes studying different content or sets of mathematics topics that have different levels of difficulty

An index of *Ability Grouping between Mathematics Classes* was derived from assigning schools to one of three categories (OECD Publications, 2004, p. 315):

(1) Schools with no ability grouping between any classes
(2) Schools with one of these forms of ability grouping between classes for some classes
(3) Schools with one of these forms of ability grouping for all classes

3.2.3.9 School Level Factors: Mathematics Extension Courses

School principals were asked to report on the occurrence of the following activities to promote engagement with mathematics at their school (OECD Publications, 2004, p. 315):

(1) Enrichment mathematics
(2) Remedial mathematics
(3) Mathematics competitions
(4) Mathematics clubs
(5) Computer clubs (specifically related to mathematics)

Schools are considered to offer extension courses when they offer enrichment or remedial mathematics courses. The index of *Mathematics Extension Courses* is simply the number of types of extension courses offered (OECD Publications, 2004, p. 315).

3.2.3.10 School Level Factors: Mathematics Activities

School principals were asked to report on the occurrence of the following activities to promote engagement with mathematics at their school (OECD Publications, 2004, p. 315):

(1) Enrichment mathematics

(2) Remedial mathematics

(3) Mathematics competitions

(4) Mathematics clubs

(5) Computer clubs (specifically related to mathematics)

Schools are considered to offer other types of mathematics activities when they offer competitions, clubs or computer clubs related to mathematics. The index of *Mathematics Activities* is simply the number of different types of activities offered at the school (OECD Publications, 2004, p. 315).

3.2.3.11 School Level Factors: Resource Autonomy

School principals were asked to report whether teachers, department heads, the school principal, an appointed or elected board or education authorities at a higher level had the main responsibility for (OECD Publications, 2004, p. 315):

(1) Selecting teachers for hire

(2) Dismissing teachers

(3) Establishing teachers' starting salaries

(4) Determining teachers' salary increases

(5) Formulating school budgets

(6) Deciding on budget allocations within the school

(7) Establishing student disciplinary policies

(8) Establishing student assessment policies

(9) Approving students for admittance to school

(10) Choosing which textbooks to use

(11) Determining course content

(12) Deciding which courses are offered

The index of *Resource Autonomy* is the number of decisions that relate to school resources that are a school responsibility (items 1 to 6) (OECD Publications, 2004, p. 315).

3.2.3.12 School Level Factors: Curricular Autonomy

School principals were asked to report whether teachers, department heads, the school principal, an appointed or elected board or education authorities at a higher level had the main responsibility for (OECD Publications, 2004, p. 315):

(1) Selecting teachers for hire
(2) Dismissing teachers
(3) Establishing teachers' starting salaries
(4) Determining teachers' salary increases
(5) Formulating school budgets
(6) Deciding on budget allocations within the school
(7) Establishing student disciplinary policies
(8) Establishing student assessment policies
(9) Approving students for admittance to school
(10) Choosing which textbooks to use
(11) Determining course content
(12) Deciding which courses are offered

The index of *Curricular Autonomy* is the number of decisions that relate to curriculum which are a school responsibility (items 8, 10, 11 and 12) (OECD Publications, 2004, p. 315).

3.2.3.13 School Level Factors: Quality of School's Physical Infrastructure

The index of *Quality of School's Physical Infrastructure* was derived from three items measuring the school principals' perceptions of potential factors hindering instruction at school (OECD Publications, 2004, p. 315):

(1) School buildings and grounds
(2) Heating / cooling and lighting systems
(3) Instructional space (e.g., classrooms)

A four-point scale with response categories "not at all"=1, "very little"=2, "to some extent"=3, and "a lot"= 4 was used. All items were inverted for scaling and positive values indicate positive evaluations of this aspect. This index was constructed using IRT scaling (OECD Publications, 2004, p. 315).

3.2.3.14 School Level Factors: Quality of School's Educational Resources

The index of *Quality of School's Educational Resources* was derived from seven items measuring the school principals' perceptions of potential factors hindering instruction at school (OECD Publications, 2004, p. 315):

(1) Instructional materials (e.g., textbooks)
(2) Computers for instruction
(3) Computer software for instruction
(4) Calculators for instruction
(5) Library materials
(6) Audio-visual resources
(7) Science laboratory equipment and materials

A four-point scale with response categories "not at all"=1, "very little"=2, "to some extent"=3, and "a lot"= 4 was used. All items were inverted for scaling and positive values indicate positive evaluations of this aspect. This index was constructed using IRT scaling (OECD Publications, 2004, p. 315).

3.2.3.15 School Level Factors: Teacher Shortage

The index of *Teacher Shortage* was derived from items measuring the school principal's perceptions of potential factors hindering instruction at school. These factors are a shortage or inadequacy of (OECD Publications, 2004, p.315):

(1) Qualified mathematics teachers
(2) Qualified science teachers
(3) Qualified test language teachers
(4) Qualified foreign language teachers
(5) Experienced teachers

A four point scale with the response categories “not at all”=1, “very little”=2, “to some extent”=3, and “a lot”=4 is used. The items were not inverted for scaling and positive values indicate school principal’s reports of teacher shortage at a school. This index was constructed using IRT scaling (OECD Publications, 2004, p. 316).

3.2.3.16 School Level Factors: Teacher Morale and Commitment

The index of *Teacher Morale and Commitment* was derived from items measuring the school principals’ perceptions of teachers’ with the following statements (OECD Publications, 2004, p. 316):

(1) The morale of teachers in this school is high
(2) Teachers work with enthusiasm
(3) Teachers take pride in this school
(4) Teachers value academic achievement

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and the categories “disagree” and “strongly disagree” were combined into one category. Positive values indicate principals’ reports of higher levels of teacher morale and commitment. This index was constructed using IRT scaling (OECD Publications, 2004, p. 316).

3.2.3.17 School Level Factors: Student Morale and Commitment

The index of *Student Morale and Commitment* was derived from items measuring the school principals’ perceptions of students at a school with the following statements (OECD Publications, 2004, p. 316):

(1) Students enjoy being at school
(2) Students work with enthusiasm
(3) Students take pride in this school
(4) Students value academic achievement
(5) Students are cooperative and respectful
(6) Students value the education they can receive in this school
(7) Students do their best to learn as much as possible

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and the categories “disagree” and “strongly disagree” were combined into one category. Positive values indicate principals’ reports of higher levels of student morale and commitment. This index was constructed using IRT scaling (OECD Publications, 2004, p. 316).

3.2.3.18 School Level Factors: Teacher-Related Factors Affecting School Climate

The index of *Teacher-Related Factors Affecting School Climate* was derived from items measuring the school principals’ reports of potential factors hindering the learning of students at school with the following statements (OECD Publications, 2004, p. 316):

(1) Teachers’ low expectations of students
(2) Poor student-teacher relations
(3) Teachers not meeting individual students’ needs
(4) Teacher absenteeism
(5) Staff resisting change
(6) Teachers being too strict with students
(7) Students not being encouraged to achieve their full potential

A four-point scale with the response categories “strongly agree”(=1), “agree”(=2), “disagree”(=3), “strongly disagree”(=4) was used. All the items were inverted for scaling and positive values indicate positive evaluations of this aspect. This index was constructed using IRT scaling (OECD Publications, 2004, p. 316).

3.2.3.19 School Level Factors: Student-Related Factors affecting School Climate

The index of *Student-Related Factors Affecting School Climate* was derived from items measuring the school principals’ perceptions of potential factors hindering the learning of students at school with the following statements (OECD Publications, 2004, p. 316):

(1) Student absenteeism
(2) Disruption of classes by students
(3) Students skipping classes
(4) Students lacking respect for teachers
(5) Students' use of alcohol or illegal drugs
(6) Students intimidating or bullying other students

A four-point scale with the response categories "strongly agree"(=1), "agree"(=2), "disagree"(=3), "strongly disagree"(=4) was used. All the items were inverted for scaling and positive values indicate positive evaluations of this aspect. This index was constructed using IRT scaling (OECD Publications, 2004, p. 316).

3.3 Validity and Reliability

3.3.1 Content-Related Evidence for Validity

Mathematics items were developed at one or more of the consortium item development centers; the Australian Council for Educational Research (ACER) in Australia, the National Institute for Educational Measurement (CITO) in the Netherlands, and the National Institute for Educational Research (NIER) in Japan. At each of the centers, professional item developers wrote and developed items. Moreover, items received from national submissions or from individuals wishing to submit items were distributed among the relevant item development centers for the required development work (OECD Publications, 2005).

The following steps were followed in the development of items. The steps are described in a linear fashion, but in reality they were often negotiated in a cyclic fashion, with items typically going through the various steps more than once. The steps were (OECD Publications, 2005, p. 21):

(1) Initial preparation: A professional item writer prepared items in a standard format, including item stimulus, one or more questions, and a proposed coding guide for each question.
(2) Item paneling: Each item was given extensive scrutiny at a meeting of a number of professional item writers. Items were revised, often extensively, following item panelling. When substantial revisions were required, items went back to the panelling stage for further consideration.

(3) Cognitive Interview: Many items were then prepared for individual students or small groups of students to attempt. A combination of think-aloud methods, individual interviews and group interviews were used with students to ascertain the thought processes typically employed by students as they attempt the items. This stage was particularly useful in clarifying wording of questions, and gave some information on likely student responses that was also useful in refining the scoring guides.

(4) International Item Panelling: All items were scrutinized by panels of professional item writers in at least two of the item development centers. The feedback provided, following scrutiny of items by international colleagues, assisted the item development teams to introduce further improvements to the items.

(5) Pilot Testing: Items were revised, often extensively, following pilot testing with large groups of students. In some cases, revised versions of items were again subjected to the pilot testing procedure. A selection of these responses were added to the scoring guides to provide additional sample answers, showing coders how to code a variety of different responses to each item.

At the conclusion of these steps, surviving items were considered ready for circulation to national centers for review and feedback.

National Project Managers were given a set of item review guidelines to assist them in reviewing items and providing feedback. A central aspect of that review was a request to national experts to rate items according to various features, including their relevance and acceptability from a cultural perspective. Other features on which national experts commented were interest, curriculum relevance, relevance to the PISA framework, and any other matters thought to be important by any national centre. The feedback frequently resulted in further significant revision of the items. In particular, issues related to translation of items into different languages were highlighted at this stage, as were other cultural issues related to the potential operation of items in different national contexts (OECD Publications, 2005, p. 22).

As well as this formal, structured process for national review of items, the bundles of mathematics items were also considered in detail at meetings of the mathematics forum. All PISA countries were invited to send national mathematics experts to meetings of the forum. A similar review process involving the mathematics expert group was also employed. A further small bundle of late developed or significantly revised mathematics items was prepared, and reviewed by the mathematics forum and the mathematics expert group at a joint meeting (OECD Publications, 2005, p. 22).

Two major approaches to validation were considered in PISA project. One method was to provide knowledgeable experts; second, the described scales were subjected to an extensive consultation process involving all PISA participating countries National project Managers (NPMs) (OECD Publications, 2005). Therefore, the validity of the items across countries was acquired.

3.3.2 Construct-Related Evidence for Validity

There are different methodological approaches for validating questionnaire constructs, each with their limitations and problems. Cross-country validation of these constructs is of particular importance, as measures derived from questionnaires are often used to explain differences in student performance within and across countries and are, thus, potential sources of policy-relevant information about ways of improving educational systems (OECD Publications, 2005, p. 281).

Structural Equation Modeling (SEM) was used to confirm theoretically expected dimensions and to re-specify the dimensional structure. In the Confirmatory Factor Analysis (CFA), maximum likelihood estimation and covariance matrices were used for the analyses of the Likert-type items. In the case of dichotomous items, weighted least squares estimation with polychoric correlations was used (OECD Publications, 2005).

Models were estimated both for the international pooled sample and for country sub-samples separately in order to assess cross-country validity of item dimensionality and constructs. Only minimal condition for factorial invariance and the equivalence of factor loadings across countries was tested within the context of cross-country validation. The context and structure of the educational systems were found to influence the relations between constructs. Thus, testing invariance of relations between constructs is of interest but not a necessary condition for cross-country validity.

3.3.3 Reliability

As previously given in this chapter of the dissertation, scale reliabilities and estimates for inter-coder reliability for Turkey, European Union Countries, and European Union Candidate Countries were presented in Tables 3.7 and 3.8. When the values in the Tables were examined, it is obvious that high percentage of consistent agreements was observed for all of the countries

Furthermore, at the international level, the reliability of the PISA mathematics scale is obtained as 0.845 when scaled separately. The final reliability of the mathematics scale is 0.918 and the reliabilities of the sub-domains of mathematics are indicated as 0.865 for space and shape, 0.905 for change and relationships, 0.905 for uncertainty, 0.895 for quantity. The reliability values for mathematics scale and for the sub-domains of mathematics scale are quite high values representing high reliability (OECD Publications, 2005).

3.4 Procedures

3.4.1 Design of the Study

In the present study, the factors will be investigated in order to get an insight about how the school level factors affect the student level factors and in turn how the student level factors influence the performance of 15-year-old students on the mathematical literacy in PISA 2003 project. Therefore, hierarchical linear modeling will be selected as a modeling technique so as to investigate the relationships between all these variables. Therefore, this study is a quantitative research. Furthermore, the design of the study could be stated as an associational research which is in fact a correlational study. As a result, the design of the present study can be mentioned as a quantitative research with non-experimental study which is actually a cross-sectional and predictive study.

3.4.2 Threats to Internal Validity of the Study

The selection of people for a study may result in the individuals or groups differing from one another in unintended ways that are related to the variables to be studied and this threat is known as subject characteristics threat (Fraenkel & Wallen, 1996). In the present study, the subjects of the study were selected based on some characteristics such as being a 15-year-old student, but all the characteristics of the subjects could not be controlled in a study. Therefore, the subject characteristics could be a threat for the present study.

No matter how carefully the subjects of a study are selected, it is common to lose some as the study progresses and this threat is known as mortality (Fraenkel & Wallen, 1996). In the present study, the subjects of the study were selected by considering the loss of subjects during the study and more than needed students were selected in order to avoid this threat. Therefore, the mortality could not be a threat for the present study.

The particular locations in which data are collected, or in which an intervention is carried out, may create alternative explanations for results and this threat is known as location threat (Fraenkel & Wallen, 1996). In the present study, the tests for literacy and the questionnaires were administered in the actual schools and classes of the students. Moreover, since the study did not include any manipulation, the location was not a very important issue as in the experimental studies. Therefore, the location could not be an essential threat for the study.

The way in which instruments are used may also constitute a threat to the internal validity of a study. Indeed, instrumentation can create problems if the nature of the instrument is changed in some way or another which is called instrument decay. The characteristics of the data gatherers can also affect results which is data collector bias. Lastly, there is also the possibility that the data collectors or scorers may unconsciously distort the data in such a way as to make certain outcomes which is data collector bias (Fraenkel & Wallen, 1996). All these conditions or situations were thought and some prevention ways were conducted in the PISA 2003 project. For instance, the data gatherers were sent some manuals and forms in order to conduct the administration process as wanted. The scoring of the instruments was carried out by many steps that were decided before. Therefore, the instrumentation could not be a threat for the present study.

The students may be alerted to what is being studied by the questions in the pretest, accordingly make a greater effort to learn the material. This increased effort on the part of the students could account for the pre-to-post improvement. It may also be that practice on the pretest by itself is responsible for the improvement and it is known as the testing threat (Fraenkel & Wallen, 1996). In the present study, since there was no manipulation and the PISA project used tests and questionnaires for only one time, the testing could not be a threat for the present study.

On occasion, one or more unanticipated, and unplanned for, events may occur during the course of a study which can affect the responses of subjects and it is known as history threat (Fraenkel & Wallen, 1996). In the present study, all these conditions were tried to be controlled by the administration units by using forms, manuals, etc. However, it was hard to say that history was not a threat for the study.

Often change during an intervention may due to the factors associated with the passing of time rather than to the intervention itself and it is known as maturation threat (Fraenkel & Wallen, 1996). In the present study, maturation could not a threat since there was no condition of passing time.

The way in which subjects view a study and their participation in it can create a threat to internal validity and it is known as attitude of subjects (Fraenkel & Wallen, 1996). In the present study, this threat was tried to be controlled by the administration units, however, attitude of subjects could be a threat for the study.

The treatment or method in any experimental study must be administered by someone such as researcher, the teachers involved in the study, a counselor, or some other person and it is known as implementer threat (Fraenkel & Wallen, 1996). In the present study, all the procedures were carried out by the trained people involved in the study; consequently, the implementation could not be a threat.

Lastly, the regression threat may be present whenever change is studied in a group that is extremely low or high in its pre-intervention performance (Fraenkel & Wallen, 1996). Since, there was no intervention in the PISA 2003 project; this regression threat could not be a problem for the present study.

3.4.3 Potentially Confounding Variables in the Study

Student achievement in mathematics was assessed using 85 test items representing approximately 210 minutes of testing time. Items were arranged into 30-minute blocks, with each student taking four blocks (two hours) of testing, including a mix of reading, mathematics, science and problem-solving blocks. It was recommended that each item did not require more than five minutes (for the average student) for completion. Each unit did not require more than 15 minutes for completion (OECD Publications, 2005). Based on the pattern of missing and not-reached items for all sessions, there appeared to be no empirical evidence to suggest that testing sessions were too long. Of they were, one would have expected that the tired students would have given up earlier in the later session than in the earlier session, but this was not the case.

3.4.4 Ethical Issues in the Study

As known, ethical problems suggest three very important issues that every researcher should address. These issues are protecting participants from harm, ensuring confidentiality and the deception of the participants.

In the PISA 2003 project, a script for introducing PISA to the students was provided in the Test Administrator's Manual. In addition, the instructions were read to the students for all of the testing sessions. Therefore, it could be said that the deception of the students was not an issue in the present study.

Furthermore, the schools were labeled with numbers and also the students were assigned numbers for the whole assessment, in order to set the confidentiality of the schools' and students' identities. Thus, the confidentiality was also ensured for the present study.

Lastly, since the students were assessed in their actual locations which were their own schools and classes, the harm for the students was also not an issue, consequently, the protection of participants from harm was also ensured by conducting the study in the actual locations.

3.5 Data Collection

An international consortium led by the Australian Council for Educational Research (ACER) was responsible for the design and implementation of PISA 2003 project. The National Institute for Educational Measurement (CITO) in the Netherlands, Westat and the Educational Testing Service (ETS) in the United States, and the National Institute for Educational Research (NIER) in Japan were the other partners in the consortium (OECD Publications, 2005).

The consortium implemented the PISA project within a framework. The framework was established by the PISA Governing Board (PGB). Representation from all countries at senior policy levels was included in the framework. Policy priorities and standards for developing indicators, for establishing assessment instruments, and for reporting results were established by the PGB. Experts from participating countries were referred to as subject matter expert groups (SMEGs). Countries ensured that the instruments were internationally valid and took into account the cultural and educational contexts of the different OECD member countries; the assessment materials had strong measurement potential; and that the instruments emphasized authenticity and educational validity by participating in the expert groups and regularly reviewing outcomes of the groups' meetings (OECD Publications, 2005).

The implementation of PISA project nationally was conducted by the National Project Managers (NPMs). These managers played a role in the development and validation of the international assessment instruments, in addition to the verification and evaluation of the survey results, analyses and reports (OECD Publications, 2005).

The data entry was done through the data entry software KeyQuest. The data were entered directly from the test booklets and the questionnaires, except for the multiple-marking study. Because the marks from the first three markers had been written on separate sheets in the multiple-marking study. Validation checks were performed as the data were entered by the KeyQuest software. A manual called Data Entry Manual is provided. The manual included the full details of the functionality of KeyQuest software and complete instructions on data entry, data management and the way to carry out validity checks. NPMs were also responsible for ensuring that many checks of the quality of their country's data were made before the data files were submitted to the consortium (OECD Publications, 2005).

PISA Quality Control and Assurance Program took place in the data cleaning process. The data cleaning and analysis phases contained detection of all anomalies and inconsistencies in submitted data and not having errors. In order to reach these high quality requirements, dual independent processing was implemented by the Consortium. The data cleaning procedures were carried out independently by two data analysts. The procedures were considered as complete only when identical results and files were produced by the two PISA databases received from countries. Specific data cleaning or recoding procedures or at least adaptation of standard data cleaning procedures were needed in data files that were submitted by national centers. Therefore, two analysts independently cleaned all submitted data files. The cleaning and analysis procedures were run with both SAS and SPSS softwares. As a result, the national databases were produced by three teams of data analysts. A team leader was included in each team who was the only person to communicate with national centers (OECD Publications, 2005).

Necessary data files used in the present study were downloaded from the PISA International Database included in the PISA Web Site, http://www.pisa.oecd.org. All the information about the structure of the data files was obtained from the codebook files contained in PISA Web Site.

3.6 Data Analyses

All the variables in the PISA 2003 Student Questionnaire and PISA 2003 School Questionnaire were examined generally. Then, all the PISA indices from student and school questionnaires and additional variables of interest were selected for the present study. All of the student and school level factors were investigated on the basis of descriptive data analyses such as missing data analyses, data cleaning procedures and descriptive statistical procedures. The descriptive data analyses were conducted in order to see the response patterns, to understand the results of the analyses, to make appropriate conclusions about the results we get from the analyses and furthermore, to discuss the results of the analyses. All these interpretations could lead to conclude, discuss and interpret the reasons of the results.

Since the variables of the study were composed of all the PISA indices, there was no need for conducting some of the inferential data analyses such as explanatory and confirmatory factor analyses. Since the factors were investigated in order to get an insight about how the school level factors affect the student level factors and in turn how the student level factors influence the performance of 15-year-old students on the mathematical literacy in PISA 2003 project, hierarchical linear modeling (HLM) was selected as a modeling technique. Hierarchical linear modeling (HLM) was preferred as a modeling technique instead of structural equation modeling

(SEM) because of the nested structure of the data sets and sampling procedures used in data collection of PISA project. Furthermore, in structural equation modeling (SEM), the relations between either student level factors and mathematical literacy performance or school level factors and mathematical literacy performance could be examined. On the other hand, all the relations between student level factors, school level factors and mathematical literacy performance could be investigated in hierarchical linear modeling (HLM). Therefore, hierarchical linear models for Turkey, European Union Countries and European Union Candidate Countries were conducted using HLM 5.05 in order to examine the relations between student and school level factors and mathematical literacy performance in the present study.

3.6.1 Procedures for Alpha, Beta, Power, Effect Size and Sample Size

The power of the study should be large enough in order to conduct a valuable research. Unless the power of the study is large, then the study does not worth investigating. As known, it is accepted that the power of a study should be at least 0.80. Furthermore, as explained previously, the effect size of the study should be large enough so as to give meaningful results and findings that can be used in practice.

The effect size can be defined as the magnitude of an independent variable's effect, usually expressed as a proportion of explained variance in the dependent variables (Weinfurt, 1995). The measure of effect size is roughly equivalent to the R^2 used in multiple regression. The classification of effect sizes of Cohen (1977) has become somewhat of a standard in social research. The proper standard classification scheme should be the one Cohen suggested for effect sizes measured in terms of R^2. The classification scheme indicates such indices for effect sizes: 0.01 is small, 0.09 is medium and 0.25 or greater is large. The social studies generally produce small to medium effect sizes (Weinfurt, 1995).

Since it was decided to conduct hierarchical linear modeling in order to assess the relationships of the factors that could have an influence on the mathematical literacy of the students, a large sample was needed to carry out the modeling of all the factors affecting mathematical literacy.

Based on these assumptions, the procedures for fixing alpha, beta, power and effect size were carried out before the process of conducting the research. Setting these indices as priori before the study led the computation of the sample size and accordingly, the minimum number of the sample size for conducting the study was obtained. At the beginning of the study, the alpha was set as 0.05 which is in fact the probability of conducting a Type I Error; the power of the study was set as 0.95 which is large enough to worth investigating; beta was set as 0.05 based on the fixed power 0.95 and lastly, the effect size of the study was set as 0.30 which is above the criterion 0.25 for large effect size. Although there were 24 student level variables and 20 school level variables included in the present study, at the beginning of the study, the number of variables included in the study was set as 100 which is the maximum number to obtain the index L. After fixing these indices as priori for the study, the sample size of the study could be calculated by using the Cohen's sample size tables.

The sample size of the study was computed as:

Fixed indices:

$\alpha = 0.05$ & $\beta = 0.05$ & power = 0.95 & effect size = $R^2 = 0.30$

$$f^2 = \frac{R^2}{1-R^2} = \frac{0.30}{1-0.30} = \frac{0.30}{0.70} = \frac{3}{7}$$

Using Cohen's table using $\alpha = 0.05$, $k_B = 100$ and power = 0.95, L is obtained as 54.44 from the table.

$$n = \frac{L}{f^2} + k_B + 1 = \frac{54.44}{\frac{3}{7}} + 100 + 1 = 54.44\frac{7}{3} + 101 = 127.027 + 101 = 228.027$$

Thus, the needed sample size for the study was computed as 228 students.

Since the present study was conducted as three parts for Turkey, European Union Countries and European Union Candidate Countries, the sample sizes for all the three samples should be at least 230, separately. Actually, the sample size for Turkey was 4 855, for European Union Countries was 5 129, and for European

Union Candidate Countries was 4 419. Obviously, these sample sizes were very large compared with the necessary sample sizes at the beginning of the study. Furthermore, the sample sizes for all three parts were also large enough to conduct modeling analyses.

3.6.2 Budget and Time Schedule

The dissertation was conducted based on the guidance of my doctoral thesis advisor and the members of authority. The planning of the conduction of the present research could be stated generally as the following.

The data and the necessary files for the study were downloaded from the web site of the PISA 2003 project in June 2005 after taking the Doctoral Qualifying Examination in May 2005. In the first six months period, from June 2005 to October 2005, The PISA 2003 questionnaire files, the codebook files, the publications, and the data files were examined. The literature about PISA 2003 project was searched and some of the studies conducted on PISA 2003 project were gathered and perused. The topic and the content of the dissertation was examined, talked and discussed with my doctoral thesis advisor. After the topic and the content were clear enough, some preliminary statistical analyses such as the frequency analyses and descriptive statistics were conducted on the Turkey sample. Lastly, the proposal of the dissertation was written. In October 2005, the proposal of the dissertation was presented to my doctoral thesis advisor and the members of authority in the first Thesis Supervising Committee.

In the second six months period, from October 2005 to May 2006, the content and the properties of hierarchical linear modeling (HLM) were studied in order to become qualified about the hierarchical linear modeling analyses. Some preliminary hierarchical linear models were constructed using the Turkey data set so as to have knowledge and become experienced on the hierarchical linear models. A study which could be accepted as the sub-study of the dissertation was conducted and presented at the Third International Conference on the Teaching of Mathematics in July 2006. This study played a vital role in the process to understand and experience the hierarchical linear modeling techniques. Moreover, the literature about the studies including the PISA project, including the relations between the factors and the mathematics achievement or mathematical literacy, using the models of structural equation modeling and hierarchical linear modeling techniques was searched for this six-month-period time. In May 2006, the steps in the process of conduction of the dissertation were explained to my doctoral thesis advisor and the members of authority in the second Thesis Supervising Committee.

In the third six months period, from May 2006 to October 2006, the content of the dissertation was clarified in terms of the countries included for the cross-cultural comparisons with my doctoral thesis advisor. Following the clarifications of the content of the dissertation, the analyses for Turkey, European Union Countries, and European Union Candidate Countries were conducted. Firstly, the descriptive statistical analyses were conducted separately for Turkey, European Union Countries and European Union Candidate Countries in order to see the general pattern of the responses and to describe distributions. Secondly, hierarchical linear models for Turkey, European Union Countries and European Union Candidate Countries were constructed separately. Furthermore, as the every six-month-period work, the literature about the studies including the PISA project, including the relations between the factors and the mathematics achievement or mathematical literacy, using the models of structural equation modeling and hierarchical linear modeling techniques was searched. Lastly, the writing process of the dissertation was achieved in the last two months period.

The research was not a part of the project, thus, there was no budget for the dissertation from outside. The mainly expensive need for the research was the LISREL and HLM computer package programs. However, the program was available in the Department of Secondary Science and Mathematics Education and I am a member of the department as a research assistant. Therefore, this expense was not a problem for the process of conducting the dissertation. The other expenses were the result of the photocopy, getting some studies from abroad, need of computer disks and flash disks and etc. These expenses were overcame by own. Therefore, there was no funding for the dissertation and the expenses which could be accepted as not much were spent by my own.

3.7 Hierarchical Linear Modeling (HLM)

3.7.1 Conceptual Background for Two-Level Hierarchical Linear Models

Behavioral and social data commonly have a nested structure. For example, if repeated observations are collected on a set of individuals and the measurement occasions are not identical for all persons, the multiple observations are properly conceived as nested within persons. Each person might also be nested within some organizational unit such as a school or workplace. Within the hierarchical linear model, each of the levels in the data structure (e.g., repeated observations within persons, persons within communities) is formally represented by its own sub-model. Each sub-model represents the structural relations occurring at that level and the residual variability at that level (Raudenbush, Bryk, Cheong, & Congdon, 2001, p.1). The sub-models express relationships among variables within a given level, and specify how variables at one level influence relations occurring at another. Although any number of levels can be represented, all the essential statistical features are found in the basic two-level model (Raudenbush, & Bryk, 2002, p. 7).

3.7.1.1 One-Way ANOVA with Random Effects

The simplest possible hierarchical linear model is equivalent to a one-way ANOVA with random effects. In this case, B_{1j} in the level-1 model is set to zero for all j, yielding:

$$Y_{ij} = B_{0j} + r_{ij} .$$

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. Notice that this model predicts the outcome within each leve-1 unit with just one level-2 parameter, the intercept, B_{0j}. In this case, B_{0j} is just the mean outcome for the jth unit. That is, $B_{0j} = \mu_{\gamma j}$ (Raudenbush, & Bryk, 2002, p. 23).

The level-2 model for one-way ANOVA with random effects is:

$$B_{0j} = \gamma_{00} + u_{0j} ,$$

with γ_{01} set to zero, γ_{00} where represents the grand-mean outcome in the population, and u_{0j} is the random effect associated with unit j and is assumed to have a mean of zero and variance τ_{00} (Raudenbush, & Bryk, 2002, p. 23, 24).

Substituting the equations together yields the combined model:

$$Y_{ij} = \gamma_{00} + u_{0j} + r_{ij},$$

which is, indeed, the one-way ANOVA model with grand mean γ_{00}; with a group (level-2) effect, u_{0j}; and with a person (level-1) effect, r_{ij}. It is a random effects model because the group effects are construed as random. Notice that the variance of the outcome is (Raudenbush, & Bryk, 2002, p. 24):

$$Var(Y_{ij}) = Var(u_{0j} + r_{ij}) = \tau_{00} + \sigma^2.$$

Estimating the one-way ANOVA model is often useful as a preliminary step in a hierarchical data analysis. It produces a point estimate and confidence interval for the grand mean, γ_{00}. More important, it provides information about the outcome variability at each of the two levels. The σ^2 parameter represents the within group variability, and τ_{00} captures the between group variability. It is referred to the hierarchical model as fully unconditional in that no predictors are specified at either level-1 or 2 (Raudenbush, & Bryk, 2002, p. 24).

A useful parameter associated with one-way random effects ANOVA is the intraclass correlation coefficient. This coefficient is given by the formula:

$$\rho = \tau_{00} / (\tau_{00} + \sigma^2)$$

and measures the proportion of the variance in the outcome that is between the level-2 units (Raudenbush, & Bryk, 2002, p. 24).

3.7.1.2 Means as Outcomes Regression

Another common statistical problem involves the means from each of many groups as an outcome to be predicted by group characteristics. This sub-model consists of:

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

as the level-1 model and, for the level-2 model, where in this simple case we have one level-2 predictor, W_j. Substituting the equation yields the combined model:

$$Y_{ij} = \gamma_{00} + \gamma_{01} W_j + u_{0j} + r_{ij}.$$

It is noted that u_{0j} now has a different meaning as contrasted with that of the previous model. Whereas the random variable u_{0j} had been the deviation of unit j's mean from the grand mean, it now represents the residual:

$$u_{0j} = B_{0j} - \gamma_{00} - \gamma_{01} W_j \, .$$

Similarly, the variance in u_{0j}, τ_{00}, is now the residual or conditional variance in B_{0j} after controlling for W_j (Raudenbush, & Bryk, 2002, p. 24, 25).

3.7.1.3 Random Coefficients Regression Model

All of the sub-models discussed are examples of random intercept models. Only the level-1 intercept coefficient, B_{0j}, was viewed as random. The level-1 slope did not exist in the one-way ANOVA or the means as outcomes cases. In the random effects ANCOVA model, B_{1j} was included but constrained to have a common effect for all groups (Raudenbush, & Bryk, 2002, p. 26).

A major class of applications of hierarchical linear models involves studies in which level-1 slopes are conceived as varying randomly over the population of level-2 units. The simplest case of this type is the random coefficients regression model. In these models, both the level-1 intercept and one or more level-1 slopes vary randomly, but no attempt is made to predict this variation (Raudenbush, & Bryk, 2002, p. 26).

Specifically, the level-1 model is identical. The level-2 model is still a simplification where γ_{01} and γ_{11} are constrained to be null. Hence, the level-2 model becomes (Raudenbush, & Bryk, 2002, p. 26, 27):

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

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

where

γ_{00} is the average intercept across the level-2 units;

γ_{10} is the average regression slope across the level-2 units;

u_{0j} is the unique increment to the intercept associated with level-2 unit j; and

u_{1j} is the unique increment to the slope associated with level-2 unit j.

It formally represents the dispersion of the level-2 random effects as a variance-covariance matrix:

$$Var\begin{bmatrix} u_{0j} \\ u_{1j} \end{bmatrix} = \begin{bmatrix} \tau_{00} & \tau_{01} \\ \tau_{10} & \tau_{11} \end{bmatrix} = T \text{ ,}$$

where

$Var(u_{0j}) = \tau_{00}$ = unconditional variance in the level-1 intercepts;

$Var(u_{1j}) = \tau_{11}$ = unconditional variance in the level-1 slopes; and

$Cov(u_{0j}, u_{1j}) = \tau_{01}$ = unconditional covariance between the level-1 intercepts and slopes.

Note that, it is referred to these as unconditional variance-covariance components because no level-2 predictors are included in either of the equations. Similarly, this model is referred to as an unconditional level-2 model (Raudenbush, & Bryk, 2002, p. 27).

Substitution of the expressions for B_{0j} and B_{1j} yields a combined model:

$$Y_{ij} = \gamma_{00} + \gamma_{10}(X_{ij} - \overline{X}_{.j}) + u_{0j} + u_{1j}(X_{ij} - \overline{X}_{.j}) + r_{ij} \cdot$$

This model implies that the outcome Y_{ij} is a function of the average regression equation, $\gamma_{00} + \gamma_{10}(X_{ij} - \overline{X}_{.j})$ plus a random error having three components: u_{0j}, the random effect of unit j on the mean; $u_{1j}(X_{ij} - \overline{X}_{.j})$, where u_{0j} is the random effect of unit j on the slope B_{1j}, and the level-1 error, r_{ij} (Raudenbush, & Bryk, 2002, p. 27).

3.7.1.4 Intercepts and Slopes as Outcomes

The random coefficients regression model allows estimating the variability in the regression coefficients (both intercepts and slopes) across the level-2 units. The next logical step is to model this variability (Raudenbush, & Bryk, 2002, p. 27).

Given one level-1 predictor, X_{ij}, and one level-2 predictor, W_j, these questions may be addressed by employing the full model. Of course, this model may be readily expanded to incorporate the effects of multiple Xs and of multiple Ws (Raudenbush, & Bryk, 2002, p. 28).

3.7.2 Centering (Choosing the Location of X and W)

Choice of location for level-1 and level-2 predictors affects the definitions of the level-1 and level-2 intercepts in two-level models. In some applications, centering around a constant such as the grand mean is advisable, while in other settings, centering around a level-2 mean such as group-mean centering will be preferable (Raudenbush, & Bryk, 2002).

In quantitative research, it is essential that the variables under study have precise meaning so that statistical results can be related to the theoretical concerns that motivate the research. In the case of hierarchical linear models, the intercept and slopes in the level-1 model become outcome variables at level-2. It is vital that the meaning of these outcome variables be clearly understood (Raudenbush, & Bryk, 2002, p. 31).

The meaning of the intercept in the level-1 model depends on the location of the level-1 predictor variables, the Xs. In the simple model;

$$Y_{ij} = \beta_{0j} + \beta_{1j} X_{ij} + r_{ij},$$

the intercept B_{0j}, is defined as the expected outcome for a student attending school j who has a value of zero on X_{ij}. If the researcher is to make sense of models that account for variation in B_{0j}, the choice of a metric for all level-1 predictors becomes important. In particular, if an X_{ij} value of zero is not meaningful, then the researcher may want to transform X_{ij}, or choose a location for X_{ij} that will render B_{0j} more meaningful. In some cases, a proper choice of location will be required in order to ensure numerical stability in estimating hierarchical linear models (Raudenbush, & Bryk, 2002, p. 32).

Similarly, interpretations regarding the intercepts in the level-2 models depend on the location of the W_j variables. The numerical stability of estimation is not affected by the location for the Ws, but a suitable choice will ease interpretation of results (Raudenbush, & Bryk, 2002, p. 32).

In the present study, two types of centering were used: group-mean centering and grand-mean centering. All student level factors (level-1 variables) were centered around the group mean. On the other hand, grand mean centering was used for all of the school level factors (level-2 variables).

3.7.2.1 Centering Around the Grand Mean

It is often useful to center the variable X around the grand mean. In this case, the level-1 predictors are of the form (Raudenbush, & Bryk, 2002, p. 33):

$$(X_{ij} - \bar{X}\ldots).$$

Now, the intercept, B_{0j}, is the expected outcome for a subject whose value on X_{ij} is equal to the grand mean, $\bar{X}$.. . This is the standard choice of location for X_{ij} in the classical ANCOVA model. As in the case in ANCOVA, grand mean centering yields an intercept that can be interpreted as an adjusted mean for group j,

$$B_{0j} = \mu_{\gamma j} - B_{1j}(\overline{X}_{.j} - \overline{X}_{..})$$

Similarly, the $Var(B_{0j}) = \tau_{00}$ is the variance among the level-2 units in the adjusted means (Raudenbush, & Bryk, 2002, p. 33).

3.7.2.2 Centering Around the Level-2 Mean (Group Mean Centering)

Another option is to center the original predictors around their corresponding level-2 unit means:

$$(X_{ij} - \bar{X}_{.j}).$$

In this case, the intercept B_{0j} becomes the unadjusted mean for group j. That is,

$$B_{0j} = \mu_{\gamma_j}$$

and $Var(B_{0j})$ is now just the variance among the level-2 unit means, μ_{γ_j} (Raudenbush, & Bryk, 2002, p. 33).

3.7.3 Random versus Fixed Variables

Suppose that the analyst wishes to use information about a second level-1 predictor. Let X_{1ij} denote the original X and let X_{2ij} denote the second level-1 predictor. Assume that there is still just a single level-2 predictor, W_j. The level-1 model, assuming group-mean centering for both X_{1ij} and X_{2ij}, becomes (Raudenbush, & Bryk, 2002, p. 29):

$$Y_{ij} = \beta_{0j} + \beta_{1j}(X_{1ij} - \overline{X}_{1.j}) + \beta_{2j}(X_{2ij} - \overline{X}_{2.j}) + r_{ij}.$$

There are three options for modeling β_{2j}. One option is that the effect of X_{2ij} is constrained to be invariant across level-2 units, implying

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

where γ_{20} is the common effect of in X_{2ij} every level-2 unit. It is said that the effect of β_{2j} is fixed across level-2 units (Raudenbush, & Bryk, 2002, p. 30).

A second option would be to model the slope β_{2j} as a function of an average value, γ_{20}, plus a random effect associated with each level-2 unit:

$$\beta_{2j} = \gamma_{20} + u_{2j}.$$

Here β_{2j} is random. Notice that this equation specifies no predictors for β_{2j}. Suppose, however, that this slope depends on W_j. One might then formulate the slopes as outcomes model:

$$\beta_{2j} = \gamma_{20} + \gamma_{21} W_j + u_{2j}.$$

According to this model, part of the variation of the slope β_{2j} can be predicted by W_j, but a random component, u_{2j}, remains unexplained. On the other hand, it may be that once the effect of W_j is taken into account, the residual variation in β_{2j}, that is, $Var(u_{2j}) = \tau_{22}$, is negligible. Then a model constraining that residual variation to be null would be sensible:

$$\beta_{2j} = \gamma_{20} + \gamma_{21} W_j.$$

In this third case, β_{2j} is a non-randomly varying slope because it varies strictly as a function of the predictor W_j (Raudenbush, & Bryk, 2002, p. 30).

So far it has been interested in just a single level-2 predictor, W_j. The introduction of multiple W_js is straightforward. Further, the level-2 model does not need to be identical for each question. One set of W_js may apply for the intercept, a different set be used for β_{1j}, another set for β_{2j}, and so on. When nonparallel specification is employed, however, extra care must be exercised in the interpretation of the results (Raudenbush, & Bryk, 2002, p. 30).

As a conclusion, the decision of whether the variable is fixed or random at level-1 is vital in hierarchical linear models. When the variable is fixed in reality and taken as fixed accordingly, the model will be simpler yielding more precise results. On the other hand, when the variable is random in reality and taken as fixed, the estimates will be biased.

In the hierarchical linear modeling computer package program, variables thought as random should include an error term at level-1, whereas variables considered as fixed do not need any error term in the equation. The fixed variables are considered as essentially the same across the schools in contrast to the random variables.

In the present study, the two-level hierarchical linear model was built by considering all the level-1 variables as random. Then, the results were investigated in order to decide the variables were random or fixed. The variables were treated as random if the results were found as significant. Otherwise, the variables were considered as fixed due to the non-significant results. The level-1 variables *(Grade, Memorisation Strategies,* and *Disciplinary Climate in Mathematics Lessons)* were random variables in the model of Turkey due to the significant results. For the model of the European Union Countries, the level-1 variables *(Grade, Teacher Support in Mathematics Lessons,* and *Disciplinary Climate in Mathematics Lessons)* were found as random variables. Lastly, the level-1 variables *(Grade, Mathematics Self-Efficacy,* and *Disciplinary Climate in Mathematics Lessons)* were random variables for the model of the European Union Candidate Countries. Furthermore, the intercept parameter in all of the three models was considered as random and the variation around it was modeled as a function of student and school characteristics across the schools.

3.7.4 Handling Missing Data

Two-level hierarchical linear modeling provides two options for handling missing data at level-1: pairwise and listwise deletion of cases. The pairwise and listwise deletions follow the conventional routines used in standard statistical packages for regression analysis and the general linear model. Although the pairwise option is included, it is cautioned against its use, especially when the amount of missing data is substantial (Raudenbush, Bryk, Cheong, & Congdon, 2001, p. 49).

At level-2, two-level hierarchical linear modeling assumes complete data. If there is missing information, one should either impute a value for the missing information, or delete the units in question. Prior to entering data into two-level hierarchical linear modeling, it is important to check that the level-2 file does not contain blanks or missing data codes as the program will read these as legitimate values (Raudenbush, Bryk, Cheong, & Congdon, 2001, p. 49, 50).

How two-level hierarchical linear modeling handles missing data differs a bit in the ASCII and non-ASCII cases. For ASCII data, it is very important that there should not be any missing data codes or blanks in the level-2 file. The two-level hierarchical linear modeling will read these as valid data; missing data codes as they are coded and blanks will be read as zeros. For non-ASCII data, the program will skip over cases that have missing data in them. Thus, the user has to prepare either system-missing values or use missing values for the missing data for non-ASCII file input (Raudenbush, Bryk, Cheong, & Congdon, 2001, p. 51).

In the present study, ASCII files were used as input files. Therefore, there should not be any missing data codes or blanks in the level-2 file. Firstly, the missing data analyses were conducted for the level-2 data files of Turkey, European Union Countries and European Union Candidate Countries in order to examine the amounts of the missing data in the level-2 variables. As known, the criterion of the missing percentage is 10%, in general for the mean replacement.

For the level-2 data file of Turkey, the missing values of the school level factors ranged from 0.6% to 3.8%. There were exceptions only in the two school level variables, *Total Student-Teacher Ratio* and *Mathematics Student-Teacher Ratio,* and these two variables had the missing values as 20.1%. Although the percentage of the missing values in these two school level variables were exceeded the criterion, mean replacement was conducted for the missing values of the nine school level factors in order not to lose any subjects in the study.

For the level-2 data file of European Union Countries, the missing values of the school level factors ranged from 0.5% to 7.9%. Since the percentage of the missing values in the school level variables were less than the criterion, mean replacement was conducted for the missing values of the nineteen school level factors.

For the level-2 data file of European Union Candidate Countries, the missing values of the school level factors ranged from 0.5% to 6.5%. Since the percentage of the missing values in the school level variables were less than the criterion, mean replacement was conducted for the missing values of the twelve school level factors.

3.7.5 Hierarchical Linear Model Variables of the Present Study

3.7.5.1 Student Level Factors (Level-1 Variables)

Twenty-three student level factors were included as the level-1 variables in the hierarchical linear models of Turkey, European Union Countries and European Union Candidate Countries. All the student level factors were selected as the PISA indices calculated except for the two variables, *Grade* and *Gender of the Students*. All twenty-three student level factors were as the following:

(1) Grade
(2) Gender
(3) Highest Parental Occupational Status
(4) Highest Educational Level of Parents
(5) Socio-Economic and Cultural Status
(6) Computer Facilities at Home
(7) Cultural Possessions of the Family
(8) Home Educational Resources
(9) Attitudes towards School
(10) Student-Teacher Relations at School
(11) Sense of Belonging at School
(12) Interest in Mathematics
(13) Instrumental Motivation in Mathematics
(14) Mathematics Self-Efficacy
(15) Mathematics Anxiety
(16) Mathematics Self-Concept
(17) Control Strategies
(18) Elaboration Strategies
(19) Memorisation Strategies
(20) Competitive Learning
(21) Cooperative Learning
(22) Teacher Support in Mathematics Lessons
(23) Disciplinary Climate in Mathematics Lessons

3.7.5.2 School Level Factors (Level-2 Variables)

Nineteen school level factors were included as the level-2 variables in the hierarchical linear models of Turkey, European Union Countries and European Union Candidate Countries. All the school level factors were selected as the PISA indices calculated. All nineteen school level factors were as the following:

(1) School Type
(2) School Size
(3) Proportion of Females Enrolled at School
(4) Total Student-Teacher Ratio
(5) Mathematics Student-Teacher Ratio
(6) Academic Selectivity
(7) Use of Assessments
(8) Ability Grouping between Mathematics Classes
(9) Mathematics Extension Courses
(10) Mathematics Activities
(11) Resource Autonomy
(12) Curricular Autonomy
(13) Teacher Shortage
(14) Quality of School's Physical Infrastructure
(15) Quality of School's Educational Resources
(16) Student Morale and Commitment
(17) Teacher Morale and Commitment
(18) Student-Related Factors Affecting School Climate
(19) Teacher-Related Factors Affecting School Climate

3.7.5.3 Controlling Variable

It is critical to control for some student factors before attempting to assess the impact of various variables related to school in order to explore the school effect. In the present study, *Mathematics Self-Efficacy* index variable was used as a control variable. The choice of the control variable depends on two reasons. Firstly, an index variable includes more than one variable and is preferred instead of a constructed variable in case of the high amount of missing data in some observed variables.

Secondly, the correlational analyses revealed that there was strong relationship between *Mathematics Self-Efficacy* and *Mathematical Literacy* for the data of Turkey, European Union Countries and European Union Candidate Countries. Indeed, the student level variable having the strongest relation with mathematical literacy performance of the students was the mathematics self-efficacy levels of the students in Turkey, European Union Countries and European Union Candidate Countries.

Correspondingly, average mathematics self-efficacy levels of the students were calculated separately for Turkey, European Union Countries and European Union Candidate Countries. Therefore, *Average Mathematics Self-Efficacy* variable was constructed as a controlling variable and added separately as the twentieth factor to the level-2 files of Turkey, European Union Countries and European Union Candidate Countries.

3.7.5.4 Outcome Variable (Five Mathematical Literacy Plausible Values)

In PISA 2003 project, not all of the students responded to all of the mathematics items. Therefore, student proficiencies or measures were not observed for all the mathematics items. Since there were missing data that could be inferred from the observed item responses, several possible alternative approaches could be applied for making this inference. PISA used two approaches such as maximum likelihood using Warm's (1985) Weighted Likelihood Estimator (WLE) and maximum likelihood using plausible values (PVs). Plausible values are a selection of likely proficiencies for students that attained each score. The plausible values are not text scores and should not be treated as such. They are random numbers drawn from the distribution of scores that could be reasonably assigned to each individual (OECD Publications, 2002b). Therefore, five overall mathematical literacy plausible values from PV1MATH to PV2MATH were computed for all of the participating students in the PISA project.

Actually, four models were built in order to investigate the effects of student and school level factors on students' mathematical literacy skills in the HLM analyses for Turkey. Similar with Turkey HLM analyses, four models were examined for European Union Countries and for European Union Candidate

Countries. In the present study, five overall mathematics literacy plausible values from PV1MATH to PV5MATH were considered as mathematical literacy variables. All the four HLM models were conducted for the five mathematical literacy plausible values separately, and then the averages of the obtained values from the results of the HLM analyses were calculated. For instance, the first HLM model for Turkey were conducted five times in the consideration of the five mathematical literacy plausible values and the average values of the obtained results from the five analyses of the first HLM model were calculated and presented as the results of the first HLM model for Turkey. This process was conducted separately for the four HLM models for Turkey. Correspondingly, the process of calculating the average values of the results of the five plausible values for each model was carried among Turkey, member and candidate countries of European Union. Thus, all the five mathematical literacy plausible values were included as the outcome variables in the hierarchical linear models of Turkey, European Union Countries and European Union Candidate Countries.

CHAPTER IV

RESULTS

This chapter of the dissertation is devoted to the presentation of the results of the present study. Two main sections such as preliminary studies and hierarchical linear modeling were included in this chapter. In preliminary studies section, the variables of the study were tested separately for Turkey, European Union Countries and European Union Candidate Countries with respect to their frequency distributions and their descriptive statistics. In hierarchical linear modeling section, hierarchical linear modeling assumptions and hierarchical linear models that were built for investigating the effects of the selected student and school level factors on mathematical literacy performance were separately explained for Turkey, European Union Countries and European Union Candidate Countries.

4.1 Preliminary Studies

All the variables included in the study were examined with respect to the appropriate descriptive statistics such as their frequency distributions and descriptive measures. The goal of finding frequency distributions of the variables was to see the general pattern of the responses. By the help of the frequency distributions, the most selected alternatives, the least selected alternatives and the percentages of the responses given to alternatives of the statements in the items could be investigated. The goal of finding descriptive measures of the variables was to describe distributions. Indicators of the average score, indicators of the spread of the differences among scores and indicators of the shape of the distribution could be examined by descriptive measures. The frequency distributions and descriptive measures were presented in three parts such as for Turkey, European Union Countries and European Union Candidate Countries.

4.1.1 Descriptive Statistics of the Variables for Turkey

There were 159 school principal data for school level variables and 4 855 student data for student level variables. As student level factors, 24 variables were included. The selected variables were grade and gender of the students as student characteristics; highest parental occupational status, highest educational level of parents, socio-economic and cultural status, computer facilities at home, cultural possessions of the family and home educational resources as student background variables; attitudes towards school, student-teacher relations at school and sense of belonging at school as school climate variables; interest in mathematics, instrumental motivation in mathematics, mathematics self-efficacy, mathematics anxiety and mathematics self-concept as self-related cognitions in mathematics variables; control strategies, elaboration strategies, memorization strategies, competitive learning and cooperative learning as learning and instruction variables; and teacher support and disciplinary climate in mathematics lessons as classroom climate variables. As school level factors, 20 variables were included. The selected variables were average mathematics self-efficacy as controlling variable; school type, school size and proportion of females enrolled at school as school characteristics; student-teacher ratio and mathematics student-teacher ratio as indicators of school resources variables; use of assessments, academic selectivity, ability grouping between mathematics classes, mathematics extension courses, mathematics activities, resource autonomy and curricular autonomy as admittance policies and instructional context variables; teacher shortage, quality of school's physical infrastructure and quality of school's educational resources as school resources variables; and student morale and commitment, teacher morale and commitment, student-related factors affecting school climate and teacher-related factors affecting school climate as school climate variables. The descriptive statistics for student and school level variables for Turkey could be found at the end of the dissertation, in Appendix F.

4.1.2 Descriptive Statistics of the Variables for European Union Countries

There were 189 school principal data for school level variables and 5 129 student data for student level variables. The same 24 student level variables and 20 school level variables included in Turkey analyses were selected for the analyses of European Union Countries. The descriptive statistics for student and school level variables for European Union Countries could be found at the end of the dissertation, in Appendix G. Moreover, the distribution of grade and gender of the students with respect to each country in the European Union was displayed at the end of the dissertation, in Appendix K.

4.1.3 Descriptive Statistics of the Variables for European Union Candidate Countries

There were 185 school principal data for school level variables and 4 419 student data for student level variables. The same 24 student level variables and 20 school level variables included in the analyses of Turkey and European Union Countries were selected for the analyses of European Union Candidate Countries. The descriptive statistics for student and school level variables for European Union Candidate Countries could be found at the end of the dissertation, in Appendix H. Furthermore, the distribution of grade and gender of the students with respect to each candidate country for the European Union was displayed at the end of the dissertation, in Appendix K.

4.2 Hierarchical Linear Modeling (HLM) Assumptions

Hierarchical Linear Models (HLM) are relatively new and there are few in-depth discussions of the consequences of violating model assumptions. Due to this, Bryk and Raudenbush (2002) state that they rely on the principles from general linear model theory and experience based on developing hierarchical model mathematics.

The validity of the inferences based on standard linear models depends on the tenability of the assumptions about both the structural and random parts of the model. In regard to the structural part, OLS requires that the model should be correctly specified and that the endogenous variable is a linear function of the regression coefficients. Specification applies at both levels for HLM. Moreover, model specification at one level can affect the results at other levels. Given that the school level equations may have correlated errors, the misspecification of one equation can bias the estimates of others. In regard to the random part of the model, OLS regression assumes independent errors with equal variances. Standard hypothesis tests also require that the errors should be normally distributed. HLM has similar assumptions for the student and school levels. A violation of these assumptions will not bias, inflate, the school level coefficients estimates, but it can adversely influence their estimated standard errors and inferential statistics.

There are several key assumptions of two level hierarchical models. Two general equations are provided to help understand the assumptions:

Student Level: $Y_{ij} = B_{0j} + \Sigma\, B_{qj}\, X_{qij} + r_{ij}$

School Level: $B_{qj} = \gamma_{q0} + \Sigma\, \gamma_{qs}\, W_{sj} + u_{qj}$

where i is the individual student, j is the school the student enrolled at, q is the number of the student level coefficients in the model, and s is the number of the school level coefficients in the model. W is used for the school level variable(s) in an attempt to differentiate from level-1 variables.

The key assumptions are:

1. Each r_{ij} is independent and normally distributed with a mean of 0 and variance σ^2 for every level-1 (student) unit i within each level-2 (school) unit j.
   [i.e., $r_{ij} \sim N(0, \sigma^2)$]
2. The student level predictors, X_{qij}, are independent of r_{ij}.
   [i.e., $Cov(X_{qij}, r_{ij}) = 0$ for all q]
3. The vector of Q + 1 random errors at school level 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 school level units.
   [i.e., $u_j = (u_{0j}, \ldots, u_{qj})' \sim N(0, T)$]

4. The set of school level predictors (i.e., all the unique elements in W_{sj} across the Q + 1 equations) are independent of every $u_{qj.}$
   [i.e., for every W_{sj} and u_{qj}, Cov (W_{sj}, u_{qj}) = 0]
5. The errors at student level and school level are also independent
   [i.e., Cov (r_{ij}, u_{qj}) = 0 for all q].

Assumptions 2, 4, and 5 focus on the relationship between the variables included in the structural portion of the model (the Xs and Ws) and those factors relegated to the error terms, r_{ij} and u_{qj}. They pertain to the adequacy of model specification. Their tenability affects the bias of γ_{qs}, that is, whether the expected value $E(\gamma_{qs}) = \gamma_{qs}$. Assumptions 1 and 3 focus only on the random portion of the model (i.e., r_{ij} and u_{qj}) and their tenability affects the accuracy of the estimates of the se(γ_{qs}), B_{qj}, σ^2, and T.

The errors in measurement in student level factors can bias estimates in the school level model. The errors in measurement of school level factors can be viewed as a specific form of misspecification. In general, if a school level predictor is measured with error, its coefficient and possibly other school level coefficients will be biased. The degree of the bias depends on the explanatory power of the true predictor, the degree of unreliability of its measurement, and the intercorrelations among the predictors.

Non-normality of the errors at student level predictors will not bias the estimation of the school level effects but will introduce bias into the standard errors at both levels and therefore into the computation of confidence intervals and hypothesis tests (Bryk & Raudenbush, 2002). Unfortunately, very little is known about the direction and severity of such effects. Estimation of fixed effects will not biased by a failure of normality at the school level and this can be examined through the Mahalanobis Distance measure.

The assumption tests for Turkey, European Union Countries and European Union Candidate Countries were presented at the end of the dissertation, in Appendix L. Finally, the only assumption that could be tested before the models were analyzed with HLM was the linearity of the student and school level variables. Utilizing scatter plots, no non-linear relationships were observed for Turkey, European Union Countries and European Union Candidate Countries.

4.3 Hierarchical Linear Modeling (HLM) Analyses

In this part of the chapter of the dissertation, the results of Hierarchical Linear Modeling (HLM) analyses were presented in three parts as the results of HLM analyses for Turkey, for European Union Countries and for European Union Candidate Countries. Four models were built in order to investigate the effects of student and school level factors on students' mathematical literacy skills in the HLM analyses for Turkey. Similar with Turkey HLM analyses, four models were examined for European Union Countries and for European Union Candidate Countries.

4.3.1 HLM Analyses for Turkey

4.3.1.1 Results of Research Question I (Analysis of Variance Model)

The first research question of HLM analyses for Turkey provided information about if there are differences in the students' mathematical literacy skills among schools in Turkey. In HLM, this research question is termed as Analysis of Variance Model.

The equations to answer this question are as such:

$$\textit{Mathematical Literacy } (Y_{ij}) = B_{0j} + r_{ij}$$

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

where

Y_{ij} = the endogenous variable, Mathematical Literacy

B_{0j} = the intercept

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of Turkey was given in the Table 4.1. The analysis of variance indicates that there are significant differences among schools. The grand mean of mathematical literacy scores is 419.53 with a standard error of 6.24, indicating a 95% confidence interval of:

Confidence Interval = 419.53 $\pm$ 1.96 (6.24) = (407.30, 431.76).

Table 4.1 Final Estimation of Fixed Effects

(Analysis of Variance Model of Turkey)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Average school mean, γ_{00}	419.53	6.24	67.28	0.000

The final estimation of variance components obtained from analysis of variance model of Turkey was given in the Table 4.2. The maximum likelihood estimate of the variance components is also provided. At the student level σ^2 = 4 944.81 and at the school level, γ_{00} is the variance of the true school means, B_{0j}, around the grand mean. The variance component for school means is τ_{00} = 5 965.26 and shows a substantial proportion of variation among schools as estimated by the intraclass correlation:

$\rho_{ic} = \tau_{00} / (\tau_{00} + \sigma^2)$ = 4 944.81 / (4 944.81 + 5 965.26) = 0.453.

Thus, 45% of the variance in mathematical literacy is among schools.

HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is impacted by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities ρ = 0.96 indicating that the sample means tend to be a reliable indicator of true school means. The equation for determining reliability of the mean mathematical literacy within each school is: $\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / n_j)]$. As can be seen from the equation, the reliability is affected by the within school size (n_j) of the sample.

Table 4.2 Final Estimation of Variance Components

(Analysis of Variance Model of Turkey)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	5 965.26	158	5 336.82	0.000
Level-1 Effect, r_{ij}	4 944.81			

Finally, the test statistic displayed at Table 4.2 (X^2 = 5 336.82, df = 158) indicates significant ($p < 0.001$) variation among schools in their mathematical literacy. The result also suggests that school level variables might account for the differences in the students' mathematical literacy skills.

4.3.1.2 Results of Research Question II (Means as Outcomes Model)

The second research question of HLM analyses for Turkey provided information about which school characteristics are associated with the differences in the students' mathematical literacy skills in Turkey. In HLM, this research question is termed as Means as Outcomes Model.

The equations to answer this question are:

$$\textit{Mathematical Literacy } (Y_{ij}) = B_{0j} + r_{ij}$$

$$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHTYPE) + \gamma_{03}*(SCHSIZE) + \gamma_{04}*(PFEMALE) + \gamma_{05}*(RATIO) + \gamma_{06}*(MRATIO) + \gamma_{07}*(ASSESS) + \gamma_{08}*(ASELECT) + \gamma_{09}*(ABGROUP) + \gamma_{10}*(EXCOURSE) + \gamma_{11}*(MACTIV) + \gamma_{12}*(AUTRES) + \gamma_{13}*(AUTCURR) + \gamma_{14}*(TSHORT) + \gamma_{15}*(PHYST) + \gamma_{16}*(EDUCRES) + \gamma_{17}*(STMORALE) + \gamma_{18}*(TMORALE) + \gamma_{19}*(STFACTOR) + \gamma_{20}*(TFACTOR) + u_{0j}$$

for j = 1, 2, …, n schools

where

B_{0j} = the school mean on mathematical literacy

γ_{00} = the grand mean for mathematical literacy scores. The average of the school means on mathematical literacy scores across the population of schools

γ_{01} = the differentiating effect of school average mathematics self-efficacy on the school mean on mathematical literacy

γ_{02} = the differentiating effect of school type on the school mean on mathematical literacy

γ_{03} = the differentiating effect of school size on the school mean on mathematical literacy

γ_{04} = the differentiating effect of proportion of females enrolled at school on the school mean on mathematical literacy

γ_{05} = the differentiating effect of total student-teacher ratio on the school mean on mathematical literacy

γ_{06} = the differentiating effect of mathematics student-teacher ratio on the school mean on mathematical literacy

γ_{07} = the differentiating effect of use of assessments on the school mean on mathematical literacy

γ_{08} = the differentiating effect of academic selectivity on the school mean on mathematical literacy

γ_{09} = the differentiating effect of ability grouping between mathematics classes on the school mean on mathematical literacy

γ_{10} = the differentiating effect of mathematics extension courses on the school mean on mathematical literacy

γ_{11} = the differentiating effect of mathematics activities on the school mean on mathematical literacy

γ_{12} = the differentiating effect of resource autonomy on the school mean on mathematical literacy

γ_{13} = the differentiating effect of curricular autonomy on the school mean on mathematical literacy

γ_{14} = the differentiating effect of teacher shortage on the school mean on mathematical literacy

γ_{15} = the differentiating effect of quality of school's physical infrastructure on the school mean on mathematical literacy

γ_{16} = the differentiating effect of quality of school's educational resources on the school mean on mathematical literacy

γ_{17} = the differentiating effect of student morale and commitment on the school mean on mathematical literacy

γ_{18} = the differentiating effect of teacher morale and commitment on the school mean on mathematical literacy

γ_{19} = the differentiating effect of student-related factors affecting school climate on the school mean on mathematical literacy

γ_{20} = the differentiating effect of teacher-related factors affecting school climate on the school mean on mathematical literacy

τ_{00} = the conditional variance or school level variance in B_{0j} after accounting for these school level variables

u_{0j} = the residual

The model was first run with all twenty factors, but *School Type*, *Use of Assessments*, *Ability Grouping between Mathematics Classes*, *Mathematics Extension Courses*, M*athematics Activities*, *Resource Autonomy*, *Curricular Autonomy*, *Teacher Shortage* and *Quality of School's Educational Resources* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of Turkey was given in the Table 4.3.

The results obtained from the Table 4.3 indicate a significant association between *Average Mathematics Self-Efficacy* and *Mean Mathematical Literacy* (γ_{01} = 117.54, se = 7.64); *School Size* and *Mean Mathematical Literacy* (γ_{02} = 0.02, se = 0.01); *Proportion of Females Enrolled at School* and *Mean Mathematical Literacy* (γ_{03} = 85.21, se = 18.66); *Total Student-Teacher Ratio* and *Mean Mathematical Literacy* (γ_{04} = -1.12, se = 0.36); *Mathematics Student-Teacher Ratio* and *Mean Mathematical Literacy* (γ_{05} = -0.27, se = 0.04); *Academic Selectivity* and *Mean Mathematical Literacy* (γ_{06} = 9.90, se = 3.81); *Quality of School's Physical Infrastructure* and *Mean Mathematical Literacy* (γ_{07} = 9.13, se = 3.41); *Student Morale and Commitment* and *Mean Mathematical Literacy* (γ_{08} = -8.60, se = 3.76); *Teacher Morale and Commitment* and *Mean Mathematical Literacy* (γ_{09} = 7.43, se = 3.48); *Student-Related Factors Affecting School Climate* and *Mean*

Mathematical Literacy (γ_{10} = 7.83, se = 3.31); and lastly *Teacher-Related Factors Affecting School Climate* and *Mean Mathematical Literacy* (γ_{11} = -10.92, se = 3.80). All these eleven factors will be reexamined during the development of the final full Intercepts and Slopes as Outcomes Model (Research Question 4).

Table 4.3 Final Estimation of Fixed Effects (Means as Outcomes Model of Turkey)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Model for School Means[1]				
Intercept, γ_{00}	417.63	3.22	130.45	0.000
MEANEFFI, γ_{01}	117.54	7.64	15.39	0.000
SCHSIZE, γ_{02}	0.02	0.01	3.75	0.000
PFEMALE, γ_{03}	85.21	18.66	4.57	0.000
RATIO, γ_{04}	-1.12	0.36	-3.13	0.003
MRATIO, γ_{05}	-0.27	0.04	-2.38	0.022
ASELECT, γ_{06}	9.90	3.81	2.60	0.010
PHYST, γ_{07}	9.13	3.41	2.68	0.008
STMORALE, γ_{08}	-8.60	3.76	-2.29	0.026
TMORALE, γ_{09}	7.43	3.48	2.13	0.035
STFACTOR, γ_{10}	7.83	3.31	2.37	0.018
TFACTOR, γ_{11}	-10.92	3.80	-2.87	0.005

[1] The school level variables were Grand Mean Centered before analysis.

The final estimation of variance components obtained from means as outcomes model of Turkey was given in the Table 4.4. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level variables included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level variables included in the model

Thus, all schools were used in this analysis and degrees of freedom for this model is: df = J – Q – 1 = 159 – 11 – 1 = 147.

Table 4.4 Final Estimation of Variance Components
(Means as Outcomes Model of Turkey)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School Mean, u_{0j}	1 438.88	147	1 293.88	0.000
Level-1 Effect, r_{ij}	4 950.79			

The residual variance between schools (τ_{00} = 1 438.88) is substantially smaller than the original variance (τ_{00} = 5 965.26) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors. By comparing the τ_{00} estimates across the two models (Analysis of Variance Model and Means as Outcomes Model), an index of proportion reduction can be developed, or more simply, the variance accounted for by the school level factors can be examined.

$$\text{Proportion of variance explained in } B_{oj} = \frac{\tau_{00}(ANOVA) - \tau_{00}(MeansasOutcomes)}{\tau_{00}(ANOVA)}$$

$$\text{Proportion of variance explained in } B_{oj} = \frac{5965.26 - 1438.88}{5965.26} = 0.759$$

This indicates that 75.9% of the true between school variance in mathematical literacy is accounted for by *Average Mathematics Self-Efficacy, School Size, Proportion of Females Enrolled at School, Total Student-Teacher Ratio, Mathematics Student-Teacher Ratio, Academic Selectivity, Quality of School's Physical Infrastructure, Student Morale and Commitment, Teacher Morale and Commitment, Student-Related Factors Affecting School Climate* and *Teacher-Related Factors Affecting School Climate*. Finally, the X^2 statistic is found as 1 293.88

(df = 147, $p < 0.001$) in the analysis indicating that these eleven school level variables did not account for all the variation in the intercepts.

4.3.1.3 Results of Research Question III (Random Coefficient Model)

The third research question of HLM analyses for Turkey provided information about which student characteristics that explain the differences in the students' mathematical literacy skills in Turkey. In HLM, this research question is termed as Random Coefficient Model.

The equations to answer this question are:

$$\begin{aligned} &\textit{Mathematical Literacy } (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) + \\ &B_{3j}*(OCCUPAR) + B_{4j}*(EDUCPAR) + B_{5j}*(SECS) + B_{6j}*(COMPHOME) + \\ &B_{7j}*(CULTURAL) + B_{8j}*(HOMEDUC) + B_{9j}*(ATTSCH) + B_{10j}*(RELATION) + \\ &B_{11j}*(BELONG) + B_{12j}*(INTEREST) + B_{13j}*(MOTIVAT) + B_{14j}*(SELFEFFI) + \\ &B_{15j}*(ANXIETY) + B_{16j}*(SELFCON) + B_{17j}*(CONTROL) + B_{18j}*(ELAB) + \\ &B_{19j}*(MEMOR) + B_{20j}*(COMPLRN) + B_{21j}*(COOPLRN) + B_{22j}*(SUPPORT) \\ &+ B_{23j}*(CLIMATE) + r_{ij} \end{aligned}$$

$$B_{0j} = \gamma_{00} + u_{0j}$$
$$B_{qj} = \gamma_{q0} + u_{qj}$$

where

Y_{ij} = mathematical literacy score of student i in school j

B_{0j} = the mean on mathematical literacy

B_{1j} = the differentiating effect of grade in school j (i.e., the degree to which grade differences among students relate to mathematical literacy)

B_{2j} = the gender gap in school j (i.e., the mean difference between mathematical literacy scores of females and males)

B_{3j} = the differentiating effect of highest parental occupational status in school j (i.e., the degree to which parental occupation differences among students relate to mathematical literacy)

B_{4j} = the differentiating effect of highest educational level of parents in school j (i.e., the degree to which parental education level differences among students relate to mathematical literacy)

B_{5j} = the differentiating effect of socio-economic and cultural status in school j (i.e., the degree to which socio-economic and cultural differences among students relate to mathematical literacy)

B_{6j} = the differentiating effect of computer facilities at home in school j (i.e., the degree to which home computer facility differences among students relate to mathematical literacy)

B_{7j} = the differentiating effect of cultural possessions of the family in school j (i.e., the degree to which family cultural possession differences among students relate to mathematical literacy)

B_{8j} = the differentiating effect of home educational resources in school j (i.e., the degree to which home educational resource differences among students relate to mathematical literacy)

B_{9j} = the differentiating effect of attitudes towards school in school j (i.e., the degree to which attitudinal differences among students towards school relate to mathematical literacy)

B_{10j} = the differentiating effect of student-teacher relations at school in school j (i.e., the degree to which student-teacher relation differences at school relate to mathematical literacy)

B_{11j} = the differentiating effect of sense of belonging at school in school j (i.e., the degree to which sense of belonging differences among students at school relate to mathematical literacy)

B_{12j} = the differentiating effect of interest in mathematics in school j (i.e., the degree to which mathematics interest differences among students relate to mathematical literacy)

B_{13j} = the differentiating effect of instrumental motivation in mathematics in school j (i.e., the degree to which mathematics instrumental motivation differences among students relate to mathematical literacy)

B_{14j} = the differentiating effect of self-efficacy in mathematics in school j (i.e., the degree to which mathematics self-efficacy differences among students relate to mathematical literacy)

B_{15j} = the differentiating effect of anxiety in mathematics in school j (i.e., the degree to which mathematics anxiety differences among students relate to mathematical literacy)

B_{16j} = the differentiating effect of self-concept in mathematics in school j (i.e., the degree to which mathematics self-concept differences among students relate to mathematical literacy)

B_{17j} = the differentiating effect of control strategies in school j (i.e., the degree to which control strategy differences among students relate to mathematical literacy)

B_{18j} = the differentiating effect of elaboration strategies in school j (i.e., the degree to which elaboration strategy differences among students relate to mathematical literacy)

B_{19j} = the differentiating effect of memorisation strategies in school j (i.e., the degree to which memorisation strategy differences among students relate to mathematical literacy)

B_{20j} = the differentiating effect of competitive learning in school j (i.e., the degree to which competitive learning differences among students relate to mathematical literacy)

B_{21j} = the differentiating effect of cooperative learning in school j (i.e., the degree to which cooperative learning differences among students relate to mathematical literacy)

B_{22j} = the differentiating effect of teacher support in math lessons in school j (i.e., the degree to which teacher support differences among students in math lessons relate to mathematical literacy)

B_{23j} = the differentiating effect of disciplinary climate in math lessons in school j (i.e., the degree to which disciplinary climate differences among students in math lessons relate to mathematical literacy)

B_{qj} = the coefficient for variable q for group j after accounting for other variables

The building strategy recommended by Bryk and Raudenbush (2002) was utilized. The student characteristic variables were first examined (*Grade, Gender*) to determine whether they were significantly related to mathematical literacy and whether or not they were randomly varying. A randomly varying coefficient or variable is defined as a slope whose value varies significantly among schools (e.g., the slope for one school may be steep and for another school may be flat). Of the first two variables, two were found to be significant and randomly varying variables.

Next, student background variables were examined (*Highest Parental Occupational Status, Highest Educational Level of Parents, Socio-Economic and Cultural Status, Computer Facilities at Home, Cultural Possessions of the Family,* and *Home Educational Resources*) along with the student characteristic variables from before. Only, the variable, *Home Educational Resources*, was found to be significant and randomly varying. The other background variables (*Highest Parental Occupational Status, Highest Educational Level of Parents, Socio-Economic and Cultural Status, Computer Facilities at Home* and *Cultural Possessions of the Family*) were found to be non-significant and non-randomly varying, thus, they were removed from the model. Moreover, in this step, the student characteristic variable, *Gender*, becomes non-randomly varying variable, so *Gender* will be examined as non-randomly varying variable in the model.

Then, school climate variables (*Attitudes towards School, Student-Teacher Relations at School* and *Sense of Belonging at School*) were added to the model. The variable, *Attitudes towards School*, was found as non-significant and non-randomly varying, it was removed from the model. The other two variables, *Student-Teacher Relations* and *Sense of Belonging at School*, were found to be significant but, they were non-randomly varying variables.

In the fourth step, variables about self-related cognitions in mathematics such as *Interest in Mathematics, Instrumental Motivation in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* were examined. *Interest in Mathematics* was found to be non-significant but, randomly varying. Since *Interest in Mathematics* was not significant, it was removed from the model. The other four variables, *Instrumental Motivation in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* were significant. But, only *Mathematics Self-Concept* was found to be randomly varying.

Next, learning and instruction factors (*Control Strategies, Elaboration Strategies, Memorisation Strategies, Competitive Learning* and *Cooperative Learning*) were added to the model. *Control, Elaboration* and *Memorisation Strategies* were significant, whereas *Competitive* and *Cooperative Learning* were non-significant. Since *Competitive* and *Cooperative Learning* were also non-randomly varying variables, they were removed from the model. When the other three significant variables were investigated whether or not they were randomly varying, all the three variables were found as non-randomly varying. Before the next step, the model was reexamined in terms of the variables entered the model before. The variable, *Instrumental Motivation in Mathematics*, about self-related cognitions in mathematics became non-significant, so it was removed from the model in this step. Furthermore, the student background variable, *Home Educational Resources* and the self-related cognitions in mathematics variable, *Mathematics Self-Concept* become non-randomly varying variables. Thus, these two variables will be examined as non-randomly varying variables in the model.

In the final step, variables about classroom climate as *Teacher Support* and *Disciplinary Climate in Mathematics Lessons* were entered to the model. *Teacher Support in Mathematics Lessons* was non-significant and non-randomly varying, so it was removed from the model. On the other hand, *Disciplinary Climate in Mathematics Lessons* was found to be significant and randomly varying.

Therefore, the final Random Coefficient Model includes twelve student level variables: *Grade* and *Gender* (student characteristics), *Home Educational Resources* (student background), *Student-Teacher Relations at School* and *Sense of Belonging at School* (school climate), *Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* (self-related cognitions in mathematics), *Control Strategies, Elaboration Strategies* and *Memorisation Strategies* (learning and instruction), and *Disciplinary Climate in Mathematics Lessons* (classroom climate). Among these twelve student level factors, only two variables such as *Grade* and *Disciplinary Climate in Mathematics Lessons* were examined as randomly varying. Therefore, the other ten factors found as non-randomly varying, were fixed in the final analysis. The final random coefficient model with the variables observed to be only significantly related to mathematical literacy and the variables observed to be both significantly related to mathematical literacy and randomly varying was presented in the results. The final estimation of fixed effects obtained from random coefficient model of Turkey was displayed in the Table 4.5.

The *Grade-Mathematical Literacy* slope coefficient (γ_{10} = 22.17, se = 2.86) indicates that students from different grades performed significantly different on the mathematical literacy assessment. Students from higher grades performed significantly higher than the students from lower grades on the mathematical literacy assessment. The *Gender-Mathematical Literacy* slope coefficient (γ_{20} = 18.79, se = 2.08) indicates that female and male students performed significantly different on the mathematical literacy assessment. Actually, female students performed significantly lower than the male students.

Table 4.5 Final Estimation of Fixed Effects (Random Coefficient Model of Turkey)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Overall mean math literacy[1], γ_{00}	419.22	6.26	67.00	0.000
GRADE, γ_{10}	22.17	2.86	7.76	0.000
GENDER, γ_{20}	18.79	2.08	9.03	0.000
HOMEDUC, γ_{30}	6.62	0.89	7.47	0.000
RELATION, γ_{40}	-6.98	0.92	-7.63	0.000
BELONG, γ_{50}	2.44	1.15	2.12	0.049
SELFEFFI, γ_{60}	17.79	1.18	15.06	0.000
ANXIETY, γ_{70}	-7.96	1.09	-7.29	0.000
SELFCON, γ_{80}	7.16	1.34	5.34	0.000
CONTROL, γ_{90}	5.69	1.28	4.44	0.000
ELAB, γ_{100}	-5.50	1.26	-4.36	0.000
MEMOR, γ_{110}	-4.24	1.25	-3.39	0.001
CLIMATE, γ_{120}	7.61	1.29	5.89	0.000

[1] The student level variables were Group Mean Centered before analysis.

The *Home Educational Resources-Mathematical Literacy* slope coefficient (γ_{30} = 6.62, se = 0.89) indicates that home educational resources is significantly and positively related to mathematical literacy. Students who have more educational resources at home performed better on the mathematical literacy assessment.

The *Student-Teacher Relations at School-Mathematical Literacy* slope coefficient (γ_{40} = -6.98, se = 0.92) indicates that student-teacher relations at school is significantly but negatively related to mathematical literacy. Students having better student-teacher relations at school performed lower on the mathematical literacy assessment. The *Sense of Belonging at School-Mathematical Literacy* slope coefficient (γ_{50} = 2.44, se = 1.15) indicates that sense of belonging at school is significantly and positively related to mathematical literacy. Students having positive feelings about their school performed higher on the mathematical literacy assessment.

The *Self-Efficacy in Mathematics-Mathematical Literacy* slope coefficient (γ_{60} = 17.79, se = 1.18) indicates that mathematics self-efficacy is significantly and positively related to mathematical literacy. Students having higher levels of mathematics self-efficacy performed better on the mathematical literacy assessment. The *Anxiety in Mathematics-Mathematical Literacy* slope coefficient (γ_{70} = -7.96, se = 1.09) indicates that mathematics anxiety is significantly but negatively related to mathematical literacy. That is, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. The *Self-Concept in Mathematics-Mathematical Literacy* slope coefficient (γ_{80} = 7.16, se = 1.34) indicates that mathematics self-concept is significantly and positively related to mathematical literacy. Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment.

The *Control Strategies-Mathematical Literacy* slope coefficient (γ_{90} = 5.69, se = 1.28) indicates that control strategies as learning strategies is significantly and positively related to mathematical literacy. Students having more preferences for this learning strategy performed higher on the mathematical literacy assessment. The *Elaboration Strategies-Mathematical Literacy* slope coefficient (γ_{100} = -5.50, se = 1.26) indicates that elaboration strategies as learning strategies is significantly but negatively related to mathematical literacy. Students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. The *Memorisation Strategies-Mathematical Literacy* slope coefficient (γ_{110} = -4.24, se = 1.25) indicates that memorisation strategies as learning strategies is significantly but negatively related to mathematical literacy. Students having more preferences for this learning strategy performed lower on the mathematical literacy assessment.

The *Disciplinary Climate in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{120} = 7.61, se = 1.29) indicates that disciplinary climate in mathematics lessons is significantly and positively related to mathematical literacy. Students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in their mathematics lessons on the mathematical literacy assessment.

The final estimation of variance components obtained from random coefficient model of Turkey was displayed in the Table 4.6. The degrees of freedom to test for the random effect for Random Coefficient Model are based on the number of schools that had sufficient data to compute a separate OLS regression. Therefore, 29 schools did not have sufficient data. The intercept and coefficients from the fixed effect portion of the table ($\gamma_{q0's}$) are based on empirical bayes estimates which utilize all data.

Table 4.6 Final Estimation of Variance Components
(Random Coefficient Model of Turkey)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	6 061.40	129	6 135.72	0.000
GRADE, u_{1j}	445.64	129	240.47	0.000
CLIMATE, u_{12j}	80.59	129	179.00	0.004
Level-1 Effect, r_{ij}	3 729.37			

Estimates of variance components for the random effects, and tests of the hypothesis that these variance components are null are also provided. *Grade* and *Disciplinary Climate in Mathematics Lessons* slopes all varied significantly as can be seen from the Table 4.6 (each has a p-value < 0.05). The significant p-value indicates that in some schools, the slopes are much steeper than for other schools, that is, the relationship with mathematical literacy is much stronger in some schools than in other schools. The variability among schools also suggests that school level variables might account for some of the differences.

The variance explained at the student level can be examined by comparing the variances in the Analysis of Variance Model and the Random Coefficient Model. The comparison is completed by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

$$\text{Proportion of variance explained at Level-1} = \frac{\sigma^2(ANOVA) - \sigma^2(RandomCoef.)}{\sigma^2(ANOVA)}$$

$$\text{Proportion of variance explained at Level-1} = \frac{5965.26 - 3729.37}{5965.26} = 0.375$$

By including these student level factors (*Grade, Gender, Home Educational Resources, Student-Teacher Relations at School, Sense of Belonging at School, Mathematics Self-Efficacy, Mathematics Anxiety, Mathematics Self-Concept, Control Strategies, Elaboration Strategies, Memorisation Strategies* and *Disciplinary Climate in Mathematics Lessons*) as predictors of mathematical literacy, within school variance was reduced by 37.5%. Therefore, these factors account for about 38% of the student level variance in mathematical literacy.

The reliability of the intercept and the randomly varying slopes can be estimated. The results provided from HLM analysis indicate that the intercept is quite reliable (.98) and the slopes are far less reliable (Grade = .41, Climate = .31). The primary reasons, according to Bryk and Raudenbush (2002), for the lower reliability of the slopes are that the true slope variance across schools is much smaller than the variance of the true means and many schools may be relatively homogeneous on the randomly varying variables (e.g., grade and disciplinary climate in mathematics lessons). Bryk and Raudenbush (2002) state that coefficient reliabilities above .05 are acceptable. The intercept reliability (.98) has increased from the Analysis of Variance Model (.96) due to the inclusion of student level predictors.

For the Random Coefficient Model, it is important to examine the variance of the errors, τ_{qq} correlations. Tau as correlations obtained from random coefficient model of Turkey was given in the Table 4.7. A high correlation indicates that essentially the same variation across the school 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 little high τ_{qq} correlation was observed between the variables, *Grade* and *Disciplinary Climate in Mathematics Lessons* (-.176).

Table 4.7 Tau as Correlations (Random Coefficient Model of Turkey)

	Intercept	*Grade*	*Disciplinary Climate in Mathematics Lessons*
Intercept	1.000	-0.152	0.337
Grade	-0.152	1.000	-0.176
Disciplinary Climate in Mathematics Lessons	0.337	-0.176	1.000

A test setting *Grade* as fixed was run and an analysis of deviance statistic computed. The deviance statistics and the number of parameters of the two models (*Grade* random versus fixed) were given in Table 4.8.

Table 4.8 Statistics for Current Covariance Components Model
(Random Coefficient Model of Turkey)

	Deviance	*Number of Estimated Parameters*
1st Model (GRADE – random)	52 168.66	7
2nd Model (GRADE – fixed)	52 197.55	4

The deviance statistic examines the hypothesis that τ_{23} (the correlation of errors between grade and disciplinary climate in mathematics lessons) equals zero. The results of variance-covariance components test were displayed in Table 4.9. As can be seen from Table 4.9, the deviance statistic between two models (*Grade* random versus fixed) was significant indicating that setting *Grade* as non-randomly varying did not create a better explanatory model. Thus, *Grade* was kept in the final Random Coefficient Model as randomly varying variable.

Table 4.9 Variance-Covariance Components Test Results
(Random Coefficient Model of Turkey)

	X^2	*df*	*p-value*
Variance-Covariance Components Test	28.90	3	0.000

4.3.1.4 Results of Research Question IV (Intercepts and Slopes as Outcomes Model)

The fourth research question of HLM analyses for Turkey provided information about which school characteristics influence the effect of student characteristics on the students' mathematical literacy skills in Turkey. In HLM, this research question is termed as Intercepts and Slopes as Outcomes Model.

For this research question, the coefficients (slopes) of the variables will be modeled. Simply, the variability in Level-1 coefficients from school to school will be examined to ascertain if Level-2 (school level) factors explain the variability. The coefficient is an indication of the amount of influence a variable has on the endogenous variable. The Level-2 variables that are significantly associated with Level-1 factors are termed as cross-level interactions. Traditionally, there is only one Level-2 equation for each Level-1 Beta value.

The general equation used to answer this question is in the form:

$$B_{qj} = \gamma_{q0} + \gamma_{q1}*(MEANEFFI) + \gamma_{q2}*(SCHSIZE) + \gamma_{q3}*(PFEMALE) + \gamma_{q4}*(RATIO) + \gamma_{q5}*(MRATIO) + \gamma_{q6}*(ASELECT) + \gamma_{q7}*(PHYST) + \gamma_{q8}*(STMORALE) + \gamma_{q9}*(TMORALE) + \gamma_{q10}*(STFACTOR) + \gamma_{q11}*(TFACTOR) + u_{qj}$$

where

B_{qj} = the slope as outcome coefficient for variable q for school j

This research question incorporates the three previous research questions and specifically examines randomly varying student level coefficients, slopes as outcomes, that can be examined with school level variables. The first model was the mathematical literacy as determined from the Analysis of Variance Model (Research Question 1). The variability of mathematical literacy was modeled with school level variables in the Means as Outcomes Model (Research Question 2).

Two student level variables or coefficients (*Grade* and *Disciplinary Climate in Mathematics Lessons*) were observed to be randomly varying in the Random Coefficient Model (Research Question 3). Due to this variability, these two coefficients can be modeled with school level variables, i.e., each randomly varying coefficient becomes a model. The school level variables that are observed to be significantly related to the random coefficients are termed as cross-level interactions. This simply means that a school level variable influences a student level slope.

The process of determining the final Intercept and Slopes as Outcomes Model begins with the results from the Random Coefficient Model (Research Question 3). The first step was to replicate the Means as Outcomes Model (Research Question 2) and include the significant student level variables from the Random Coefficient Model (Research Question 3).

The equations for first model in this analysis are:

Student Level:

$$\text{Mathematical Literacy } (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) + B_{3j}*(HOMEDUC) + B_{4j}*(RELATION) + B_{5j}*(BELONG) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(CONTROL) + B_{10j}*(ELAB) + B_{11j}*(MEMOR) + B_{12j}*(CLIMATE) + r_{ij}$$

School Level:

$$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(PFEMALE) + \gamma_{04}*(RATIO) + \gamma_{05}*(MRATIO) + \gamma_{06}*(ASELECT) + \gamma_{07}*(PHYST) + \gamma_{08}*(STMORALE) + \gamma_{09}*(TMORALE) + \gamma_{10}*(STFACTOR) + \gamma_{11}*(TFACTOR) + u_{0j}$$

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

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

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

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

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

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

$B_{7j} = \gamma_{70}$

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

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

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

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

$B_{12j} = \gamma_{120} + u_{12j}$

Of the eleven school level variables, only one variable, *Teacher Morale and Commitment*, was found as non-significant and removed from the model. Thus, the other ten school level factors were significantly related to mathematical literacy.

Next, eleven school level factors were included in the *Grade* coefficient model with the previous results.

The equations for second model in this analysis are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) + B_{3j}*(HOMEDUC) + B_{4j}*(RELATION) + B_{5j}*(BELONG) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(CONTROL) + B_{10j}*(ELAB) + B_{11j}*(MEMOR) + B_{12j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(PFEMALE) + \gamma_{04}*(RATIO) + \gamma_{05}*(MRATIO) + \gamma_{06}*(ASELECT) + \gamma_{07}*(PHYST) + \gamma_{08}*(STMORALE) + \gamma_{09}*(STFACTOR) + \gamma_{010}*(TFACTOR) + u_{0j}$

$B_{1j} = \gamma_{10} + \gamma_{11}*(MEANEFFI) + \gamma_{12}*(SCHSIZE) + \gamma_{13}*(PFEMALE) + \gamma_{14}*(RATIO) + \gamma_{15}*(MRATIO) + \gamma_{16}*(ASELECT) + \gamma_{17}*(PHYST) + \gamma_{18}*(STMORALE) + \gamma_{19}*(TMORALE) + \gamma_{110}*(STFACTOR) + \gamma_{111}*(TFACTOR) + u_{1j}$

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

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

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

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

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

$B_{7j} = \gamma_{70}$

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

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

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

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

$B_{12j} = \gamma_{120} + u_{12j}$

Of the eleven school level variables, all of the variables were not significantly related to the *Grade* slope and all were removed from the model. Moreover, in the first model, *Student Morale and Commitment* and *Student-Related Factors Affecting School Climate* became as non-significantly related to mathematical literacy. Therefore, these two school level variables were also removed from the model.

Lastly, eleven school level factors were included in the *Disciplinary Climate in Mathematics Lessons* coefficient model with the previous results.

The equations for fourth model in this analysis are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) + B_{3j}*(HOMEDUC) + B_{4j}*(RELATION) + B_{5j}*(BELONG) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(CONTROL) + B_{10j}*(ELAB) + B_{11j}*(MEMOR) + B_{12j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(PFEMALE) + \gamma_{04}*(RATIO) + \gamma_{05}*(MRATIO) + \gamma_{06}*(ASELECT) + \gamma_{07}*(PHYST) + u_{0j}$

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

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

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

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

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

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

$B_{7j} = \gamma_{70}$

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

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

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

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

$B_{12j} = \gamma_{120} + \gamma_{121}*(MEANEFFI) + \gamma_{122}*(SCHSIZE) + \gamma_{123}*(PFEMALE) + \gamma_{124}*(RATIO) + \gamma_{125}*(MRATIO) + \gamma_{126}*(ASELECT) + \gamma_{127}*(PHYST) + \gamma_{128}*(STMORALE) + \gamma_{129}*(TMORALE) + \gamma_{1210}*(STFACTOR) + \gamma_{1211}*(TFACTOR) + u_{12j}$

Of the eleven school level variables, nine variables were not significantly related to the *Disciplinary Climate in Mathematics Lessons* slope and all were subsequently removed from the model. Only two school level variables, *School Size* and *Mathematics Student-Teacher Ratio*, were found to be significantly related to *Disciplinary Climate in Mathematics Lessons* slope.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) +$
$B_{3j}*(HOMEDUC) + B_{4j}*(RELATION) + B_{5j}*(BELONG) + B_{6j}*(SELFEFFI) +$
$B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(CONTROL) + B_{10j}*(ELAB) +$
$B_{11j}*(MEMOR) + B_{12j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(PFEMALE) + \gamma_{04}*(RATIO) +$
$\gamma_{05}*(MRATIO) + \gamma_{06}*(ASELECT) + \gamma_{07}*(PHYST) + u_{0j}$

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

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

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

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

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

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

$B_{7j} = \gamma_{70}$

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

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

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

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

$B_{12j} = \gamma_{120} + \gamma_{121}*(SCHSIZE) + \gamma_{122}*(MRATIO) + u_{12j}$

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model of Turkey were presented in Appendix M, at the end of the dissertation. As stated previously, the results from Means as Outcomes Model (Research Question 2) were reported in the final full Intercepts and Slopes as Outcomes Model. *Average Mathematics Self-Efficacy, School Size, Proportion of Females Enrolled at School, Student-Teacher Ratio, Mathematics Student-Teacher Ratio, Academic Selectivity,* and *Quality of School's Physical Infrastructure* are significantly related to mean school mathematical literacy.

The *Average Mathematics Self-Efficacy* coefficient (γ_{01} = 114.66, se = 7.36) indicates that average mathematics self-efficacy is positively related to mathematical literacy. The *School Size* coefficient (γ_{02} = 0.02, se = 0.01) indicates that school size is significantly and positively related to mathematical literacy. The larger the school size, the higher the mean school mathematical literacy. The *Proportion of Females Enrolled at School* coefficient (γ_{03} = 80.18, se = 18.02) indicates that proportion of females enrolled at school is significantly and positively related to mathematical literacy indicating that the higher the proportion of females enrolled at school, the higher the mean school mathematical literacy. The *Total Student-Teacher Ratio* coefficient (γ_{04} = -1.35, se = 0.36) indicates that total student-teacher ratio is significantly but negatively related to mathematical literacy. The lower the total student-teacher ratio, the higher the mean school mathematical literacy. The *Mathematics Student-Teacher Ratio* coefficient (γ_{05} = -0.10, se = 0.04) indicates that mathematics student-teacher ratio is significantly but negatively related to mathematical literacy indicating that the lower the mathematics student-teacher ratio, the higher the mean school mathematical literacy performance. The *Academic Selectivity* coefficient (γ_{06} = 8.09, se = 3.82) indicates that academic selectivity is significantly and positively related to mathematical literacy. Thus, the higher the academic selectivity, the higher the mean school mathematical literacy performance. The *Quality of School's Physical Infrastructure* coefficient (γ_{07} = 7.33, se = 3.38) indicates that quality of school's physical infrastructure is significantly and positively related to mathematical literacy. The mean school mathematical literacy performance is higher in schools where the quality of physical infrastructure is higher.

Overall, schools with higher average mathematics self-efficacy, larger school size, higher proportion of females enrolled at school, lower total student-teacher ratio, lower mathematics student-teacher ratio, higher academic selectivity, and higher quality of physical infrastructure have higher mathematical literacy performance than schools with lower average mathematics self-efficacy, smaller school size, lower proportion of females enrolled at school, higher total student-teacher ratio, higher mathematics student-teacher ratio, lower academic selectivity, and lower quality of physical infrastructure.

As stated previously, the results from the Random Coefficient Model (Research Question 3) are reported in the final full Intercepts and Slopes as Outcomes Model as well. *Grade, Gender, Home Educational Resources, Student-Teacher Relations at School, Sense of Belonging at School, Mathematics Self-Efficacy, Mathematics Anxiety, Mathematics Self-Concept, Control Strategies, Elaboration Strategies, Memorisation Strategies,* and *Disciplinary Climate in Mathematics Lessons* are significantly related to mathematical literacy.

The average *Grade-Mathematical Literacy* slope coefficient (γ_{10} = 21.56, se = 2.88) indicates that students from higher grades performed significantly higher than the students from lower grades on the mathematical literacy assessment. The average *Gender-Mathematical Literacy* slope coefficient (γ_{20} = 18.64, se = 2.08) indicates that female students performed significantly lower than the male students. The average *Home Educational Resources-Mathematical Literacy* slope coefficient (γ_{30} = 6.60, se = 0.89) indicates that students who have more educational resources at home performed better on the mathematical literacy assessment. The average *Student-Teacher Relations at School-Mathematical Literacy* slope coefficient (γ_{40} = -6.98, se = 0.92) indicates that students having better student-teacher relations at school performed lower on the mathematical literacy assessment. The average *Sense of Belonging at School-Mathematical Literacy* slope coefficient (γ_{50} = 2.41, se = 1.15) indicates that students having positive feelings about their school performed higher on the mathematical literacy assessment. The average *Self-Efficacy in Mathematics-Mathematical Literacy* slope coefficient (γ_{60} = 17.68, se = 1.18) indicates that students having higher levels of mathematics self-efficacy performed better on the mathematical literacy assessment. The average *Anxiety in Mathematics-Mathematical Literacy* slope coefficient (γ_{70} = -8.15, se = 1.09) indicates that students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. The average *Self-Concept in Mathematics-Mathematical Literacy* slope coefficient (γ_{80} = 6.96, se = 1.34) indicates that students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment. The average *Control Strategies-Mathematical Literacy* slope coefficient (γ_{90} = 5.82, se = 1.28) indicates that students having more preferences for this learning strategy performed higher on the mathematical literacy assessment. The average *Elaboration Strategies-Mathematical Literacy* slope coefficient (γ_{100} = -5.51, se = 1.26) indicates that students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. The average *Memorisation Strategies-Mathematical Literacy* slope coefficient (γ_{110} = -4.27, se = 1.25) indicates that students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. Lastly, the average *Disciplinary Climate in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{120} = 7.21, se = 1.28) indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in their mathematics lessons on the mathematical literacy assessment. As can be seen easily, the coefficients have slight differences in magnitude, but the directions and the interpretations are same with the Random Coefficient Model (Research Question 3). The slight differences in magnitude exist because the number of schools and therefore, the number of students analyzed in the final full model are a subsample of the Random Coefficient Model (Research Question 3).

In the final full Intercepts and Slopes as Outcomes Model, only two school level variables were significantly related to a student level slope. As previously stated, the *Disciplinary Climate in Mathematics Lessons* coefficient model had two significant school level variables; School Size (γ_{121} = 0.01, se = 0.00) and *Mathematics Student-Teacher Ratio* (γ_{122} = -0.04, se = 0.02). Therefore, disciplinary climate in mathematics lessons has more of an influence on mathematical literacy in schools with larger school size and with smaller mathematics student-teacher ratio than in schools with smaller school size and with larger mathematics student-teacher ratio.

The *Disciplinary Climate in Mathematics Lessons - Mathematical Literacy* model is:

$B_{12} = \gamma_{120} + \gamma_{121}$*(SCHSIZE) + γ_{122}*(MRATIO) + u_{12}

where

B_{12} = the overall Disciplinary Climate in Mathematics Lessons slope

γ_{120} = the average Disciplinary Climate in Mathematics Lessons – Mathematical Literacy slope across the schools

γ_{121} = the effect of School Size on the overall slope

γ_{122} = the effect of Mathematics Student-Teacher Ratio on the overall slope

u_{12} = the random effect or error

From the results, $\gamma_{120} = 7.21$, $\gamma_{121} = 0.01$ and $\gamma_{122} = -0.04$ and substituting the values into the equation produces:

$B_{12} = 7.21 + 0.01$ (SCHSIZE) – 0.04 (MRATIO) + u_{12}

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model of Turkey were presented in Table 4.10. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level variables included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level variables included in the model

Thus, 29 schools did not have sufficient data to be included, so 29 schools were not used in this analysis and degrees of freedom values for this model are:

df = J – Q – 1 = 130 – 7 – 1 = 122 (df for *School Mean*)

df = J – Q – 1 = 130 – 0 – 1 = 129 (df for *Grade*)

df = J – Q – 1 = 130 – 2 – 1 = 127 (df for *Disciplinary Climate in Mathematics Lessons*)

Table 4.10 Final Estimation of Variance Components (Final Full Model of Turkey)

Random Effect	*Variance Component*	*df*	*X^2*	*p-value*
School mean, u_{0j}	1 632.34	122	1 366.23	0.000
Grade, u_{1j}	456.54	129	240.25	0.000
Disciplinary Climate in Math Lessons, u_{12j}	72.29	127	165.66	0.019
Level-1 Effect, r_{ij}	3 730.14			

The proportion of variance explained for each literacy slope model with significant school level variables could be examined. For this study, that would be *Mathematical Literacy* and *Disciplinary Climate in Mathematics Lessons*. The equation is:

Proportion of variance explained in $B_{qj} = \dfrac{\tau_{qq}(RandomCoefficient) - \tau_{qq}(FullModel)}{\tau_{qq}(RandomCoefficient)}$

B_{qj} = mathematical literacy or the slope coefficient for a given variable

Proportion of variance explained in Mathematical Literacy, $B_{0j} = \dfrac{6061.40 - 1632.34}{6061.40}$

Proportion of variance explained in Mathematical Literacy, $B_{0j} = 0.731$

Proportion of variance explained in Disciplinary Climate in Mathematics Lessons,

$B_{12j} = \dfrac{80.59 - 72.29}{80.59} = 0.103$

Note that this value (0.731) was lower than the one observed in the results from Means as Outcomes Model (0.759) and it was a result of the difference in the samples between the two models. Moreover, 10% reduction in the variance was accounted for by *School Size* and *Mathematics Student-Teacher Ratio*. Both of these proportions showed that substantial amount of variation had been accounted for.

In the Random Coefficient and Intercepts and Slopes as Outcomes Models, only 130 from 159 schools were used to test if the two variables (*Grade* and *Disciplinary Climate in Mathematics Lessons*) were randomly varying. Due to this loss in degrees of freedom, Bryk and Raudenbush (2002) state that the Chi-Square tests provide only approximate probability values. They also suggest that a comparison of the deviance statistic of the randomly varying model and a restricted model (non-randomly varying model) should be completed.

A test setting all two variables (*Grade* and *Disciplinary Climate in Mathematics Lessons*) as fixed was run and an analysis of deviance statistic computed. The deviance statistics and the number of parameters of the two models (*Grade* and *Disciplinary Climate in Mathematics Lessons* random versus fixed) were given in Table 4.11.

Table 4.11 Statistics for Current Covariance Components Model (Final Full Model of Turkey)

	Deviance	*Number of Estimated Parameters*
1st Model (Two variables-random)	51 973.81	7
2nd Model (Two variables-fixed)	52 017.68	2

A comparison of the deviance statistic of the randomly varying model and a restricted model was conducted. The results of variance-covariance components test were displayed in Table 4.12. As can be seen from Table 4.12, the deviance statistic between two models (*Grade* and *Disciplinary Climate in Mathematics Lessons* random versus fixed) was significant indicating that setting *Grade* and *Disciplinary Climate in Mathematics Lessons* as non-randomly varying did not create a better model. Thus, the results from the comparison that the variables; *Grade* and *Disciplinary Climate in Mathematics Lessons* should remain randomly varying.

Table 4.12 Variance-Covariance Components Test Results
(Final Full Model of Turkey)

	X^2	*df*	*p-value*
Variance-Covariance Components Test	43.87	5	0.000

4.3.2 HLM Analyses for European Union Countries

4.3.2.1 Results of Research Question I (Analysis of Variance Model)

The first research question of HLM analyses for European Union Countries provided information about if there are differences in the students' mathematical literacy skills among schools in European Union Countries. In HLM, this research question is termed as Analysis of Variance Model.

The equations to answer this question are as such:

$$\textit{Mathematical Literacy } (Y_{ij}) = B_{0j} + r_{ij}$$

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

where

Y_{ij} = the endogenous variable, Mathematical Literacy

B_{0j} = the intercept

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of European Union Countries was given in the Table 4.13. The analysis of variance indicates that there are significant differences among schools. The grand mean of mathematical literacy scores is 509.73 with a standard error of 4.75, indicating a 95% confidence interval of:

Confidence Interval = 509.73 $\pm$ 1.96 (4.75) = (500.42, 519.04).

Table 4.13 Final Estimation of Fixed Effects
(Analysis of Variance Model of European Union Countries)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Average school mean, γ_{00}	509.73	4.75	107.72	0.000

The final estimation of variance components obtained from analysis of variance model of European Union Countries was given in the Table 4.14. The maximum likelihood estimate of the variance components is also provided. At the student level σ^2 = 5 324.51 and at the school level, γ_{00} is the variance of the true school means, B_{0j}, around the grand mean. The variance component for school means is τ_{00} = 3 974.96 and shows a substantial proportion of variation among schools as estimated by the intraclass correlation:
$\rho_{ic} = \tau_{00} / (\tau_{00} + \sigma^2)$ = 5 324.51 / (5 324.51 + 3 974.96) = 0.573.
Thus, 57% of the variance in mathematical literacy is among schools.

HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is impacted by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities ρ = 0.93 indicating that the sample means tend to be a reliable indicator of true school means. The equation for determining reliability of the mean mathematical literacy within each school is: $\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / n_j)]$. As can be seen from the equation, the reliability is affected by the within school size (n_j) of the sample.

Table 4.14 Final Estimation of Variance Components
(Analysis of Variance Model of European Union Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	3 974.96	188	3 439.26	0.000
Level-1 Effect, r_{ij}	5 324.51			

Finally, the test statistic displayed at Table 4.14 (X^2 = 3 439.26, df = 188) indicates significant ($p < 0.001$) variation among schools in their mathematical literacy. The result also suggests that school level variables might account for the differences in the students' mathematical literacy skills.

4.3.2.2 Results of Research Question II (Means as Outcomes Model)

The second research question of HLM analyses for European Union Countries provided information about which school characteristics are associated with the differences in the students' mathematical literacy skills in European Union Countries. In HLM, this research question is termed as Means as Outcomes Model.

The equations to answer this question are:

$$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + r_{ij}$$

$$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHTYPE) + \gamma_{03}*(SCHSIZE) + \gamma_{04}*(PFEMALE) + \gamma_{05}*(RATIO) + \gamma_{06}*(MRATIO) + \gamma_{07}*(ASSESS) + \gamma_{08}*(ASELECT) + \gamma_{09}*(ABGROUP) + \gamma_{10}*(EXCOURSE) + \gamma_{11}*(MACTIV) + \gamma_{12}*(AUTRES) + \gamma_{13}*(AUTCURR) + \gamma_{14}*(TSHORT) + \gamma_{15}*(PHYST) + \gamma_{16}*(EDUCRES) + \gamma_{17}*(STMORALE) + \gamma_{18}*(TMORALE) + \gamma_{19}*(STFACTOR) + \gamma_{20}*(TFACTOR) + u_{0j}$$

for $j = 1, 2, \ldots, n$ schools

where

B_{0j} = the school mean on mathematical literacy

γ_{00} = the grand mean for mathematical literacy scores. The average of the school means on mathematical literacy scores across the population of schools

γ_{01} = the differentiating effect of school average mathematics self-efficacy on the school mean on mathematical literacy

γ_{02} = the differentiating effect of school type on the school mean on mathematical literacy

γ_{03} = the differentiating effect of school size on the school mean on mathematical literacy

γ_{04} = the differentiating effect of proportion of females enrolled at school on the school mean on mathematical literacy

γ_{05} = the differentiating effect of total student-teacher ratio on the school mean on mathematical literacy

γ_{06} = the differentiating effect of mathematics student-teacher ratio on the school mean on mathematical literacy

γ_{07} = the differentiating effect of use of assessments on the school mean on mathematical literacy

γ_{08} = the differentiating effect of academic selectivity on the school mean on mathematical literacy

γ_{09} = the differentiating effect of ability grouping between mathematics classes on the school mean on mathematical literacy

γ_{10} = the differentiating effect of mathematics extension courses on the school mean on mathematical literacy

γ_{11} = the differentiating effect of mathematics activities on the school mean on mathematical literacy

γ_{12} = the differentiating effect of resource autonomy on the school mean on mathematical literacy

γ_{13} = the differentiating effect of curricular autonomy on the school mean on mathematical literacy

γ_{14} = the differentiating effect of teacher shortage on the school mean on mathematical literacy

γ_{15} = the differentiating effect of quality of school's physical infrastructure on the school mean on mathematical literacy

γ_{16} = the differentiating effect of quality of school's educational resources on the school mean on mathematical literacy

γ_{17} = the differentiating effect of student morale and commitment on the school mean on mathematical literacy

γ_{18} = the differentiating effect of teacher morale and commitment on the school mean on mathematical literacy

γ_{19} = the differentiating effect of student-related factors affecting school climate on the school mean on mathematical literacy

γ_{20} = the differentiating effect of teacher-related factors affecting school climate on the school mean on mathematical literacy

τ_{00} = the conditional variance or school level variance in B_{0j} after accounting for these school level variables

u_{0j} = the residual

The model was first run with all twenty factors, but *School Type*, *Proportion of Females Enrolled at School, Total Student-Teacher Ratio, Mathematics Student-Teacher Ratio, Use of Assessments*, *Academic Selectivity, Ability Grouping between Mathematics Classes*, *Mathematics Extension Courses, Mathematics Activities*, *Resource Autonomy, Curricular Autonomy*, *Teacher Shortage, Quality of School's Physical Infrastructure, Quality of School's Educational Resources, Student Morale and Commitment, Teacher Morale and Commitment,* and *Teacher-Related Factors Affecting School Climate* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of European Union Countries was given in the Table 4.15.

Table 4.15 Final Estimation of Fixed Effects
(Means as Outcomes Model of European Union Countries)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Model for School Means[1]				
Intercept, γ_{00}	510.71	4.09	124.80	0.000
MEANEFFI, γ_{01}	58.03	10.22	5.08	0.000
SCHSIZE, γ_{02}	0.02	0.01	2.26	0.025
STFACTOR, γ_{03}	18.11	4.26	4.26	0.000

[1] The school level variables were Grand Mean Centered before analysis.

The results obtained from the Table 4.15 indicate a significant association between *Average Mathematics Self-Efficacy* and *Mean Mathematical Literacy* (γ_{01} = 58.03, se = 10.22); *School Size* and *Mean Mathematical Literacy* (γ_{02} = 0.02, se = 0.01); and lastly *Student-Related Factors Affecting School Climate and Mean Mathematical Literacy* (γ_{03} = 18.11, se = 4.26). All these three factors will be reexamined during the development of the final full Intercepts and Slopes as Outcomes Model (Research Question 4).

The final estimation of variance components obtained from means as outcomes model of European Union Countries was given in the Table 4.16. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level variables included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level variables included in the model

Thus, all schools were used in this analysis and degrees of freedom for this model is: df = J – Q – 1 = 189 – 3 – 1 = 185.

Table 4.16 Final Estimation of Variance Components
(Means as Outcomes Model of European Union Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School Mean, u_{0j}	2 864.64	185	2 509.90	0.000
Level-1 Effect, r_{ij}	5 324.24			

The residual variance between schools (τ_{00} = 2 864.64) is substantially smaller than the original variance (τ_{00} = 3 974.96) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors. By comparing the τ_{00} estimates across the two models (Analysis of Variance Model and

Means as Outcomes Model), an index of proportion reduction can be developed, or more simply, the variance accounted for by the school level factors can be examined.

Proportion of variance explained in B_{oj} = $\dfrac{\tau_{00}(ANOVA) - \tau_{00}(MeansasOutcomes)}{\tau_{00}(ANOVA)}$

Proportion of variance explained in B_{oj} = $\dfrac{3974.96 - 2864.64}{3974.96} = 0.279$

This indicates that 27.9% of the true between school variance in mathematical literacy is accounted for by *Average Mathematics Self-Efficacy, School Size* and *Student-Related Factors Affecting School Climate*. Finally, the X^2 statistic is found as 2 509.90 (df = 185, p < 0.001) in the analysis indicating that these three school level variables did not account for all the variation in the intercepts.

4.3.2.3 Results of Research Question III (Random Coefficient Model)

The third research question of HLM analyses for European Union Countries provided information about which student characteristics that explain the differences in the students' mathematical literacy skills in European Union Countries. In HLM, this research question is termed as Random Coefficient Model.

The equations to answer this question are:

Mathematical Literacy $(Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) + B_{3j}*(OCCUPAR) + B_{4j}*(EDUCPAR) + B_{5j}*(SECS) + B_{6j}*(COMPHOME) + B_{7j}*(CULTURAL) + B_{8j}*(HOMEDUC) + B_{9j}*(ATTSCH) + B_{10j}*(RELATION) + B_{11j}*(BELONG) + B_{12j}*(INTEREST) + B_{13j}*(MOTIVAT) + B_{14j}*(SELFEFFI) + B_{15j}*(ANXIETY) + B_{16j}*(SELFCON) + B_{17j}*(CONTROL) + B_{18j}*(ELAB) + B_{19j}*(MEMOR) + B_{20j}*(COMPLRN) + B_{21j}*(COOPLRN) + B_{22j}*(SUPPORT) + B_{23j}*(CLIMATE) + r_{ij}$

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

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

where

Y_{ij} = mathematical literacy score of student i in school j

B_{0j} = the mean on mathematical literacy

B_{1j} = the differentiating effect of grade in school j (i.e., the degree to which grade differences among students relate to mathematical literacy)

B_{2j} = the gender gap in school j (i.e., the mean difference between mathematical literacy scores of females and males)

B_{3j} = the differentiating effect of highest parental occupational status in school j (i.e., the degree to which parental occupation differences among students relate to mathematical literacy)

B_{4j} = the differentiating effect of highest educational level of parents in school j (i.e., the degree to which parental education level differences among students relate to mathematical literacy)

B_{5j} = the differentiating effect of socio-economic and cultural status in school j (i.e., the degree to which socio-economic and cultural differences among students relate to mathematical literacy)

B_{6j} = the differentiating effect of computer facilities at home in school j (i.e., the degree to which home computer facility differences among students relate to mathematical literacy)

B_{7j} = the differentiating effect of cultural possessions of the family in school j (i.e., the degree to which family cultural possession differences among students relate to mathematical literacy)

B_{8j} = the differentiating effect of home educational resources in school j (i.e., the degree to which home educational resource differences among students relate to mathematical literacy)

B_{9j} = the differentiating effect of attitudes towards school in school j (i.e., the degree to which attitudinal differences among students towards school relate to mathematical literacy)

B_{10j} = the differentiating effect of student-teacher relations at school in school j (i.e., the degree to which student-teacher relation differences at school relate to mathematical literacy)

B_{11j} = the differentiating effect of sense of belonging at school in school j (i.e., the degree to which sense of belonging differences among students at school relate to mathematical literacy)

B_{12j} = the differentiating effect of interest in mathematics in school j (i.e., the degree to which mathematics interest differences among students relate to mathematical literacy)

B_{13j} = the differentiating effect of instrumental motivation in mathematics in school j (i.e., the degree to which mathematics instrumental motivation differences among students relate to mathematical literacy)

B_{14j} = the differentiating effect of self-efficacy in mathematics in school j (i.e., the degree to which mathematics self-efficacy differences among students relate to mathematical literacy)

B_{15j} = the differentiating effect of anxiety in mathematics in school j (i.e., the degree to which mathematics anxiety differences among students relate to mathematical literacy)

B_{16j} = the differentiating effect of self-concept in mathematics in school j (i.e., the degree to which mathematics self-concept differences among students relate to mathematical literacy)

B_{17j} = the differentiating effect of control strategies in school j (i.e., the degree to which control strategy differences among students relate to mathematical literacy)

B_{18j} = the differentiating effect of elaboration strategies in school j (i.e., the degree to which elaboration strategy differences among students relate to mathematical literacy)

B_{19j} = the differentiating effect of memorisation strategies in school j (i.e., the degree to which memorisation strategy differences among students relate to mathematical literacy)

B_{20j} = the differentiating effect of competitive learning in school j (i.e., the degree to which competitive learning differences among students relate to mathematical literacy)

B_{21j} = the differentiating effect of cooperative learning in school j (i.e., the degree to which cooperative learning differences among students relate to mathematical literacy)

B_{22j} = the differentiating effect of teacher support in math lessons in school j (i.e., the degree to which teacher support differences among students in math lessons relate to mathematical literacy)

B_{23j} = the differentiating effect of disciplinary climate in math lessons in school j (i.e., the degree to which disciplinary climate differences among students in math lessons relate to mathematical literacy)

B_{qj} = the coefficient for variable q for group j after accounting for other variables

The building strategy recommended by Bryk and Raudenbush (2002) was utilized. The student characteristic variables were first examined (*Grade, Gender*) to determine whether they were significantly related to mathematical literacy and whether or not they were randomly varying. A randomly varying coefficient or variable is defined as a slope whose value varies significantly among schools (e.g., the slope for one school may be steep and for another school may be flat). Of the first two variables, two were found to be significant and randomly varying variables.

Next, student background variables were examined (*Highest Parental Occupational Status, Highest Educational Level of Parents, Socio-Economic and Cultural Status, Computer Facilities at Home, Cultural Possessions of the Family,* and *Home Educational Resources*) along with the student characteristic variables from before. The background variable, *Socio-Economic and Cultural Status,* was found to be non-significant and non-randomly varying, thus, it was removed from the model. The other five background variables (*Highest Parental Occupational Status, Highest Educational Level of Parents, Computer Facilities at Home, Cultural Possessions of the Family* and *Home Educational Resources)* were found to be significant. Among the five significant variables, only *Highest Parental Occupational Status* was found to be randomly varying. The other four significant variables (*Highest Educational Level of Parents, Computer Facilities at Home, Cultural Possessions of the Family* and *Home Educational Resources*) were found to be non-randomly varying. Moreover, in this step, the student characteristic variable, *Gender*, becomes non-randomly varying variable, so *Gender* will be examined as non-randomly varying variable in the model.

Then, school climate variables (*Attitudes towards School, Student-Teacher Relations at School* and *Sense of Belonging at School*) were added to the model. The variable, *Attitudes towards School*, was found as non-significant and randomly varying. The variable, *Student-Teacher Relations at School,* was not significant and non-randomly varying. Therefore, the variables, *Attitudes towards School* and *Student-Teacher Relations at School,* were removed from the model. The other school climate variable, *Sense of Belonging at School,* was found to be significant but it was a non-randomly varying variable. Furthermore, in this step, the student background variable, *Highest Parental Occupational Status*, becomes non-randomly varying variable, so *Highest Parental Occupational Status* will be examined as non-randomly varying variable in the model.

In the fourth step, variables about self-related cognitions in mathematics such as *Interest in Mathematics, Instrumental Motivation in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* were examined. Only one variable, *Instrumental Motivation in Mathematics,* was found as non-significant and non-randomly varying, thus, it was removed from the model. The other four variables about self-related cognitions in mathematics (*Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept)* were found as significant and non-randomly varying variables. Before the next step, the model was reexamined in terms of the variables entered the model before. The student characteristic variable, *Gender* and the student background variable, *Cultural Possessions of the Family,* become non-significant; therefore, these two variables were removed from the model after this step.

Next, learning and instruction factors (*Control Strategies, Elaboration Strategies, Memorisation Strategies, Competitive Learning* and *Cooperative Learning*) were added to the model. From the learning strategies, the variables, *Elaboration Strategies* and *Memorisation Strategies*, were found as significant and non-randomly varying variables. The other variable about learning strategies, *Control Strategies,* was not significant and non-randomly varying, so it was removed from the model. The variables about learning situations, *Competitive Learning* and *Cooperative Learning,* were also found to be non-significant. The variable, *Competitive Learning*, was randomly varying variable, whereas, the variable, *Cooperative Learning* was non-randomly varying variable. Since these two variables about learning situations were not significant variables, these two variables were removed from the model.

In the final step, variables about classroom climate as *Teacher Support* and *Disciplinary Climate in Mathematics Lessons* were entered to the model. Two of the variables (*Teacher Support* and *Disciplinary Climate in Mathematics Lessons)* were found to be significant. But, only the variable, *Disciplinary Climate in Mathematics Lessons*, was found as randomly varying variable. Thus, *Disciplinary Climate in Mathematics Lessons* will be examined as randomly varying variable, whereas *Teacher Support in Mathematics Lessons* will be examined as non-randomly varying variable in the model.

Therefore, the final Random Coefficient Model includes fourteen student level variables: *Grade* (student characteristics), *Highest Parental Occupational Status, Highest Educational Level of Parents, Computer Facilities at Home* and *Home Educational Resources* (student background), *Sense of Belonging at School* (school climate), *Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* (self-related cognitions in mathematics), *Elaboration Strategies* and *Memorisation Strategies* (learning and instruction), and *Teacher Support in Mathematics Lessons* and *Disciplinary Climate in Mathematics Lessons* (classroom climate). Among these fourteen student level factors, only two variables such as *Grade* and *Disciplinary Climate in Mathematics Lessons* were found as randomly varying. Therefore, the other twelve factors found as non-randomly varying, were fixed in the final analysis. The final random coefficient model with the variables observed to be only significantly related to mathematical literacy and the variables observed to be both significantly related to mathematical literacy and randomly varying was presented in the results. The final estimation of fixed effects obtained from random coefficient model of European Union Countries was displayed in the Table 4.17.

The *Grade-Mathematical Literacy* slope coefficient (γ_{10} = 32.20, se = 2.46) indicates that students from different grades performed significantly different on the mathematical literacy assessment. Students from higher grades performed significantly higher than the students from lower grades on the mathematical literacy assessment.

Table 4.17 Final Estimation of Fixed Effects

(Random Coefficient Model of European Union Countries)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Overall mean math literacy[1], γ_{00}	509.03	4.79	106.28	0.000
GRADE, γ_{10}	32.51	2.35	13.84	0.000
OCCUPAR, γ_{20}	0.45	0.05	9.40	0.000
EDUCPAR, γ_{30}	-0.51	0.11	-4.84	0.000
COMPHOME, γ_{40}	3.85	1.07	3.61	0.001
HOMEDUC, γ_{50}	5.86	1.00	5.85	0.000
BELONG, γ_{60}	-6.67	0.84	-7.94	0.000
INTEREST, γ_{70}	-4.58	1.16	-3.96	0.000
SELFEFFI, γ_{80}	22.84	1.06	21.49	0.000
ANXIETY, γ_{90}	-8.29	1.06	-7.84	0.000
SELFCON, γ_{100}	16.63	1.32	12.63	0.000
ELAB, γ_{110}	-3.78	1.02	-3.71	0.000
MEMOR, γ_{120}	-6.17	0.95	-6.51	0.000
SUPPORT, γ_{130}	-4.51	0.93	-4.87	0.000
CLIMATE, γ_{140}	5.43	0.94	5.76	0.000

[1] The student level variables were Group Mean Centered before analysis.

The *Highest Parental Occupational Status-Mathematical Literacy* slope coefficient (γ_{20} = 0.45, se = 0.05) indicates that highest parental occupational status is significantly and positively related to mathematical literacy. Students having parents with higher occupational status performed better on the mathematical literacy assessment. The *Highest Educational Level of Parents-Mathematical Literacy* slope coefficient (γ_{30} = -0.51, se = 0.12) indicates that highest educational level of parents is significantly but negatively related to mathematical literacy. Students in the European Union Countries who have parents with higher educational level performed lower on the mathematical literacy assessment. The *Computer Facilities at Home-Mathematical Literacy* slope coefficient (γ_{40} = 3.95, se = 1.17) indicates that computer facilities at home is significantly and positively related to mathematical literacy. Students having more computer facilities at home performed higher on the mathematical literacy assessment. Lastly, the *Home Educational Resources-Mathematical Literacy* slope coefficient (γ_{50} = 5.78, se = 1.10) indicates that home educational resources is significantly and positively related to mathematical literacy. Students who have more educational resources at home performed better on the mathematical literacy assessment.

The *Sense of Belonging at School-Mathematical Literacy* slope coefficient (γ_{60} = -6.67, se = 0.93) indicates that sense of belonging at school is significantly but negatively related to mathematical literacy. Students having positive feelings about their school performed lower on the mathematical literacy assessment.

The *Interest in Mathematics-Mathematical Literacy* slope coefficient (γ_{70} = -4.64, se = 1.28) indicates that interest in mathematics is significantly but negatively related to mathematical literacy. Students having higher interest in mathematics performed lower on the mathematical literacy assessment. The *Self-Efficacy in Mathematics-Mathematical Literacy* slope coefficient (γ_{80} = 22.85, se = 1.17) indicates that mathematics self-efficacy is significantly and positively related to mathematical literacy. Students having higher levels of mathematics self-efficacy performed better on the mathematical literacy assessment. The *Anxiety in Mathematics-Mathematical Literacy* slope coefficient (γ_{90} = -8.37, se = 1.16) indicates that mathematics anxiety is significantly but negatively related to mathematical literacy. That is, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. The *Self-Concept in Mathematics-Mathematical Literacy* slope coefficient (γ_{100} = 16.57, se = 1.45) indicates that mathematics self-concept is significantly and positively related to mathematical literacy. Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment.

The *Elaboration Strategies-Mathematical Literacy* slope coefficient (γ_{110} = -3.79, se = 1.12) indicates that elaboration strategies as learning strategies is significantly but negatively related to mathematical literacy. Students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. The *Memorisation Strategies-Mathematical Literacy* slope coefficient

(γ_{120} = -6.21, se = 1.04) indicates that memorisation strategies as learning strategies is significantly but negatively related to mathematical literacy. Students having more preferences for this learning strategy performed lower on the mathematical literacy assessment.

The *Teacher Support in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{130} = -4.36, se = 0.95) indicates that teacher support in mathematics lessons is significantly but negatively related to mathematical literacy. Students having more support from their teachers in mathematics lessons performed lower on the mathematical literacy assessment. The *Disciplinary Climate in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{140} = 5.51, se = 1.02) indicates that disciplinary climate in mathematics lessons is significantly and positively related to mathematical literacy. Students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in their mathematics lessons on the mathematical literacy assessment.

The final estimation of variance components obtained from random coefficient model of European Union Countries was displayed in the Table 4.18. The degrees of freedom to test for the random effect for Random Coefficient Model are based on the number of schools that had sufficient data to compute a separate OLS regression. Therefore, 36 schools did not have sufficient data. The intercept and coefficients from the fixed effect portion of the table ($\gamma_{q0's}$) are based on empirical bayes estimates which utilize all data.

Table 4.18 Final Estimation of Variance Components
(Random Coefficient Model of European Union Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	4 141.14	152	4 534.37	0.000
GRADE, u_{1j}	272.66	152	242.83	0.000
CLIMATE, u_{12j}	29.38	152	196.75	0.019
Level-1 Effect, r_{ij}	3 537.19			

Estimates of variance components for the random effects, and tests of the hypothesis that these variance components are null are also provided. *Grade* and *Disciplinary Climate in Mathematics Lessons* slopes all varied significantly as can be seen from the Table 4.18 (each has a p-value < 0.05). The significant p-value indicates that in some schools, the slopes are much steeper than for other schools, that is, the relationship with mathematical literacy is much stronger in some schools than in other schools. The variability among schools also suggests that school level variables might account for some of the differences.

The variance explained at the student level can be examined by comparing the variances in the Analysis of Variance Model and the Random Coefficient Model. The comparison is completed by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

$$\text{Proportion of variance explained at Level-1} = \frac{\sigma^2(ANOVA) - \sigma^2(RandomCoef.)}{\sigma^2(ANOVA)}$$

$$\text{Proportion of variance explained at Level-1} = \frac{3974.96 - 3537.19}{3974.96} = 0.110$$

By including these student level factors (*Grade, Highest Parental Occupational Status, Highest Educational Level of Parents, Computer Facilities at Home, Home Educational Resources, Sense of Belonging at School, Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety, Mathematics Self-Concept, Elaboration Strategies, Memorisation Strategies, Teacher Support in Mathematics Lessons* and *Disciplinary Climate in Mathematics Lessons*) as predictors of mathematical literacy, within school variance was reduced by 11.0%. Therefore, these factors account for about 11% of the student level variance in mathematical literacy.

The reliability of the intercept and the randomly varying slopes can be estimated. The results provided from HLM analysis indicate that the intercept is quite reliable (.96) and the slopes are far less reliable (Grade = .29, Climate = .17). The primary reasons, according to Bryk and Raudenbush (2002), for the lower reliability of the slopes are that the true slope variance across schools is much smaller than the variance of the true means and many schools may be relatively homogeneous on the randomly varying variables (e.g., grade and disciplinary climate in mathematics lessons). Bryk and Raudenbush (2002) state that coefficient reliabilities above .05 are acceptable. The intercept reliability (.96) has increased from the Analysis of Variance Model (.93) due to the inclusion of student level predictors.

For the Random Coefficient Model, it is important to examine the variance of the errors, τ_{qq} correlations. Tau as correlations obtained from random coefficient model of European Union Countries was given in the Table 4.19. A high correlation indicates that essentially the same variation across the school 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 little high τ_{qq} correlation was observed between the variables, *Grade* and *Disciplinary Climate in Mathematics Lessons* (-.045).

Table 4.19 Tau as Correlations
(Random Coefficient Model of European Union Countries)

	Intercept	*Grade*	*Disciplinary Climate in Mathematics Lessons*
Intercept	1.000	-0.066	-0.082
Grade	-0.066	1.000	-0.045
Disciplinary Climate in Mathematics Lessons	-0.082	-0.045	1.000

A test setting *Grade* as fixed was run and an analysis of deviance statistic computed. The deviance statistics and the number of parameters of the two models (*Grade* random versus fixed) were given in Table 4.20.

Table 4.20 Statistics for Current Covariance Components Model
(Random Coefficient Model of European Union Countries)

	Deviance	*Number of Estimated Parameters*
1st Model (GRADE – random)	55 681.19	7
2nd Model (GRADE – fixed)	55 699.09	4

The deviance statistic examines the hypothesis that τ_{23} (the correlation of errors between grade and disciplinary climate in mathematics lessons) equals zero. The results of variance-covariance components test were displayed in Table 4.21. As can be seen from Table 4.21, the deviance statistic between two models (*Grade* random versus fixed) was significant indicating that setting *Grade* as non-randomly varying did not create a better explanatory model. Thus, *Grade* was kept in the final Random Coefficient Model as randomly varying variable.

Table 4.21 Variance-Covariance Components Test Results
(Random Coefficient Model of European Union Countries)

	X^2	*df*	*p-value*
Variance-Covariance Components Test	17.90	3	0.002

4.3.2.4 Results of Research Question IV (Intercepts and Slopes as Outcomes Model)

The fourth research question of HLM analyses for European Union Countries provided information about which school characteristics influence the effect of student characteristics on the students' mathematical literacy skills in European Union Countries. In HLM, this research question is termed as Intercepts and Slopes as Outcomes Model.

For this research question, the coefficients (slopes) of the variables will be modeled. Simply, the variability in Level-1 coefficients from school to school will be examined to ascertain if Level-2 (school level) factors explain the variability. The coefficient is an indication of the amount of influence a variable has on the endogenous variable. The Level-2 variables that are significantly associated with Level-1 factors are termed as cross-level interactions. Traditionally, there is only one Level-2 equation for each Level-1 Beta value.

The general equation used to answer this question is in the form:

$$B_{qj} = \gamma_{q0} + \gamma_{q1}*(MEANEFFI) + \gamma_{q2}*(SCHSIZE) + \gamma_{q3}*(STFACTOR) + u_{qj}$$

where

B_{qj} = the slope as outcome coefficient for variable q for school j

This research question incorporates the three previous research questions and specifically examines randomly varying student level coefficients, slopes as outcomes, that can be examined with school level variables. The first model was the mathematical literacy as determined from the Analysis of Variance Model (Research Question 1). The variability of mathematical literacy was modeled with school level variables in the Means as Outcomes Model (Research Question 2).

Only two student level variables or coefficients (*Grade* and *Disciplinary Climate in Mathematics Lessons*) were observed to be randomly varying in the Random Coefficient Model (Research Question 3). Due to this variability, these two coefficients can be modeled with school level variables, i.e., each randomly varying coefficient becomes a model. The school level variables that are observed to be significantly related to the random coefficients are termed as cross-level interactions. This simply means that a school level variable influences a student level slope.

The process of determining the final Intercept and Slopes as Outcomes Model begins with the results from the Random Coefficient Model (Research Question 3). The first step was to replicate the Means as Outcomes Model (Research Question 2) and include the significant student level variables from the Random Coefficient Model (Research Question 3).

The equations for first model in this analysis are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(EDUCPAR) + B_{4j}*(COMPHOME) + B_{5j}*(HOMEDUC) + B_{6j}*(BELONG) + B_{7j}*(INTEREST) + B_{8j}*(SELFEFFI) + B_{9j}*(ANXIETY) + B_{10j}*(SELFCON) + B_{11j}*(ELAB) + B_{12j}*(MEMOR) + B_{13j}*(SUPPORT) + B_{14j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(STFACTOR) + u_{0j}$

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

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

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

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

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

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

$B_{7j} = \gamma_{70}$

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

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

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

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

$B_{12j} = \gamma_{120}$

$B_{13j} = \gamma_{130}$

$B_{14j} = \gamma_{140} + u_{14j}$

Of the three school level variables, all school level factors were significantly related to mathematical literacy.

Next, three school level factors were included in the *Grade* coefficient model with the previous results.

The equations for second model in this analysis are:

Student Level:

$$\text{Mathematical Literacy } (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(EDUCPAR) + B_{4j}*(COMPHOME) + B_{5j}*(HOMEDUC) + B_{6j}*(BELONG) + B_{7j}*(INTEREST) + B_{8j}*(SELFEFFI) + B_{9j}*(ANXIETY) + B_{10j}*(SELFCON) + B_{11j}*(ELAB) + B_{12j}*(MEMOR) + B_{13j}*(SUPPORT) + B_{14j}*(CLIMATE) + r_{ij}$$

School Level:

$$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(STFACTOR) + u_{0j}$$

$$B_{1j} = \gamma_{10} + \gamma_{11}*(MEANEFFI) + \gamma_{12}*(SCHSIZE) + \gamma_{13}*(STFACTOR) + u_{1j}$$

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

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

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

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

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

$$B_{7j} = \gamma_{70}$$

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

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

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

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

$$B_{12j} = \gamma_{120}$$

$$B_{13j} = \gamma_{130}$$

$$B_{14j} = \gamma_{140} + u_{14j}$$

Of the three school level variables, all of the variables were not significantly related to the *Grade* slope and all were removed from the model.

Lastly, three school level factors were included in the *Disciplinary Climate in Mathematics Lessons* coefficient model with the previous results.

The equations for third model in this analysis are:

Student Level:

$$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(EDUCPAR) + B_{4j}*(COMPHOME) + B_{5j}*(HOMEDUC) + B_{6j}*(BELONG) + B_{7j}*(INTEREST) + B_{8j}*(SELFEFFI) + B_{9j}*(ANXIETY) + B_{10j}*(SELFCON) + B_{11j}*(ELAB) + B_{12j}*(MEMOR) + B_{13j}*(SUPPORT) + B_{14j}*(CLIMATE) + r_{ij}$$

School Level:

$$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(STFACTOR) + u_{0j}$$

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

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

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

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

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

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

$$B_{7j} = \gamma_{70}$$

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

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

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

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

$$B_{12j} = \gamma_{120}$$

$$B_{13j} = \gamma_{130}$$

$$B_{14j} = \gamma_{140} + \gamma_{141}*(MEANEFFI) + \gamma_{142}*(SCHSIZE) + \gamma_{143}*(STFACTOR) + u_{14j}$$

Of the three school level variables, all of the variables were not significantly related to the *Disciplinary Climate in Mathematics Lessons* slope and all were removed from the model.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(EDUCPAR) + B_{4j}*(COMPHOME) + B_{5j}*(HOMEDUC) + B_{6j}*(BELONG) + B_{7j}*(INTEREST) + B_{8j}*(SELFEFFI) + B_{9j}*(ANXIETY) + B_{10j}*(SELFCON) + B_{11j}*(ELAB) + B_{12j}*(MEMOR) + B_{13j}*(SUPPORT) + B_{14j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHSIZE) + \gamma_{03}*(STFACTOR) + u_{0j}$

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

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

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

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

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

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

$B_{7j} = \gamma_{70}$

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

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

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

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

$B_{12j} = \gamma_{120}$

$B_{13j} = \gamma_{130}$

$B_{14j} = \gamma_{140} + u_{14j}$

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model of European Union Countries were presented in Appendix M, at the end of the dissertation. As stated previously, the results from Means as Outcomes Model (Research Question 2) were reported in the final full Intercepts and Slopes as Outcomes Model. *Average Mathematics Self-Efficacy, School Size,* and *Student-Related Factors Affecting School Climate* are significantly related to mean school mathematical literacy.

The *Average Mathematics Self-Efficacy* coefficient (γ_{01} = 58.02, se = 10.18) indicates that average mathematics self-efficacy is positively related to mathematical literacy. The *School Size* coefficient (γ_{02} = 0.24, se = 0.01) indicates that school size is significantly and positively related to mathematical literacy. The larger the school size, the higher the mean school mathematical literacy. The *Student-Related Factors Affecting School Climate* coefficient (γ_{03} = 18.44, se = 4.28) indicates that student-related factors affecting school climate is significantly and positively related to mathematical literacy. The more positive evaluations of student-related factors affecting school climate, the higher the mean school mathematical literacy.

Overall, schools with higher average mathematics self-efficacy, larger school size, and more positive student-related factors affecting school climate have higher mathematical literacy performance than schools with lower average mathematics self-efficacy, smaller school size, and more negative student-related factors affecting school climate.

As stated previously, the results from the Random Coefficient Model (Research Question 3) are reported in the final full Intercepts and Slopes as Outcomes Model as well. *Grade, Highest Parental Occupational Status, Highest Educational Level of Parents, Computer Facilities at Home, Home Educational Resources, Sense of Belonging at School, Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety, Mathematics Self-Concept, Elaboration Strategies, Memorisation Strategies, Teacher Support in Mathematics Lessons* and *Disciplinary Climate in Mathematics Lessons* are significantly related to mathematical literacy.

The average *Grade-Mathematical Literacy* slope coefficient (γ_{10} = 32.17, se = 2.46) indicates that students from higher grades performed significantly higher than the students from lower grades on the mathematical literacy assessment. The average *Highest Parental Occupational Status-Mathematical Literacy* slope coefficient (γ_{20} = 0.45, se = 0.05) indicates that students having parents with higher occupational status performed better on the mathematical literacy assessment. The average *Highest Educational Level of Parents-Mathematical Literacy* slope coefficient (γ_{30} = -0.51, se = 0.12) indicates that who have parents with higher educational level performed lower on the mathematical literacy assessment. The average *Computer Facilities at Home-Mathematical Literacy* slope coefficient (γ_{40} = 3.96, se = 1.17) indicates that students having more computer facilities at home performed higher on the mathematical literacy assessment. The average *Home Educational Resources-Mathematical Literacy* slope coefficient (γ_{50} = 5.77, se = 1.10) indicates that students who have more educational resources at home performed better on the mathematical literacy assessment. The average *Sense of Belonging at School-Mathematical Literacy* slope coefficient (γ_{60} = -6.68, se = 0.93) indicates that students having positive feelings about their school performed lower on the mathematical literacy assessment. The average *Interest in Mathematics-Mathematical Literacy* slope coefficient (γ_{70} = -4.63, se = 1.28) indicates that students having higher interest in mathematics performed lower on the mathematical literacy assessment. The average *Self-Efficacy in Mathematics-Mathematical Literacy* slope coefficient (γ_{80} = 22.85, se = 1.17) indicates students having higher levels of mathematics self-efficacy performed better on the mathematical literacy assessment. The average *Anxiety in Mathematics-Mathematical Literacy* slope coefficient (γ_{90} = -8.37, se = 1.16) indicates that students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. The average *Self-Concept in Mathematics-Mathematical Literacy* slope coefficient (γ_{100} = 16.57, se = 1.45) indicates that students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment. The average *Elaboration Strategies-Mathematical Literacy* slope coefficient (γ_{110} = -3.80, se = 1.12) indicates that students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. The average *Memorisation Strategies-Mathematical Literacy* slope coefficient (γ_{120} = -6.20, se = 1.04) indicates that students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. The average *Teacher Support in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{130} = -4.37, se = 0.95) indicates that students having more support from their teachers in mathematics lessons performed lower on the mathematical literacy assessment. Lastly, the average *Disciplinary Climate in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{140} = 5.47, se = 1.02) indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in their mathematics lessons on the mathematical literacy assessment.

As can be seen easily, the coefficients have slight differences in magnitude, but the directions and the interpretations are same with the Random Coefficient Model (Research Question 3). The slight differences in magnitude exist because the number of schools and therefore, the number of students analyzed in the final full model are a subsample of the Random Coefficient Model (Research Question 3). However, in the final full Intercepts and Slopes as Outcomes Model, none of the school level variables were significantly related to a student level slope.

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model of European Union Countries were presented in Table 4.22. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level variables included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level variables included in the model

Thus, 36 schools did not have sufficient data to be included, so 36 schools were not used in this analysis and degrees of freedom values for this model are:

df = J – Q – 1 = 153 – 3 – 1 = 149 (df for *School Mean*)

df = J – Q – 1 = 153 – 0 – 1 = 152 (df for *Grade*)

df = J – Q – 1 = 153 – 0 – 1 = 152 (df for *Disciplinary Climate in Mathematics Lessons*)

Table 4.22 Final Estimation of Variance Components
(Final Full Model of European Union Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	3 010.00	149	3 162.03	0.000
Grade, u_{1j}	273.51	152	242.82	0.000
Disciplinary Climate in Math Lessons, u_{14j}	29.54	152	196.79	0.018
Level-1 Effect, r_{ij}	3 536.75			

The proportion of variance explained for mathematical literacy can be examined by comparing the variances in the last two models; the Random Coefficient Model and the Intercepts and Slopes as Outcomes Model (Full Model). Thus, the equation is:

Proportion of variance explained in Mathematical Literacy, $B_{0j} = \dfrac{4141.14 - 3010.00}{4141.14}$

Proportion of variance explained in Mathematical Literacy, $B_{0j} = 0.273$

Note that this value (0.273) was lower than the one observed in the results from Means as Outcomes Model (0.279) and it was a result of the difference in the samples between the two models.

In the Random Coefficient and Intercepts and Slopes as Outcomes Models, only 153 from 189 schools were used to test if the two variables (*Grade* and *Disciplinary Climate in Mathematics Lessons*) were randomly varying. Due to this loss in degrees of freedom, Bryk and Raudenbush (2002) state that the Chi-Square tests provide only approximate probability values. They also suggest that a comparison of the deviance statistic of the randomly varying model and a restricted model (non-randomly varying model) should be completed.

A test setting all two variables (*Grade* and *Disciplinary Climate in Mathematics Lessons*) as fixed was run and an analysis of deviance statistic computed. The deviance statistics and the number of parameters of the two models (*Grade* and *Disciplinary Climate in Mathematics Lessons* random versus fixed) were given in Table 4.23.

Table 4.23 Statistics for Current Covariance Components Model (Final Full Model of European Union Countries)

	Deviance	*Number of Estimated Parameters*
1st Model (Two variables – random)	55 618.85	7
2nd Model (Two variables– fixed)	55 641.86	2

A comparison of the deviance statistic of the randomly varying model and a restricted model was conducted. The results of variance-covariance components test were displayed in Table 4.24. As can be seen from Table 4.24, the deviance statistic between two models (*Grade* and *Disciplinary Climate in Mathematics Lessons* random versus fixed) was significant indicating that setting *Grade* and *Disciplinary Climate in Mathematics Lessons* as non-randomly varying did not create a better model. Thus, the results from the comparison that the variables; *Grade* and *Disciplinary Climate in Mathematics Lessons* should remain randomly varying.

Table 4.24 Variance-Covariance Components Test Results (Final Full Model of European Union Countries)

	X^2	*df*	*p-value*
Variance-Covariance Components Test	23.01	5	0.001

4.3.3 HLM Analyses for European Union Candidate Countries

4.3.3.1 Results of Research Question I (Analysis of Variance Model)

The first research question of HLM analyses for European Union Candidate Countries provided information about if there are differences in the students' mathematical literacy skills among schools in European Union Candidate Countries. In HLM, this research question is termed as Analysis of Variance Model.

The equations to answer this question are as such:

$$\textit{Mathematical Literacy } (Y_{ij}) = B_{0j} + r_{ij}$$

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

where

Y_{ij} = the endogenous variable, Mathematical Literacy

B_{0j} = the intercept

r_{ij} = the student level error

γ_{00} = the grand mean

u_{0j} = the random effect associated with unit j (school)

The final estimation of fixed effects obtained from analysis of variance model of European Union Candidate Countries was given in the Table 4.25. The analysis of variance indicates that there are significant differences among schools. The grand mean of mathematical literacy scores is 491.01 with a standard error of 5.13, indicating a 95% confidence interval of:

Confidence Interval = 491.01 $\pm$ 1.96 (5.13) = (480.96, 501.07).

Table 4.25 Final Estimation of Fixed Effects
(Analysis of Variance Model of European Union Candidate Countries)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Average school mean, γ_{00}	491.01	5.13	95.64	0.000

The final estimation of variance components obtained from analysis of variance model of European Union Candidate Countries was given in the Table 4.26. The maximum likelihood estimate of the variance components is also provided. At the student level σ^2 = 5 214.66 and at the school level, γ_{00} is the variance of the true school means, B_{0j}, around the grand mean. The variance component for school means is τ_{00} = 4 440.23 and shows a substantial proportion of variation among schools as estimated by the intraclass correlation:

$\rho_{ic} = \tau_{00} / (\tau_{00} + \sigma^2)$ = 5 214.66 / (5 214.66 + 4 440.23) = 0.540.

Thus, 54% of the variance in mathematical literacy is among schools.

HLM also provides an estimate of the reliability of the sample mean in any school. The reliability is an estimate of the true school mean and is impacted by the sample size within each school. The overall estimate of reliability is the average of the school reliabilities ρ = 0.92 indicating that the sample means tend to be a reliable indicator of true school means. The equation for determining reliability of the mean mathematical literacy within each school is: $\rho = \tau_{00} / [\tau_{00} + (\sigma^2 / n_j)]$. As can be seen from the equation, the reliability is affected by the within school size (n_j) of the sample.

Table 4.26 Final Estimation of Variance Components
(Analysis of Variance Model of European Union Candidate Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	4 440.23	182	3 512.43	0.000
Level-1 Effect, r_{ij}	5 214.66			

Finally, the test statistic displayed at Table 4.26 (X^2 = 3 512.43, df = 182) indicates significant ($p < 0.001$) variation among schools in their mathematical literacy. The result also suggests that school level variables might account for the differences in the students' mathematical literacy skills.

4.3.3.2 Results of Research Question II (Means as Outcomes Model)

The second research question of HLM analyses for European Union Candidate Countries provided information about which school characteristics are associated with the differences in the students' mathematical literacy skills in European Union Candidate Countries. In HLM, this research question is termed as Means as Outcomes Model.

The equations to answer this question are:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + r_{ij}$

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(SCHTYPE) + \gamma_{03}*(SCHSIZE) +$
$\gamma_{04}*(PFEMALE) + \gamma_{05}*(RATIO) + \gamma_{06}*(MRATIO) + \gamma_{07}*(ASSESS) + \gamma_{08}*(ASELECT)$
$+ \gamma_{09}*(ABGROUP) + \gamma_{10}*(EXCOURSE) + \gamma_{11}*(MACTIV) + \gamma_{12}*(AUTRES) +$
$\gamma_{13}*(AUTCURR) + \gamma_{14}*(TSHORT) + \gamma_{15}*(PHYST) + \gamma_{16}*(EDUCRES) +$
$\gamma_{17}*(STMORALE) + \gamma_{18}*(TMORALE) + \gamma_{19}*(STFACTOR) + \gamma_{20}*(TFACTOR) + u_{0j}$

for j = 1, 2, …, n schools

where

B_{0j} = the school mean on mathematical literacy

γ_{00} = the grand mean for mathematical literacy scores. The average of the school means on mathematical literacy scores across the population of schools

γ_{01} = the differentiating effect of school average mathematics self-efficacy on the school mean on mathematical literacy

γ_{02} = the differentiating effect of school type on the school mean on mathematical literacy

γ_{03} = the differentiating effect of school size on the school mean on mathematical literacy

γ_{04} = the differentiating effect of proportion of females enrolled at school on the school mean on mathematical literacy

γ_{05} = the differentiating effect of total student-teacher ratio on the school mean on mathematical literacy

γ_{06} = the differentiating effect of mathematics student-teacher ratio on the school mean on mathematical literacy

γ_{07} = the differentiating effect of use of assessments on the school mean on mathematical literacy

γ_{08} = the differentiating effect of academic selectivity on the school mean on mathematical literacy

γ_{09} = the differentiating effect of ability grouping between mathematics classes on the school mean on mathematical literacy

γ_{10} = the differentiating effect of mathematics extension courses on the school mean on mathematical literacy

γ_{11} = the differentiating effect of mathematics activities on the school mean on mathematical literacy

γ_{12} = the differentiating effect of resource autonomy on the school mean on mathematical literacy

γ_{13} = the differentiating effect of curricular autonomy on the school mean on mathematical literacy

γ_{14} = the differentiating effect of teacher shortage on the school mean on mathematical literacy

γ_{15} = the differentiating effect of quality of school's physical infrastructure on the school mean on mathematical literacy

γ_{16} = the differentiating effect of quality of school's educational resources on the school mean on mathematical literacy

γ_{17} = the differentiating effect of student morale and commitment on the school mean on mathematical literacy

γ_{18} = the differentiating effect of teacher morale and commitment on the school mean on mathematical literacy

γ_{19} = the differentiating effect of student-related factors affecting school climate on the school mean on mathematical literacy

γ_{20} = the differentiating effect of teacher-related factors affecting school climate on the school mean on mathematical literacy

τ_{00} = the conditional variance or school level variance in B_{0j} after accounting for these school level variables

u_{0j} = the residual

The model was first run with all twenty factors, but *School Type*, *School Size, Proportion of Females Enrolled at School, Total Student-Teacher Ratio, Mathematics Student-Teacher Ratio, Use of Assessments*, *Ability Grouping between Mathematics Classes*, *Mathematics Extension Courses, Resource Autonomy, Curricular Autonomy*, *Teacher Shortage, Quality of School's Physical Infrastructure, Quality of School's Educational Resources, Student Morale and Commitment, Teacher Morale and Commitment, Student-Related Factors Affecting School Climate* and *Teacher-Related Factors Affecting School Climate* were not significant and were removed from the final analysis. The final estimation of fixed effects obtained from means as outcomes model of European Union Candidate Countries was given in the Table 4.27.

The results obtained from the Table 4.27 indicate a significant association between *Average Mathematics Self-Efficacy* and *Mean Mathematical Literacy* (γ_{01} = 92.67, se = 7.85); *Academic Selectivity* and *Mean Mathematical Literacy* (γ_{02} = 13.97, se = 3.13); and lastly *Mathematics Activities* and *Mean Mathematical Literacy* (γ_{03} = -11.14, se = 4.45). All these three factors will be reexamined during the development of the final full Intercepts and Slopes as Outcomes Model (Research Question 4).

Table 4.27 Final Estimation of Fixed Effects
(Means as Outcomes Model of European Union Candidate Countries)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Model for School Means[1]				
Intercept, γ_{00}	490.39	3.25	150.91	0.000
MEANEFFI, γ_{01}	92.67	7.85	11.81	0.000
ASELECT, γ_{02}	13.97	3.13	4.47	0.000
MACTIV, γ_{03}	-11.14	4.45	-2.50	0.014

[1] The school level variables were Grand Mean Centered before analysis.

The final estimation of variance components obtained from means as outcomes model of European Union Candidate Countries was given in the Table 4.28. The degrees of freedom for this model (Means as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level variables included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level variables included in the model

Thus, 2 schools from 185 schools were not used in this analysis because of inadequate data and degrees of freedom for this model is:

df = J – Q – 1 = 183 – 3 – 1 = 179.

Table 4.28 Final Estimation of Variance Components
(Means as Outcomes Model of European Union Candidate Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School Mean, u_{0j}	1 595.96	179	1 351.44	0.000
Level-1 Effect, r_{ij}	5 215.77			

The residual variance between schools (τ_{00} = 1 595.96) is substantially smaller than the original variance (τ_{00} = 4 440.23) resulting from the analysis of variance model. This reduction is due to the inclusion of school level factors. By comparing the τ_{00} estimates across the two models (Analysis of Variance Model and Means as Outcomes Model), an index of proportion reduction can be developed, or more simply, the variance accounted for by the school level factors can be examined.

$$\text{Proportion of variance explained in } B_{oj} = \frac{\tau_{00}(ANOVA) - \tau_{00}(MeansasOutcomes)}{\tau_{00}(ANOVA)}$$

$$\text{Proportion of variance explained in } B_{oj} = \frac{4440.23 - 1595.96}{4440.23} = 0.641.$$

This indicates that 64% of the true between school variance in mathematical literacy is accounted for by *Average Mathematics Self-Efficacy, Academic Selectivity* and *Mathematics Activities*. Finally, the X^2 statistic is found as 1 351.44 (df = 179, $p < 0.001$) in the analysis indicating that these four school level variables did not account for all the variation in the intercepts.

4.3.3.3 Results of Research Question III (Random Coefficient Model)

The third research question of HLM analyses for European Union Candidate Countries provided information about which student characteristics that explain the differences in the students' mathematical literacy skills in European Union Candidate Countries. In HLM, this research question is termed as Random Coefficient Model.

The equations to answer this question are:

Mathematical Literacy $(Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(GENDER) + B_{3j}*(OCCUPAR) + B_{4j}*(EDUCPAR) + B_{5j}*(SECS) + B_{6j}*(COMPHOME) + B_{7j}*(CULTURAL) + B_{8j}*(HOMEDUC) + B_{9j}*(ATTSCH) + B_{10j}*(RELATION) + B_{11j}*(BELONG) + B_{12j}*(INTEREST) + B_{13j}*(MOTIVAT) + B_{14j}*(SELFEFFI) + B_{15j}*(ANXIETY) + B_{16j}*(SELFCON) + B_{17j}*(CONTROL) + B_{18j}*(ELAB) + B_{19j}*(MEMOR) + B_{20j}*(COMPLRN) + B_{21j}*(COOPLRN) + B_{22j}*(SUPPORT) + B_{23j}*(CLIMATE) + r_{ij}$

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

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

where

Y_{ij} = mathematical literacy score of student i in school j

B_{0j} = the mean on mathematical literacy

B_{1j} = the differentiating effect of grade in school j (i.e., the degree to which grade differences among students relate to mathematical literacy)

B_{2j} = the gender gap in school j (i.e., the mean difference between mathematical literacy scores of females and males)

B_{3j} = the differentiating effect of highest parental occupational status in school j (i.e., the degree to which parental occupation differences among students relate to mathematical literacy)

B_{4j} = the differentiating effect of highest educational level of parents in school j (i.e., the degree to which parental education level differences among students relate to mathematical literacy)

B_{5j} = the differentiating effect of socio-economic and cultural status in school j (i.e., the degree to which socio-economic and cultural differences among students relate to mathematical literacy)

B_{6j} = the differentiating effect of computer facilities at home in school j (i.e., the degree to which home computer facility differences among students relate to mathematical literacy)

B_{7j} = the differentiating effect of cultural possessions of the family in school j (i.e., the degree to which family cultural possession differences among students relate to mathematical literacy)

B_{8j} = the differentiating effect of home educational resources in school j (i.e., the degree to which home educational resource differences among students relate to mathematical literacy)

B_{9j} = the differentiating effect of attitudes towards school in school j (i.e., the degree to which attitudinal differences among students towards school relate to mathematical literacy)

B_{10j} = the differentiating effect of student-teacher relations at school in school j (i.e., the degree to which student-teacher relation differences at school relate to mathematical literacy)

B_{11j} = the differentiating effect of sense of belonging at school in school j (i.e., the degree to which sense of belonging differences among students at school relate to mathematical literacy)

B_{12j} = the differentiating effect of interest in mathematics in school j (i.e., the degree to which mathematics interest differences among students relate to mathematical literacy)

B_{13j} = the differentiating effect of instrumental motivation in mathematics in school j (i.e., the degree to which mathematics instrumental motivation differences among students relate to mathematical literacy)

B_{14j} = the differentiating effect of self-efficacy in mathematics in school j (i.e., the degree to which mathematics self-efficacy differences among students relate to mathematical literacy)

B_{15j} = the differentiating effect of anxiety in mathematics in school j (i.e., the degree to which mathematics anxiety differences among students relate to mathematical literacy)

B_{16j} = the differentiating effect of self-concept in mathematics in school j (i.e., the degree to which mathematics self-concept differences among students relate to mathematical literacy)

B_{17j} = the differentiating effect of control strategies in school j (i.e., the degree to which control strategy differences among students relate to mathematical literacy)

B_{18j} = the differentiating effect of elaboration strategies in school j (i.e., the degree to which elaboration strategy differences among students relate to mathematical literacy)

B_{19j} = the differentiating effect of memorisation strategies in school j (i.e., the degree to which memorisation strategy differences among students relate to mathematical literacy)

B_{20j} = the differentiating effect of competitive learning in school j (i.e., the degree to which competitive learning differences among students relate to mathematical literacy)

B_{21j} = the differentiating effect of cooperative learning in school j (i.e., the degree to which cooperative learning differences among students relate to mathematical literacy)

B_{22j} = the differentiating effect of teacher support in math lessons in school j (i.e., the degree to which teacher support differences among students in math lessons relate to mathematical literacy)

B_{23j} = the differentiating effect of disciplinary climate in math lessons in school j (i.e., the degree to which disciplinary climate differences among students in math lessons relate to mathematical literacy)

B_{qj} = the coefficient for variable q for group j after accounting for other variables

The building strategy recommended by Bryk and Raudenbush (2002) was utilized. The student characteristic variables were first examined (*Grade, Gender*) to determine whether they were significantly related to mathematical literacy and whether or not they were randomly varying. A randomly varying coefficient or variable is defined as a slope whose value varies significantly among schools (e.g., the slope for one school may be steep and for another school may be flat). Of the first two variables, two were found to be significant and randomly varying variables.

Next, student background variables were examined (*Highest Parental Occupational Status, Highest Educational Level of Parents, Socio-Economic and Cultural Status, Computer Facilities at Home, Cultural Possessions of the Family,* and *Home Educational Resources*) along with the student characteristic variables from before. The background variable, *Highest Educational Level of Parents,* was found to be non-significant and non-randomly varying, thus, it was removed from the model. *Socio-Economic and Cultural Status* was found to be non-significant but randomly varying. Since this variable was not significant, it was also removed from the model. On the other hand, the variables, *Computer Facilities at Home* and *Home Educational Resources,* were found as significant but non-randomly varying variables. The variables, *Highest Parental Occupational Status* and *Cultural Possessions of the Family,* were found as significant and randomly varying variables. Moreover, in this step, the student characteristic variable, *Gender*, becomes non-randomly varying variable, so *Gender* will be examined as non-randomly varying variable in the model.

Then, school climate variables (*Attitudes towards School, Student-Teacher Relations at School* and *Sense of Belonging at School*) were added to the model. The variables, *Attitudes towards School and Student-Teacher Relations at School*, were found as non-significant and non-randomly varying. Therefore, the variables, *Attitudes towards School* and *Student-Teacher Relations at School,* were removed from the model. The other school climate variable, *Sense of Belonging at School,* was found to be significant but it was a non-randomly varying variable.

In the fourth step, variables about self-related cognitions in mathematics such as *Interest in Mathematics, Instrumental Motivation in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* were examined. Only one variable, *Instrumental Motivation in Mathematics,* was found as non-significant and non-randomly varying, thus, it was removed from the model. The other four variables about self-related cognitions in mathematics (*Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept)* were found as significant variables. Indeed, *Interest in Mathematics* and *Mathematics Self-Concept* were non-randomly varying variables, whereas *Mathematics Self-Efficacy* and *Mathematics Anxiety* were randomly varying variables. Before the next step, the model was reexamined in terms of the variables entered the model before. The student background variables, *Highest Parental Occupational Status* and *Cultural Possessions of the Family,* become non-randomly varying variables. Thus, these two student background variables will be treated as non-randomly varying variables in the model.

Next, learning and instruction factors (*Control Strategies, Elaboration Strategies, Memorisation Strategies, Competitive Learning* and *Cooperative Learning*) were added to the model. From the learning strategies, the variables, *Control Strategies, Elaboration Strategies, Competitive Learning* and *Cooperative Learning*, were found as non-significant variables. Among these four learning and instruction variables, only the variable, *Elaboration Strategies,* was randomly varying variable. However, these four variables were removed from the model because of the non-significant results. Only, the variable, *Memorisation Strategies,* was a significant variable. Moreover, *Memorisation Strategies* was non-randomly varying in the model. Similarly, the model was reexamined in terms of the variables entered the model before. The student characteristic variable, *Gender,* and the school climate variable, *Sense of Belonging at School,* become non-significant variables. Therefore, these two variables were removed from the model in this step.

In the final step, variables about classroom climate as *Teacher Support* and *Disciplinary Climate in Mathematics Lessons* were entered to the model. Two of the variables (*Teacher Support* and *Disciplinary Climate in Mathematics Lessons)* were found to be significant. *Teacher Support in Mathematics Lessons* was found as non-randomly varying variable, whereas *Disciplinary Climate in Mathematics Lessons* was found as randomly varying variable. The model was again reexamined in terms of the variables entered the model before. The student background variable, *Cultural Possessions of the Family,* becomes a non-significant variable and accordingly, it was removed from the model in this step. Moreover, the variable about self-related cognitions in mathematics, *Mathematics Anxiety,* becomes a non-randomly varying variable and it will be examined as non-randomly varying variable in the model.

Therefore, the final Random Coefficient Model includes eleven student level variables: *Grade* (student characteristics), *Highest Parental Occupational Status, Computer Facilities at Home* and *Home Educational Resources* (student background), *Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* (self-related cognitions in mathematics), *Memorisation Strategies* (learning and instruction), and *Teacher Support in Mathematics Lessons* and *Disciplinary Climate in Mathematics Lessons* (classroom climate). Among these eleven student level factors, only three variables such as *Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons* were found as randomly varying. Therefore, the other eight factors found as non-randomly varying, were fixed in the final analysis. The final random coefficient model with the variables observed to be only significantly related to mathematical literacy and the variables observed to be both significantly related to mathematical literacy and randomly varying was presented in the results. The final estimation of fixed effects obtained from random coefficient model of European Union Candidate Countries was displayed in the Table 4.29.

The *Grade-Mathematical Literacy* slope coefficient (γ_{10} = 30.22, se = 3.36) indicates that students from different grades performed significantly different on the mathematical literacy assessment. Students from higher grades performed significantly higher than the students from lower grades on the mathematical literacy assessment.

Table 4.29 Final Estimation of Fixed Effects
(Random Coefficient Model of European Union Candidate Countries)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Overall mean math literacy[1], γ_{00}	490.18	5.18	94.56	0.000
GRADE, γ_{10}	30.22	3.36	9.00	0.000
OCCUPAR, γ_{20}	0.40	0.06	6.68	0.000
COMPHOME, γ_{30}	3.28	1.01	3.28	0.003
HOMEDUC, γ_{40}	4.16	1.15	3.61	0.002
INTEREST, γ_{50}	-5.75	1.46	-3.94	0.001
SELFEFFI, γ_{60}	25.86	1.48	17.44	0.000
ANXIETY, γ_{70}	-12.06	1.43	-8.41	0.000
SELFCON, γ_{80}	18.40	1.72	10.68	0.000
MEMOR, γ_{90}	-9.15	1.19	-7.70	0.000
SUPPORT, γ_{100}	-5.87	1.11	-5.31	0.000
CLIMATE, γ_{110}	4.08	1.19	3.43	0.001

[1] The student level variables were Group Mean Centered before analysis.

The *Highest Parental Occupational Status-Mathematical Literacy* slope coefficient (γ_{20} = 0.40, se = 0.06) indicates that highest parental occupational status is significantly and positively related to mathematical literacy. Students having parents with higher occupational status performed better on the mathematical literacy assessment. The *Computer Facilities at Home-Mathematical Literacy* slope coefficient (γ_{30} = 3.28, se = 1.01) indicates that computer facilities at home is significantly and positively related to mathematical literacy. Students having more computer facilities at home performed higher on the mathematical literacy assessment. Lastly, the *Home Educational Resources-Mathematical Literacy* slope coefficient (γ_{40} = 4.16, se = 1.15) indicates that home educational resources is significantly and positively related to mathematical literacy. Students who have more educational resources at home performed better on the mathematical literacy assessment.

The *Interest in Mathematics-Mathematical Literacy* slope coefficient (γ_{50} = -5.75, se = 1.46) indicates that interest in mathematics is significantly but negatively related to mathematical literacy. Students having higher interest in mathematics performed lower on the mathematical literacy assessment. The *Self-Efficacy in Mathematics-Mathematical Literacy* slope coefficient (γ_{60} = 25.86, se = 1.48) indicates that mathematics self-efficacy is significantly and positively related to mathematical literacy. Students having higher levels of mathematics self-efficacy performed better on the mathematical literacy assessment. The *Anxiety in Mathematics-Mathematical Literacy* slope coefficient (γ_{70} = -12.06, se = 1.43) indicates that mathematics anxiety is significantly but negatively related to mathematical literacy. That is, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. The *Self-Concept in Mathematics-Mathematical Literacy* slope coefficient (γ_{80} = 18.40, se = 1.72) indicates that mathematics self-concept is significantly and positively related to mathematical literacy. Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment.

The *Memorisation Strategies-Mathematical Literacy* slope coefficient (γ_{90} = -9.15, se = 1.19) indicates that memorisation strategies as learning strategies is significantly but negatively related to mathematical literacy. Students having more preferences for this learning strategy performed lower on the mathematical literacy assessment.

The *Teacher Support in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{100} = -5.87, se = 1.11) indicates that teacher support in mathematics lessons is significantly but negatively related to mathematical literacy. Students having more support from their teachers in mathematics lessons performed lower on the mathematical literacy assessment. The *Disciplinary Climate in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{110} = 4.08, se = 1.19) indicates that disciplinary climate in mathematics lessons is significantly and positively related to mathematical literacy. Students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in their mathematics lessons on the mathematical literacy assessment.

The final estimation of variance components obtained from random coefficient model of European Union Candidate Countries was displayed in the Table 4.30. The degrees of freedom to test for the random effect for Random Coefficient Model are based on the number of schools that had sufficient data to compute a separate OLS regression. Therefore, 91 schools did not have sufficient data. The intercept and coefficients from the fixed effect portion of the table ($\gamma_{q0's}$) are based on empirical bayes estimates which utilize all data.

Table 4.30 Final Estimation of Variance Components
(Random Coefficient Model of European Union Candidate Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	4 658.16	93	3 726.72	0.000
GRADE, u_{1j}	290.15	93	131.34	0.007
SELFEFFI, u_{6j}	94.95	93	149.66	0.001
CLIMATE, u_{11j}	47.81	93	121.56	0.046
Level-1 Effect, r_{ij}	3 337.30			

Estimates of variance components for the random effects, and tests of the hypothesis that these variance components are null are also provided. *Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons* slopes all varied significantly as can be seen from the Table 4.30 (each has a p-value < 0.05). The significant p-value indicates that in some schools, the slopes are much steeper than for other schools, that is, the relationship with mathematical literacy is much stronger in some schools than in other schools. The variability among schools also suggests that school level variables might account for some of the differences.

The variance explained at the student level can be examined by comparing the variances in the Analysis of Variance Model and the Random Coefficient Model. The comparison is completed by creating an index of the proportion of reduction in variance at the student level by comparing the σ^2 estimates from these two models.

$$\text{Proportion of variance explained at Level-1} = \frac{\sigma^2(ANOVA) - \sigma^2(RandomCoef.)}{\sigma^2(ANOVA)}$$

$$\text{Proportion of variance explained at Level-1} = \frac{4440.23 - 3337.30}{4440.23} = 0.248.$$

By including these student level factors (*Grade, Highest Parental Occupational Status, Computer Facilities at Home, Home Educational Resources, Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety, Mathematics Self-Concept, Memorisation Strategies, Teacher Support in Mathematics Lessons* and *Disciplinary Climate in Mathematics Lessons*) as predictors of mathematical literacy, within school variance was reduced by 24.8%. Therefore, these factors account for about 25% of the student level variance in mathematical literacy.

The reliability of the intercept and the randomly varying slopes can be estimated. The results provided from HLM analysis indicate that the intercept is quite reliable (.97) and the slopes are far less reliable (Grade = .25, Selfeffi = .33, Climate = .21). The primary reasons, according to Bryk and Raudenbush (2002), for the lower reliability of the slopes are that the true slope variance across schools is much smaller than the variance of the true means and many schools may be relatively homogeneous on the randomly varying variables (e.g., grade, mathematics self-efficacy and disciplinary climate in mathematics lessons). Bryk and Raudenbush (2002) state that coefficient reliabilities above .05 are acceptable. The intercept reliability (.97) has increased from the Analysis of Variance Model (.92) due to the inclusion of student level predictors.

For the Random Coefficient Model, it is important to examine the variance of the errors, τ_{qq} correlations. Tau as correlations obtained from random coefficient model of European Union Candidate Countries was given in the Table 4.31. A high correlation indicates that essentially the same variation across the school 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 little high τ_{qq} correlation was observed between the variables, *Grade* and *Mathematics Self-Efficacy* (.607).

Table 4.31 Tau as Correlations
(Random Coefficient Model of European Candidate Union Countries)

	Intercept	*Grade*	*Mathematics Self-Efficacy*	*Disciplinary Climate in Mathematics Lessons*
Intercept	1.000	-0.297	-0.296	-0.418
Grade	-0.297	1.000	0.607	-0.328
Mathematics Self-Efficacy	-0.296	0.607	1.000	0.215
Disciplinary Climate in Mathematics Lessons	-0.418	-0.328	0.215	1.000

A test setting *Mathematics Self-Efficacy* as fixed was run and an analysis of deviance statistic computed. The deviance statistics and the number of parameters of the two models (*Mathematics Self-Efficacy* random versus fixed) were given in Table 4.32.

Table 4.32 Statistics for Current Covariance Components Model
(Random Coefficient Model of European Union Candidate Countries)

	Deviance	*Number of Estimated Parameters*
1st Model (SELFEFFI – random)	48 739.92	11
2nd Model (SELFEFFI – fixed)	48 765.33	7

The deviance statistic examines the hypothesis that τ_{23} (the correlation of errors between grade and mathematics self-efficacy) equals zero. The results of variance-covariance components test were displayed in Table 4.33. As can be seen from 4.33, the deviance statistic between two models (*Mathematics Self-Efficacy* random versus fixed) was significant indicating that setting *Mathematics Self-Efficacy* as non-randomly varying did not create a better explanatory model. Thus, *Mathematics Self-Efficacy* was kept in the final Random Coefficient Model as randomly varying variable.

Table 4.33 Variance-Covariance Components Test Results
(Random Coefficient Model of European Union Candidate Countries)

	X^2	*df*	*p-value*
Variance-Covariance Components Test	25.42	4	0.000

4.3.3.4 Results of Research Question IV (Intercepts and Slopes as Outcomes Model)

The fourth research question of HLM analyses for European Union Candidate Countries provided information about which school characteristics influence the effect of student characteristics on the students' mathematical literacy skills in European Union Candidate Countries. In HLM, this research question is termed as Intercepts and Slopes as Outcomes Model.

For this research question, the coefficients (slopes) of the variables will be modeled. Simply, the variability in Level-1 coefficients from school to school will be examined to ascertain if Level-2 (school level) factors explain the variability. The coefficient is an indication of the amount of influence a variable has on the endogenous variable. The Level-2 variables that are significantly associated with Level-1 factors are termed as cross-level interactions. Traditionally, there is only one Level-2 equation for each Level-1 Beta value.

The general equation used to answer this question is in the form:

$$B_{qj} = \gamma_{q0} + \gamma_{q1}*(MEANEFFI) + \gamma_{q2}*(ASELECT) + \gamma_{q3}*(MACTIV) + u_{qj}$$

where

B_{qj} = the slope as outcome coefficient for variable q for school j

This research question incorporates the three previous research questions and specifically examines randomly varying student level coefficients, slopes as outcomes, that can be examined with school level variables. The first model was the mathematical literacy as determined from the Analysis of Variance Model (Research Question 1). The variability of mathematical literacy was modeled with school level variables in the Means as Outcomes Model (Research Question 2).

Only three student level variables or coefficients (*Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons*) were observed to be randomly varying in the Random Coefficient Model (Research Question 3). Due to this variability, these three coefficients can be modeled with school level variables, i.e., each randomly varying coefficient becomes a model. The school level variables that are observed to be significantly related to the random coefficients are termed as cross-level interactions. This simply means that a school level variable influences a student level slope.

The process of determining the final Intercept and Slopes as Outcomes Model begins with the results from the Random Coefficient Model (Research Question 3). The first step was to replicate the Means as Outcomes Model (Research Question 2) and include the significant student level variables from the Random Coefficient Model (Research Question 3).

The equations for first model in this analysis are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(COMPHOME) + B_{4j}*(HOMEDUC) + B_{5j}*(INTEREST) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(MEMOR) + B_{10j}*(SUPPORT) + B_{11j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(ASELECT) + \gamma_{03}*(MACTIV) + u_{0j}$

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

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

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

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

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

$B_{6j} = \gamma_{60} + u_{6j}$

$B_{7j} = \gamma_{70}$

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

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

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

$B_{11j} = \gamma_{110} + u_{11j}$

Of the three school level variables, all school level factors were significantly related to mathematical literacy.

Next, three school level factors were included in the *Grade* coefficient model with the previous results.

The equations for second model in this analysis are:

Student Level:

$Mathematical\ Literacy\ (Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(COMPHOME) + B_{4j}*(HOMEDUC) + B_{5j}*(INTEREST) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(MEMOR) + B_{10j}*(SUPPORT) + B_{11j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(ASELECT) + \gamma_{03}*(MACTIV) + u_{0j}$

$B_{1j} = \gamma_{10} + \gamma_{11}*(MEANEFFI) + \gamma_{12}*(ASELECT) + \gamma_{13}*(MACTIV) + u_{1j}$

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

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

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

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

$B_{6j} = \gamma_{60} + u_{6j}$

$B_{7j} = \gamma_{70}$

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

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

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

$B_{11j} = \gamma_{110} + u_{11j}$

Of the three school level variables, two of the variables *(Average Mathematics Self-Efficacy* and *Mathematics Activities)* were not significantly related to the *Grade* slope and two of the school variables were removed from the model. Only, the school factor, *Academic Selectivity,* was significantly related to the *Grade* slope.

Then, three school level factors were included in the *Mathematics Self-Efficacy* coefficient model with the previous results.

The equations for third model in this analysis are:

Student Level:

Mathematical Literacy $(Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(COMPHOME) + B_{4j}*(HOMEDUC) + B_{5j}*(INTEREST) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(MEMOR) + B_{10j}*(SUPPORT) + B_{11j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(ASELECT) + \gamma_{03}*(MACTIV) + u_{0j}$

$B_{1j} = \gamma_{10} + \gamma_{11}*(ASELECT) + u_{1j}$

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

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

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

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

$B_{6j} = \gamma_{60} + \gamma_{61}*(MEANEFFI) + \gamma_{62}*(ASELECT) + \gamma_{63}*(MACTIV) + u_{6j}$

$B_{7j} = \gamma_{70}$

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

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

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

$B_{11j} = \gamma_{110} + u_{11j}$

Of the three school level variables, two of the variables *(Average Mathematics Self-Efficacy* and *Mathematics Activities)* were not significantly related to the *Mathematics Self-Efficacy* slope and two of the school variables were removed from the model. Only, the school factor, *Academic Selectivity,* was significantly related to the *Mathematics Self-Efficacy* slope.

Lastly, three school level factors were included in the *Disciplinary Climate in Mathematics Lessons* coefficient model with the previous results.

The equations for fourth model in this analysis are:

Student Level:

Mathematical Literacy $(Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(COMPHOME) + B_{4j}*(HOMEDUC) + B_{5j}*(INTEREST) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(MEMOR) + B_{10j}*(SUPPORT) + B_{11j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(ASELECT) + \gamma_{03}*(MACTIV) + u_{0j}$

$B_{1j} = \gamma_{10} + \gamma_{11}*(ASELECT) + u_{1j}$

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

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

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

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

$B_{6j} = \gamma_{60} + \gamma_{61}*(ASELECT) + u_{6j}$

$B_{7j} = \gamma_{70}$

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

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

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

$B_{11j} = \gamma_{110} + \gamma_{111}*(MEANEFFI) + \gamma_{112}*(ASELECT) + \gamma_{113}*(MACTIV) + u_{11j}$

Of the three school level variables, all of the variables were not significantly related to the *Disciplinary Climate in Mathematics Lessons* slope and all were removed from the model.

Finally, the full final Intercepts and Slopes as Outcomes Model was analyzed and the equations for the final full model are:

Student Level:

Mathematical Literacy $(Y_{ij}) = B_{0j} + B_{1j}*(GRADE) + B_{2j}*(OCCUPAR) + B_{3j}*(COMPHOME) + B_{4j}*(HOMEDUC) + B_{5j}*(INTEREST) + B_{6j}*(SELFEFFI) + B_{7j}*(ANXIETY) + B_{8j}*(SELFCON) + B_{9j}*(MEMOR) + B_{10j}*(SUPPORT) + B_{11j}*(CLIMATE) + r_{ij}$

School Level:

$B_{0j} = \gamma_{00} + \gamma_{01}*(MEANEFFI) + \gamma_{02}*(ASELECT) + \gamma_{03}*(MACTIV) + u_{0j}$

$B_{1j} = \gamma_{10} + \gamma_{11}*(ASELECT) + u_{1j}$

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

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

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

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

$B_{6j} = \gamma_{60} + \gamma_{61}*(ASELECT) + u_{6j}$

$B_{7j} = \gamma_{70}$

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

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

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

$B_{11j} = \gamma_{110} + u_{11j}$

The results of the final estimation of fixed effects obtained from the full final Intercepts and Slopes as Outcomes Model of European Union Candidate Countries were presented in Appendix M, at the end of the dissertation. As stated previously, the results from Means as Outcomes Model (Research Question 2) were reported in the final full Intercepts and Slopes as Outcomes Model. *Average Mathematics Self-Efficacy, Academic Selectivity* and *Mathematics Activities* are significantly related to mean school mathematical literacy.

The *Average Mathematics Self-Efficacy* coefficient (γ_{01} = 93.83, se = 7.76) indicates that average mathematics self-efficacy is positively related to mathematical literacy. The *Academic Selectivity* coefficient (γ_{02} = 13.50, se = 3.14) indicates that academic selectivity is significantly and positively related to mathematical literacy. The higher the academic selectivity at school, the higher the mean school mathematical literacy. The *Mathematics Activities* coefficient (γ_{03} = -12.06, se = 4.43) indicates that mathematics activities is significantly but negatively related to mathematical literacy. The more mathematics activities done in mathematics lessons at school, the lower the mean school mathematical literacy.

Overall, schools with higher average mathematics self-efficacy, higher academic selectivity and fewer mathematics activities have higher mathematical literacy performance than schools with lower average mathematics self-efficacy, lower academic selectivity and more mathematics activities.

As stated previously, the results from the Random Coefficient Model (Research Question 3) are reported in the final full Intercepts and Slopes as Outcomes Model as well. *Grade, Highest Parental Occupational Status, Computer Facilities at Home, Home Educational Resources, Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety, Mathematics Self-Concept, Memorisation Strategies, Teacher Support in Mathematics Lessons* and *Disciplinary Climate in Mathematics Lessons* are significantly related to mathematical literacy.

The average *Grade-Mathematical Literacy* slope coefficient (γ_{10} = 30.39, se = 3.30) indicates that students from higher grades performed significantly higher than the students from lower grades on the mathematical literacy assessment. The average *Highest Parental Occupational Status-Mathematical Literacy* slope coefficient (γ_{20} = 0.41, se = 0.06) indicates that students having parents with higher occupational status performed better on the mathematical literacy assessment. The average *Computer Facilities at Home-Mathematical Literacy* slope coefficient (γ_{30} = 3.20, se = 1.01) indicates that students having more computer facilities at home performed higher on the mathematical literacy assessment. The average *Home Educational Resources-Mathematical Literacy* slope coefficient (γ_{40} = 4.21, se = 1.15) indicates that students who have more educational resources at home performed better on the mathematical literacy assessment. The average *Interest in Mathematics-Mathematical Literacy* slope coefficient (γ_{50} = -5.75, se = 1.46) indicates that students having higher interest in mathematics performed lower on the mathematical literacy assessment. The average *Self-Efficacy in Mathematics-Mathematical Literacy* slope coefficient (γ_{60} = 26.08, se = 1.47) indicates students having higher levels of mathematics self-efficacy performed better on the mathematical literacy assessment. The average *Anxiety in Mathematics-Mathematical Literacy* slope coefficient (γ_{70} = -11.99, se = 1.43) indicates that students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. The average *Self-Concept in Mathematics-Mathematical Literacy* slope coefficient (γ_{80} = 18.34, se = 1.73) indicates that students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment. The average *Memorisation Strategies-Mathematical Literacy* slope coefficient (γ_{90} = -9.30, se = 1.19) indicates that students having more preferences for this learning strategy performed lower on the mathematical literacy assessment. The average *Teacher Support in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{100} = -5.88, se = 1.11) indicates that students having more support from their teachers in mathematics lessons performed lower on the mathematical literacy assessment. Lastly, the average *Disciplinary Climate in Mathematics Lessons-Mathematical Literacy* slope coefficient (γ_{110} = 3.66, se = 1.20) indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in their mathematics lessons on the mathematical literacy assessment.

As can be seen easily, the coefficients have slight differences in magnitude, but the directions and the interpretations are same with the Random Coefficient Model (Research Question 3). The slight differences in magnitude exist because the number of schools and therefore, the number of students analyzed in the final full model are a subsample of the Random Coefficient Model (Research Question 3).

In the final full Intercepts and Slopes as Outcomes Model, only one school level variable was significantly related to two student level slopes. Firstly, the *Grade* coefficient model had one significant school level variable; Academic Selectivity (γ_{11} = -6.41, se = 2.95). Therefore, grade of the students has more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity.

The *Grade - Mathematical Literacy* model is:

$B_1 = \gamma_{10} + \gamma_{11}*(ASELECT) + u_1$

where

B_1 = the overall Grade slope

γ_{10} = the average Grade – Mathematical Literacy slope across the schools

γ_{11} = the effect of Academic Selectivity on the overall slope

u_1 = the random effect or error

From the results, $\gamma_{10} = 30.39$, $\gamma_{11} = -6.41$ and substituting the values into the equation produces:

$B_1 = 30.39 - 6.41 \text{ (ASELECT)} + u_{12}$

Furthermore, the *Mathematics Self-Efficacy* coefficient model had one significant school level variable; Academic Selectivity ($\gamma_{61} = -3.91$, se = 1.13). Therefore, mathematics self-efficacy levels of the students have more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity.

The *Mathematics Self-Efficacy - Mathematical Literacy* model is:

$B_6 = \gamma_{60} + \gamma_{61}*(\text{ASELECT}) + u_6$

where

B_6 = the overall Mathematics Self-Efficacy slope

γ_{60} = the average Mathematics Self-Efficacy – Mathematical Literacy slope across the schools

γ_{61} = the effect of Academic Selectivity on the overall slope

u_6 = the random effect or error

From the results, $\gamma_{60} = 26.08$, $\gamma_{61} = -3.91$ and substituting the values into the equation produces:

$B_6 = 26.08 - 3.91 \text{ (ASELECT)} + u_6$

The results of the final estimation of variance components obtained from the full final Intercepts and Slopes as Outcomes Model of European Union Candidate Countries were presented in Table 4.34. The degrees of freedom for this model (Intercepts and Slopes as Outcomes Model) is based on the number of schools with sufficient data, and the number of school level variables included in the model.

Degrees of Freedom = J – Q – 1, where

J = the number of schools with sufficient data

Q = number of school level variables included in the model

Thus, 91 schools did not have sufficient data to be included, so 91 schools were not used in this analysis and degrees of freedom values for this model are:

df = J – Q – 1 = 94 – 3 – 1 = 90 (df for *School Mean*)

df = J – Q – 1 = 94 – 1 – 1 = 92 (df for *Grade*)

df = J – Q – 1 = 94 – 1 – 1 = 92 (df for *Mathematics Self-Efficacy*)

df = J – Q – 1 = 94 – 0 – 1 = 93 (df for *Disciplinary Climate in Mathematics Lessons*)

Table 4.34 Final Estimation of Variance Components
(Final Full Model of European Union Candidate Countries)

Random Effect	*Variance Component*	*df*	X^2	*p-value*
School mean, u_{0j}	1 755.54	90	1 395.59	0.000
Grade, u_{1j}	236.82	92	125.63	0.013
Mathematics Self-Efficacy, u_{6j}	77.33	92	143.28	0.002
Disciplinary Climate in Math Lessons, u_{11j}	48.47	93	121.00	0.048
Level-1 Effect, r_{ij}	3 338.02			

The proportion of variance explained for each literacy slope model with significant school level variables could be examined. For this study, that would be *Grade* & *Mathematical Literacy* and *Mathematics Self-Efficacy* & *Mathematical Literacy*.

The equation is:

$$\text{Proportion of variance explained in } B_{qj} = \frac{\tau_{qq}(RandomCoefficient) - \tau_{qq}(FullModel)}{\tau_{qq}(RandomCoefficient)}$$

B_{qj} = mathematical literacy or the slope coefficient for a given variable

$$\text{Proportion of variance explained in Math Literacy, } B_{0j} = \frac{4658.16 - 1755.54}{4658.16} = 0.623$$

$$\text{Proportion of variance explained in Grade, } B_{1j} = \frac{290.15 - 236.82}{290.15} = 0.184$$

Proportion of variance explained in Math Self-Efficacy, $B_{6j} = \frac{94.95 - 77.33}{94.95} = 0.186$

Note that this value (0.623) was lower than the one observed in the results from Means as Outcomes Model (0.641) and it was a result of the difference in the samples between the two models. Moreover, 18% reduction in the variance was accounted for by *Academic Selectivity* for *Grade* and 19% reduction in the variance was accounted for by *Academic Selectivity* for *Mathematics Self-Efficacy*. All of these proportions showed that substantial amount of variation had been accounted for.

In the Random Coefficient and Intercepts and Slopes as Outcomes Models, only 94 from 189 schools were used to test if the three variables (*Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons*) were randomly varying. Due to this loss in degrees of freedom, Bryk and Raudenbush (2002) state that the Chi-Square tests provide only approximate probability values. They also suggest that a comparison of the deviance statistic of the randomly varying model and a restricted model (non-randomly varying model) should be completed.

A test setting all three variables (*Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons*) as fixed was run and an analysis of deviance statistic computed. The deviance statistics and the number of parameters of the two models (*Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons* random versus fixed) were given in Table 4.35.

Table 4.35 Statistics for Current Covariance Components Model
(Final Full Model of European Union Candidate Countries)

	Deviance	*Number of Estimated Parameters*
1st Model (Three variables – random)	48 747.13	11
2nd Model (Three variables– fixed)	48 580.74	2

A comparison of the deviance statistic of the randomly varying model and a restricted model was conducted. The results of variance-covariance components test were displayed in Table 4.36. As can be seen from Table 4.36, the deviance statistic between two models (*Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons* random versus fixed) was significant indicating that setting *Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons* as non-randomly varying did not create a better model. Thus, the results from the comparison that the variables; *Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons* should remain randomly varying.

Table 4.36 Variance-Covariance Components Test Results
(Final Full Model of European Union Candidate Countries)

	X^2	*df*	*p-value*
Variance-Covariance Components Test	33.61	9	0.001

CHAPTER V

DISCUSSION, CONCLUSION AND IMPLICATIONS

This chapter of the dissertation is devoted to the discussion of the results of the present study. Six main sections such as summary of the study, discussion of the results, conclusions drawn on the discussed results, implications of the study, limitations of the study and recommendations for further researchers were included in this chapter. The present study was summarized in the first section. In the discussion of the results section, the student and school level factors included in the study were discussed in compatible with the literature across Turkey, member and candidate countries of European Union. In conclusions section, the results of the study were interpreted across different cultural settings. In implications section, the implications of the study were stated in accordance with the conclusions. The limitations of the study were examined in the limitations section and lastly, recommendations were indicated for further researchers were presented in the recommendations section.

5.1 Summary of the Study

The purpose of the study was to gain a more complete understanding of the student and school level factors, the interaction of these two levels, and their impact on students' mathematical literacy skills. Schools are a system consisted of various inputs, processes, and outputs that influence the student mathematics performance. Within the school system, there are school, teacher, and student factors that can have more or less of an impact on student performance in mathematics.

In the present study, it was aimed to gain a more complete understanding of 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 through the Programme for International Student Assessment (PISA) 2003. Previous studies conducted have investigated the variables at the student level only, ignoring the nested structure of the data, or they have used student level data to school level, ignoring bias introduced in estimating the coefficients and standard errors. Therefore, the present study addresses these problems by using a multilevel analysis technique that takes into account the nested nature of the data to produce more precise coefficients.

The present study investigated the student and school level factors that influenced 15-year-old students' mathematical literacy skills across Turkey, member and candidate countries of European Union using Hierarchical Linear Modeling (HLM) as a multilevel analysis technique and a large public database (PISA). The models in the previous literature provided a theoretical framework for identifying the student and school level factors to be included in the analyses: grade of the students, gender of the students, highest parental occupational status, highest educational level of parents, socio-economic and cultural status, computer facilities at home, cultural possessions of the family, home educational resources, attitudes towards school, student-teacher relations at school, sense of belonging at school, interest in mathematics, instrumental motivation in mathematics, mathematics self-efficacy, mathematics anxiety, mathematics self-concept, control strategies, elaboration strategies, memorization strategies, competitive learning, cooperative learning, teacher support in mathematics lessons, disciplinary climate in mathematics lessons, average mathematics self-efficacy, school type, school size, proportion of females enrolled at school, total student-teacher ratio, mathematics student-teacher ratio, academic selectivity, use of assessments, ability grouping between mathematics classes, mathematics extension courses, mathematics activities, resource autonomy, curricular autonomy, quality of school's physical infrastructure, quality of school's educational resources, teacher shortage, teacher morale and commitment, student morale and commitment, teacher-related factors affecting school climate, student-related factors affecting school climate. The average mathematics self-efficacy was set as a controlling variable due to the high correlation with the mathematical literacy score, whereas the outcome variable was the mathematical literacy score obtained from the average of the five plausible values calculated in PISA project. The findings and implications were based on the results of the final full model which was the Intercepts and Slopes as Outcomes Model conducted separately through Turkey, member and candidate countries of European Union.

5.2 Discussion of the Results

The discussion of the results in this section of the dissertation was presented in two main sections: Student-Level Factors and School Level Factors. It is reminded that the discussion of the results was stated for three parts as for Turkey, for member and candidate countries of European Union in all two main sections.

5.2.1 Student Level Factors

5.2.1.1 Student Level Factors for Turkey

Only two variable slopes *(Grade* and *Disciplinary Climate in Mathematics Lessons)* were significantly related to mathematical literacy and randomly varying across schools in Turkey.

Grade Level of the students was significantly and positively related to mathematical literacy performance. That is, students from higher grade levels performed significantly higher than the students from lower grade levels on the mathematical literacy assessment. This observation is consistent with the results of the previous studies (OECD Publications, 2004) that the higher the grade level of the students, the higher the mathematics performance. It was an expected result since the students in higher grade levels tend to have more knowledge and skills than the students in lower grade levels. Learning more knowledge and skills through the higher grade levels affects the understanding and relating the concepts with each other and in turn makes the students to accommodate and assimilate these skills more easily.

As stated earlier, the magnitude of the relationship between *grade level* and mathematical literacy performance significantly varies from school to school. In other words, grade level influenced mathematical literacy performance more in some schools than in other schools. The reasons for the difference among schools are in fact unknown. Many variables might explain the differences among schools such as the environment of schools, performance level of schools, cooperation between parents and school, class' characteristics, performance levels of students and so on. Though the present study attempt to examine the impacts of student level factors among schools, it did not attempt to explain why the impacts of the student level factors are greater in some schools than others. Therefore, further studies are needed to investigate the differences among schools with respect to the significant student level factors.

As another factor having randomly varying slope, *Disciplinary Climate in Mathematics Lessons* was found as a significant factor having a positive impact on mathematical literacy performance of the students. This result indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in mathematics lessons on the mathematical literacy assessment. Actually, there were inconsistent results in the association between disciplinary climate in mathematics lessons and mathematics performance when looked at the results of previous studies. PISA 2000 results were supposed that the disciplinary climate have an influence on students' performance (OECD Publications, 2001). On the other hand, there is a tendency for participated counties in PISA 2003 project with more positive students' perceptions of disciplinary climate to perform better, but this relationship is not statistically significant (OECD Publications, 2004). Similar to PISA 2003 results, Bos and Kuiper (1999) found class climate did not show significant relationships with mathematics achievement in the most of the models of European countries. Therefore, this result could be stated as consistent with some of the PISA 2000 and 2003 results indicating a significant and positive relationship with the mathematical literacy.

The magnitude of the relationship between *disciplinary climate in mathematics lessons* and mathematical literacy performance significantly varies from school to school. In other words, disciplinary climate in mathematics lessons influenced mathematical literacy performance more in some schools than in other schools.

As stated before, the present study did not attempt to explain why the impacts of grade level and disciplinary climate in mathematics lessons are greater in some schools than in other schools. The reasons of why these slopes *(Grade* and *Disciplinary Climate in Mathematics Lessons)* varied randomly among schools are difficult to provide. The analysis technology of hierarchical linear modeling is new and only recently has the chance of answering the types of questions have been asked as "Does the effect of disciplinary climate in mathematics lessons vary from school to school?". In order to answer the reasons of varying slopes among schools, more complete data and more sensitive analyses are needed.

When the student level variables significantly related to mathematical literacy, but not randomly varying across schools in Turkey were considered, ten student level factors were obtained: gender of the students, home educational resources, student-teacher relations, sense of belonging at school, mathematics self-efficacy, mathematics anxiety, mathematics self-concept, control strategies, elaboration strategies and memorization strategies.

The association between *Gender* of the students and mathematical literacy performance was found as significant and positive indicating that female students performed significantly lower than the male students on the mathematical literacy assessment. Many studies have more males than females and this inequality in the selection impacts the observed difference between males and females. However, this inequality could not be a reason for this gender difference on mathematical literacy performance levels of females and males, because the sample used for Turkey part of the study has approximately the same number of females and males as 2 090 (43%) females and 2 765 (57%) males. Another argument for the gender difference is societal pressure or expectation, but it is hard to say that because of insufficient information in the data set to examine this hypothesis. The observation of males outperforming females influencing mathematical literacy performance suggest that the problem of gender disparity exists although it is believed that there is not significant gender difference on performance in Turkey.

As student background variable, *Home Educational Resources* was significantly and positively related to mathematical literacy performance. That is, students having more educational resources at their home performed higher than the students having fewer educational resources at home on the mathematical literacy assessment. This result was also consistent with the results of the previous research (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Boocock, as cited in Dowson & McInerney, 1998; Bos & Kuiper, 1999; OECD Publications, 2004). Actually, the amount of home educational resources is closely interrelated to the students' socio-economic backgrounds. Since socio-economic backgrounds have a considerable impact in shaping opportunities for the students which provide discriminatory educational experiences. Therefore, this provides a significant potential effect on their academic achievement.

When the variables about school climate were considered, *Student-Teacher Relations* and *Sense of Belonging at School* were found as significantly related to mathematical literacy. A negative association between *Student-Teacher Relations* and mathematical literacy was observed in the study. Students having better student-teacher relations at school performed lower on the mathematical literacy assessment. It cannot be said that this result supports the previous studies (Hill, & Rowe, 1998; OECD Publications, 2004) indicating a positive relationship between student-teacher relations and mathematics performance. A possible explanation for the result in Turkey could be that the teachers typically use more supportive practices in the classes attended by a majority of less able students. Since the teachers mostly communicate and pay attention to the less able students, the association between the student-teacher relations and the performance of the students would be expected to be negative. The relationship between *Sense of Belonging at School* and mathematical literacy measure was found as positive. Students having positive feelings about their school performed higher on the mathematical literacy assessment. Actually, most students tend to have good relations with school staff and with other students, and they feel that they belong at school. The sense of belonging at school can be, for some students, indicative of economic or educational success and long-term health and well-being. This result is consistent with the previous literature (OECD Publications, 2004) that this perception deserves to be treated alongside academic performance as an important outcome of schooling.

As the variables about self-related cognitions in mathematics, *Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* were found as significantly related to student mathematics performance. *Mathematics Self-Efficacy* had a positive impact on mathematical literacy. Students having higher levels of mathematics self-efficacy performed higher on the mathematical literacy assessment. This result supports the findings of the previous research (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999; OECD Publications, 2004) that students' belief of their mathematical abilities is a powerful predictor of student success, course and career selection. Actually, the mathematics self-efficacy was found as one of the strongest predictors of student performance in mathematical literacy that supports previous findings of reports published about PISA (OECD Publications, 2004). Similarly, *Mathematics Self-Concept* was positively associated with the mathematical literacy. Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment. This association provides consistency with the previous studies (Marsh, 1986; OECD Publications, 2004) that students' academic self-concept is both an important outcome of education and a powerful predictor of student success. Indeed, there was another consistent result that students' self-efficacy in mathematics is even more closely related to student performance on the PISA 2003 mathematics assessment than self-concept in mathematics (OECD Publications, 2004). *Mathematics Anxiety*, on the other hand, was significantly but negatively related to mathematical literacy. Thus, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. This result provides support (OECD Publications, 2004) that students with an absence of anxiety about mathematics perform strongly in mathematics. In fact, the association between anxiety in mathematics and mathematics performance is not only strong at student levels as was the case with self-efficacy which was reported in the reports of PISA project (OECD Publications, 2004). Moreover, there is considerable cross-country variation in the degree to which students feel anxiety when dealing with mathematics, with students in Turkey reporting feeling most concerned.

Among the student level factors about learning and instruction, *Control Strategies, Elaboration Strategies,* and *Memorisation Strategies* were found as significantly related to student performance in mathematics. *Control Strategies* had a positive association with the mathematical literacy indicating students having more preferences for control strategies as learning strategy performed higher on the mathematical literacy assessment. This finding is consistent with PISA 2003 results that the relationship between control strategies and student performance in mathematics tends to be relatively weak (OECD Publications, 2004). On the other hand, *Elaboration Strategies* was negatively related to mathematical literacy. That is, students having more preferences for elaboration strategies as learning strategy performed lower on the mathematical literacy assessment. Elaboration strategies were described as making connections to related areas or thinking about alternative solutions. Therefore, elaboration strategies are used to achieve understanding. This result is a surprising result since the association between elaboration strategies and mathematical literacy is expected as positive. However, it seems that there is a problematic situation in terms of the elaboration strategies in Turkey. One possible reason for this negative relation could be the responses of the Turkish students as they might have given unreliable responses to the items in the questionnaire. For instance, the students perhaps thought that they are making connections to related areas and thinking about alternative solutions but actually they could not achieve these skills correctly. *Memorisation Strategies* was also found as significantly and negatively related to mathematical literacy performance. Students having more preferences for memorisation learning strategy performed lower on the mathematical literacy assessment. This result supports previous research (OECD Publications, 2004) that memorisation of the knowledge cannot lead academic success. PISA project assessed the ability to complete tasks relating to real life, depending on a broad understanding of key concepts, rather than limiting the assessment to the possession of subject-specific knowledge. Indeed, memorisation strategies were described as learning key terms or repeated learning of material. Then, it is obvious that the skills achieved only from memorisation learning strategies would not sufficient for the high performance on mathematical literacy assessment supporting the negative association.

Overall, in Turkey, male students and students from higher grades, students having more home educational resources at home, lower student-teacher relations, positive feelings about their school, higher levels of mathematics self-efficacy, lower levels of mathematics anxiety, more positive self-concept in mathematics, more preferences for control strategies, less preferences for elaboration strategies and memorisation strategies, and more positive disciplinary climate in mathematics lessons have higher mathematical literacy performance.

5.2.1.2 Student-Level Factors for Member Countries of European Union

Only two variable slopes *(Grade* and *Disciplinary Climate in Mathematics Lessons)* were significantly related to mathematical literacy and randomly varying across schools in the member countries of European Union.

Grade Level of the students was significantly and positively related to mathematical literacy performance. That is, students from higher grade levels performed significantly higher than the students from lower grade levels on the mathematical literacy assessment. This observation is consistent with the results of the previous studies (OECD Publications, 2004) that the higher the grade level of the students, the higher the mathematics performance. It was an expected result since the students in higher grade levels tend to have more knowledge and skills than the students in lower grade levels. Learning more knowledge and skills through the higher grade levels affects the understanding and relating the concepts with each other and in turn makes the students to accommodate and assimilate these skills more easily.

As stated earlier, the magnitude of the relationship between *grade level* and mathematical literacy performance significantly varies from school to school. In other words, grade level influenced mathematical literacy performance more in some schools than in other schools. Further studies are necessary to investigate the differences among schools in terms of influences of grade levels of the students.

As the last student level factor having randomly varying slope, *Disciplinary Climate in Mathematics Lessons* was found as a significant variable having a positive impact on mathematical literacy performance of the students. This result indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in mathematics lessons on the mathematical literacy assessment. Actually, there were inconsistent results in the association between disciplinary climate in mathematics lessons and mathematics performance when looked at the results of previous studies. PISA 2000 results were supposed that the disciplinary climate have an influence on students' performance (OECD Publications, 2001). On the other hand, there is a tendency for participated counties in PISA 2003 project with more positive students' perceptions of disciplinary climate to perform better, but this relationship is not statistically significant (OECD Publications, 2004). Similar to PISA 2003 results, Bos and Kuiper (1999) found class climate did not show significant relationships with mathematics achievement in the most of the models of European countries. Therefore, this result could be stated as consistent with some of the PISA 2000 and 2003 results indicating a significant and positive relationship with the mathematical literacy.

The magnitude of the relationship between *disciplinary climate in mathematics lessons* and mathematical literacy performance significantly varies from school to school. In other words, disciplinary climate in mathematics lessons influenced mathematical literacy performance more in some schools than in other schools.

The present study did not attempt to explain why the impacts of grade level and disciplinary climate in mathematics lessons are greater in some schools than in other schools. The reasons of why these slopes *(Grade* and *Disciplinary Climate in Mathematics Lessons)* varied randomly among schools are difficult to provide. The analysis technology of hierarchical linear modeling is new and only recently has the chance of answering the types of questions have been asked as "Does the effect of disciplinary climate in mathematics lessons vary from school to school?". In order to answer the reasons of varying slopes among schools, more complete data and more sensitive analyses are needed.

When the student level variables significantly related to mathematical literacy, but not randomly varying across schools in the member countries of European Union were considered, twelve student level factors were obtained: highest parental occupational status, highest educational level of parents, computer facilities at home, home educational resources, sense of belonging at school, interest in mathematics, mathematics self-efficacy, mathematics anxiety, mathematics self-concept, elaboration strategies, memorization strategies, and teacher support in mathematics lessons.

As student background variables, *Highest Parental Occupational Status, Highest Educational Level of Parents, Computer Facilities at Home,* and *Home Educational Resources* were significantly related to mathematical literacy performance. *Highest Parental Occupational Status, Computer Facilities at Home,* and *Home Educational Resources* were positively associated with the mathematical literacy measure. That is, students having parents with higher occupational status, students having more computer facilities at their home, and students having more educational resources at their home performed higher than the students having parents with lower occupational status, students having fewer computer facilities at their home, and students having fewer educational resources at their home on the mathematical literacy assessment. These results were consistent with the literature (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Boocock, as cited in Dowson & McInerney, 1998; Bos & Kuiper, 1999; OECD Publications, 2004) that occupational status of parents, computer facilities at home and home educational resources at home provide a significant potential effect on academic achievement. In fact, this result provides some support that parental occupational status has a strong association with student performance (OECD Publications, 2004). On the contrary, *Highest Educational Level of Parents* had a negative impact on student mathematics performance. In other words, students who have parents with higher educational level performed lower on the mathematical literacy assessment. This result is surprising and unexpected since this result is not consistent with the previous research results (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Boocock, as cited in Dowson & McInerney, 1998; Bos & Kuiper, 1999; OECD Publications, 2004). Actually, parent education may also be of significant educational benefit for children. In addition to the parents' own level of education, parents' support for their children's education is widely deemed to be an essential element of success at school (OECD Publications, 2004). One reason could be the relationship between parents and their children. That is, the parents whose educational attainment is limited could spend more time with their children and could have better interactions both with their children and with their children's schools in ways that enhance their children's learning. Thus, the reasons for this negative relationship should be investigated in the further studies.

When the variables about school climate were considered, only *Sense of Belonging at School* was found as significantly related to mathematical literacy. A negative association between *Sense of Belonging at School* and mathematical literacy was observed in the study. Students having positive feelings about their school performed lower on the mathematical literacy assessment. This is an unexpected result and it cannot be said that this result supports the previous studies (OECD Publications, 2004) that this perception deserves to be treated alongside academic performance as an important outcome of schooling. Perhaps, some students do not share the sense of belonging at school and in turn these feelings and attitudes may result in their becoming disaffected with school (Finn, 1989; Jenkins, 1995, as cited in OECD Publications, 2004).

As the variables about self-related cognitions in mathematics, *Interest in Mathematics, Mathematics Self-Efficacy, Mathematics Anxiety* and *Mathematics Self-Concept* were found as significantly related to student mathematics performance. *Interest in Mathematics* was negatively associated with the mathematical literacy measure. Students having higher interest in mathematics performed lower on the mathematical literacy assessment. This result is also surprising since a positive relation was expected between interest in mathematics and mathematics performance. Interest in subject and performance may be mutually reinforcing and may also be affected by other factors, such as the social backgrounds of students and their schools. The students might have given unreliable responses to the items in the questionnaire. For instance, they might give the answer that they enjoy reading about mathematics, where the real answer is not that. *Mathematics Self-Efficacy* had a positive impact on mathematical literacy. Students having higher levels of mathematics self-efficacy performed higher on the mathematical literacy assessment. This result supports the findings of the previous research (Cooper &

Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999; OECD Publications, 2004) that students' belief of their mathematical abilities is a powerful predictor of student success, course and career selection. Actually, the mathematics self-efficacy was found as one of the strongest predictors of student performance in mathematical literacy that supports previous findings of reports published about PISA (OECD Publications, 2004). Similarly, *Mathematics Self-Concept* was positively associated with the mathematical literacy. Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment. This association provides consistency with the previous studies (Marsh, 1986; OECD Publications, 2004) that students' academic self-concept is both an important outcome of education and a powerful predictor of student success. Indeed, there was another consistent result that students' self-efficacy in mathematics is even more closely related to student performance on the PISA 2003 mathematics assessment than self-concept in mathematics (OECD Publications, 2004). *Mathematics Anxiety*, on the other hand, was significantly but negatively related to mathematical literacy. Thus, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. This result provides support (OECD Publications, 2004) that students with an absence of anxiety about mathematics perform strongly in mathematics. In fact, the association between anxiety in mathematics and mathematics performance is not only strong at student levels as was the case with self-efficacy which was reported in the reports of PISA project (OECD Publications, 2004).

Among the student level factors about learning and instruction, *Elaboration Strategies* and *Memorisation Strategies* were found as significantly related to student performance in mathematics. *Elaboration Strategies* had a negative association with the mathematical literacy indicating students having more preferences for elaboration strategies as learning strategy performed lower on the mathematical literacy assessment. Elaboration strategies were described as making connections to related areas or thinking about alternative solutions. Therefore, elaboration strategies are used to achieve understanding. This result is a surprising result since the association between elaboration strategies and mathematical literacy is expected as positive. However, it seems that there is a problematic situation in terms of the elaboration strategies in the members of European Union. One possible reason for this negative relation could be the responses of the students as they might have given unreliable responses to the items in the questionnaire. For instance, the students perhaps thought that they are making connections to related areas and thinking about alternative solutions but actually they could not achieve these skills correctly. Similarly, *Memorisation Strategies* was found as significantly and negatively related to mathematical literacy performance. Students having more preferences for memorisation learning strategy performed lower on the mathematical literacy assessment. However, this result is consistent with the previous findings (OECD Publications, 2004) that memorisation of the knowledge cannot lead academic success. PISA project assessed the ability to complete tasks relating to real life, depending on a broad understanding of key concepts, rather than limiting the assessment to the possession of subject-specific knowledge. Indeed, memorisation strategies were described as learning key terms or repeated learning of material. Then, it is obvious that the skills achieved only from memorisation learning strategies would not sufficient for the high performance on mathematical literacy assessment supporting the negative association.

The classroom climate variable, *Teacher Support in Mathematics Lessons* was significantly but negatively related to mathematical literacy measure. Thus, students having more support from their teachers in mathematics lessons performed lower than students having less support from their teachers in mathematics lessons on the mathematical literacy assessment. This is consistent with the finding that to the extent that teachers typically use more supportive practices for weaker students or classes attended by a majority of less able students, the correlations between support and performance would be expected to be negative (OECD Publications, 2004). Therefore, it could be thought that teachers typically use more supportive practices for weaker students or classes attended by a majority of less able students in the member countries of European Union.

Overall, in the member countries of European Union, students from higher grades, students having parents with higher occupational status, parents with lower educational levels, more computer facilities at their home, more home educational resources at their home, negative feelings about their school, lower interest in mathematics, higher levels of mathematics self-efficacy, lower levels of mathematics anxiety, more positive self-concept in mathematics, less preferences for elaboration strategies, less preferences for memorisation strategies, less support from their teachers in mathematics lessons, and more positive disciplinary climate in mathematics lessons have higher mathematical literacy performance.

5.2.1.3 Student-Level Factors for Candidate Countries of European Union

Only three variable slopes *(Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons)* were significantly related to mathematical literacy and randomly varying across schools in the candidate countries of European Union.

Grade Level of the students was significantly and positively related to mathematical literacy performance. That is, students from higher grade levels performed significantly higher than the students from lower grade levels on the mathematical literacy assessment. This observation is consistent with the results of the previous studies (OECD Publications, 2004) that the higher the grade level of the students, the higher the mathematics performance. It was an expected result since the students in higher grade levels tend to have more knowledge and skills than the students in lower grade levels. Learning more knowledge and skills through the higher grade levels affects the understanding and relating the concepts with each other and in turn makes the students to accommodate and assimilate these skills more easily.

The magnitude of the relationship between *grade level* and mathematical literacy performance significantly varies from school to school. In other words, grade level influenced mathematical literacy performance more in some schools than in other schools. Further studies are necessary to investigate the differences among schools in terms of influences of grade levels of the students.

The *Mathematics Self-Efficacy* was significantly and positively related to mathematical literacy measure. Students having higher levels of mathematics self-efficacy performed higher on the mathematical literacy assessment. This result supports the findings of the previous research (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999; OECD Publications, 2004) that students' belief of their mathematical abilities is a powerful predictor of student success, course and career selection. Actually, the mathematics self-efficacy was found as one of the strongest predictors of student performance in mathematical literacy that supports previous findings of reports published about PISA (OECD Publications, 2004).

The magnitude of the relationship between *mathematics self-efficacy* and mathematical literacy performance significantly varies from school to school. In other words, mathematics self-efficacy influenced mathematical literacy performance more in some schools than in other schools. Further studies are necessary to investigate the differences among schools in terms of influences of grade levels of the students.

As the last student level factor having randomly varying slope, *Disciplinary Climate in Mathematics Lessons* was found as a significant variable having a positive impact on mathematical literacy performance of the students. This result indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in mathematics lessons on the mathematical literacy assessment. Actually, there were inconsistent results in the association between disciplinary climate in mathematics lessons and mathematics performance when looked at the results of previous studies. PISA 2000 results were supposed that the disciplinary climate have an influence on students' performance (OECD Publications, 2001). On the other hand, there is a tendency for participated counties in PISA 2003 project with more positive students' perceptions of disciplinary climate to perform better, but this relationship is not statistically significant (OECD Publications, 2004). Similar to PISA 2003 results, Bos and Kuiper (1999) found class climate did not show significant relationships with mathematics achievement in the most of the models of European countries. Therefore, this result could be stated as consistent with some of the PISA 2000 and 2003 results indicating a significant and positive relationship with the mathematical literacy.

The magnitude of the relationship between *disciplinary climate in mathematics lessons* and mathematical literacy performance significantly varies from school to school. In other words, disciplinary climate in mathematics lessons influenced mathematical literacy performance more in some schools than in other schools.

As stated before, the present study did not attempt to explain why the impacts of grade level, mathematics self-efficacy and disciplinary climate in mathematics lessons are greater in some schools than in other schools. The reasons of why these slopes *(Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons)* varied randomly among schools are difficult to provide. The analysis technology of hierarchical linear modeling is new and only recently has the chance of answering the types of questions have been asked as "Does the effect of disciplinary climate in mathematics lessons vary from school to school?". In order to answer the reasons of varying slopes among schools, more complete data and more sensitive analyses are needed.

When the student level variables significantly related to mathematical literacy, but not randomly varying across schools in the candidate countries of European Union were considered, eight student level factors were obtained: highest parental occupational status, computer facilities at home, home educational resources, interest in mathematics, mathematics anxiety, mathematics self-concept, memorization strategies, and teacher support in mathematics lessons.

As student background variables, *Highest Parental Occupational Status, Computer Facilities at Home,* and *Home Educational Resources* were significantly related to mathematical literacy performance. *Highest Parental Occupational Status, Computer Facilities at Home,* and *Home Educational Resources* were positively associated with the mathematical literacy measure. That is, students having parents with higher occupational status, students having more computer facilities at their home, and students having more educational resources at their home performed higher than the students having parents with lower occupational status, students having fewer computer facilities at their home, and students having fewer educational resources at their home on the mathematical literacy assessment. These results were consistent with the literature (Alwin & Thornton, 1984; Baker & Stevenson, 1986; Boocock, as cited in Dowson & McInerney, 1998; Bos & Kuiper, 1999; OECD Publications, 2004) that occupational status of parents, computer facilities at home and home educational resources at home provide a significant potential effect on academic achievement. In fact, this result provides some support that parental occupational status has a strong association with student performance (OECD Publications, 2004).

As the variables about self-related cognitions in mathematics, *Interest in Mathematics, Mathematics Anxiety* and *Mathematics Self-Concept* were found as significantly related to student mathematics performance. *Interest in Mathematics* was negatively associated with the mathematical literacy measure. Students having higher interest in mathematics performed lower on the mathematical literacy assessment. This result is also surprising since a positive relation was expected between interest in mathematics and mathematics performance. Interest in a subject and performance may be mutually reinforcing and may also be affected by other factors, such as the social backgrounds of students and their schools. The students might have given unreliable responses to the items in the questionnaire. For instance, they might give the answer that they look forward to their mathematics lessons, where the real answer is not that. On the other hand, *Mathematics Self-Concept* was positively associated with the mathematical literacy. Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment. This association provides consistency with the previous studies (Marsh, 1986; OECD Publications, 2004) that students' academic self-concept is both an important outcome of education and a powerful predictor of student success. Indeed, there was another consistent result that students' self-efficacy in mathematics is even more closely related to student performance on the PISA 2003 mathematics assessment than self-concept in mathematics (OECD Publications, 2004). *Mathematics Anxiety* was significantly but negatively related to mathematical literacy. Thus, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment. This result provides support (OECD Publications, 2004) that students with an absence of anxiety about mathematics perform strongly in mathematics. In fact, the association between anxiety in mathematics and mathematics performance is not only strong at student levels as was the case with self-efficacy which was reported in the reports of PISA project (OECD Publications, 2004).

Among the student level factors about learning and instruction, only *Memorisation Strategies* was found as significantly related to student performance in mathematics. *Memorisation Strategies* was found as negatively related to mathematical literacy performance. Students having more preferences for memorisation learning strategy performed lower on the mathematical literacy assessment. However, this result is consistent with the previous findings (OECD Publications, 2004) that memorisation of the knowledge cannot lead academic success. PISA project assessed the ability to complete tasks relating to real life, depending on a broad understanding of key concepts, rather than limiting the assessment to the possession of subject-specific knowledge. Indeed, memorisation strategies were described as learning key terms or repeated learning of material. Then, it is obvious that the skills achieved only from memorisation learning strategies would not sufficient for the high performance on mathematical literacy assessment supporting the negative association.

The classroom climate variable, *Teacher Support in Mathematics Lessons* was significantly but negatively related to mathematical literacy measure. Thus, students having more support from their teachers in mathematics lessons performed lower than students having less support from their teachers in mathematics lessons on the mathematical literacy assessment. This is consistent with the finding that to the extent that teachers typically use more supportive practices for weaker students or classes attended by a majority of less able students, the correlations between support and performance would be expected to be negative (OECD Publications, 2004). Therefore, it could be thought that teachers typically use more supportive practices for weaker students or classes attended by a majority of less able students in the candidate countries of European Union.

Overall, in the candidate countries of European Union, students from higher grades, students having parents with higher occupational status, more computer facilities at their home, more home educational resources at their home, lower interest in mathematics, higher levels of mathematics self-efficacy, lower levels of mathematics anxiety, more positive self-concept in mathematics, less preferences for memorisation strategies, less support from their teachers in mathematics lessons, and more positive disciplinary climate in mathematics lessons have higher mathematical literacy performance.

5.2.2 School Level Factors

5.2.2.1 School Level Factors for Turkey

The *Disciplinary Climate in Mathematics Lessons – Mathematical Literacy* slope was the only coefficient included in the hierarchical linear model of Turkey that had two significant school level factors (cross-level interaction).

The first interaction provides observation that *School Size* is positively related to the *Disciplinary Climate in Mathematics Lessons*. The result indicates that in schools that have higher school sizes, disciplinary climate in mathematics lessons has more of an impact on mathematical literacy (steeper slopes). If there is a positive disciplinary climate in the mathematics lessons, and the school has a large school size, the impact of disciplinary climate may be stronger than a similar positive disciplinary climate in mathematics lessons in a school with a smaller school size. In other words, disciplinary climate in mathematics lessons has more of an influence on mathematical literacy in schools with larger school size than in schools with smaller school size.

The second interaction provides observation that *Mathematics Student-Teacher Ratio* is negatively related to the *Disciplinary Climate in Mathematics Lessons*. The result indicates that in schools with smaller mathematics student-teacher ratio, disciplinary climate in mathematics lessons has more of an impact on mathematical literacy. If there is a positive disciplinary climate in the mathematics lessons, and the school has a small mathematics student-teacher ratio, the impact of disciplinary climate may be stronger than a similar positive disciplinary climate in mathematics lessons in a school with a larger mathematics student-teacher ratio. In other words, disciplinary climate in mathematics lessons has more of an influence on mathematical literacy in schools with smaller mathematics student-teacher ratio than in schools with larger mathematics student-teacher ratio.

Overall, these two cross-level interactions indicate that disciplinary climate in mathematics lessons has more of an impact on mathematical literacy skills of the students in schools with larger school size and with smaller mathematics student-teacher ratio than in schools with smaller school size and larger mathematics student-teacher ratio.

When the school level variables significantly related to mathematical literacy in Turkey were considered, seven school level factors were obtained: average mathematics self-efficacy, school size, proportion of females enrolled at school, total student-teacher ratio, mathematics student-teacher ratio, academic selectivity, and quality of school's physical infrastructure.

The *Average Mathematics Self-Efficacy* impacted the mathematical literacy performance of the schools. This positive impact indicates that mathematics self-efficacy is strongly associated with mathematical literacy performance which supports the previous observations (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999; OECD Publications, 2004).

When the variables about school characteristics were considered, *School Size,* and *Proportion of Females Enrolled at School* were found as significantly related to mathematical literacy. A positive association between *School Size* and mathematical literacy was observed in the study. The larger the school size, the higher the mean school mathematical literacy performance. This result is consistent with PISA results indicating that school size tends to be positively related to school performance, all other things equal (OECD Publications, 2004). Similar to the school size, *Proportion of Females Enrolled at School* was positively related to mathematical literacy. The larger the proportion of females enrolled at school, the higher the mean school mathematical literacy performance. Although the females performed lower than the males on the mathematical literacy assessment, the proportion of females enrolled at school positively influences the school performance on mathematical literacy assessment. One possible explanation for this result could be the indirect influences of proportion of females enrolled at school on the school performance in mathematics and further research is also suggested for this result of the study.

When the variables about indicators of school resources were considered, *Total Student-Teacher Ratio* and *Mathematics Student-Teacher Ratio* were found as significantly related to mathematical literacy. The *Total Student-Teacher Ratio* and *Mathematics Student-Teacher Ratio* had negative impacts on mathematical literacy. Thus, the larger the student-teacher ratio, the lower the mean school mathematical literacy performance. As stated previously, total student-teacher ratio is an indicator of the availability of teachers in relation to the number of students to be taught, whereas mathematics student-teacher ratio is the availability of mathematics teachers. When the teacher handles more students during a class session, his/her response to them will be less refined. Then, the teacher has less information to attend and less time to evaluate it for each student. Therefore, the aggregate level of achievement will be lower when the number of students per teacher is more. This result supports the findings of the previous research (Bidwell, & Kasarda, 1975; OECD Publications, 2004) that higher student-teacher ratio should be associated with lower levels of student attainment.

Among the school level factors about admittance policies and instructional context, only *Academic Selectivity* was found as significantly and positively related to student performance in mathematics. Schools having higher academic selectivity performed higher on the mathematical literacy assessment. This result is consistent with that the academic background of students is positively related to mathematics achievement (Lee, & Bryk, 1989; OECD Publications, 2004). Actually, at the cross-country level, the prevalence of some of the attributes of academic selectivity, including the use of students' academic record or recommendations from feeder schools tend to be positively related to country performance, but only weakly and not statistically significantly (OECD Publications, 2004, p. 228). However, the academic selectivity level of the schools has a statistically significant impact on school performance on mathematical literacy assessment in Turkey. One possible explanation for this result could be the examination based education system of Turkey.

As the school resources variable, only *Quality of School's Physical Infrastructure* was significantly and positively related to mathematical literacy. The mean school mathematical literacy performance was higher in schools where the quality of physical infrastructure is better. This result provides support to the previous research (OECD Publications, 2004) that buildings in good condition and adequate amounts of teaching space all contribute to a physical environment that is conducive to learning. Furthermore, the association of quality of school's educational resources with school performance on mathematics tended to be slightly stronger than with regard to the quality of school's physical infrastructure, but remains weak (OECD Publications, 2004). However, the school principals frequently reported that the quality of their school's physical infrastructure and their supply and quality of educational resources hindered learning in Turkey (OECD Publications, 2004).

Overall, in Turkey, schools with higher average mathematics self-efficacy, larger school size, higher proportion of females enrolled at school, lower total student-teacher ratio, lower mathematics student-teacher ratio, higher academic selectivity, and higher quality of physical infrastructure have higher mathematical literacy performance than schools with lower average mathematics self-efficacy, smaller school size, lower proportion of females enrolled at school, higher total student-teacher ratio, higher mathematics student-teacher ratio, lower academic selectivity, and lower quality of physical infrastructure.

5.2.2.2 School Level Factors for Member Countries of European Union

None of the school level factors were significantly related to a student level slope. Thus, there was no cross-level interaction in the hierarchical linear model of the member countries of European Union.

When the school level variables significantly related to mathematical literacy in the member countries of European Union were considered, four school level factors were obtained: average mathematics self-efficacy, school size, resource autonomy, and student-related factors affecting school climate.

The *Average Mathematics Self-Efficacy* impacted the mathematical literacy performance of the schools. This positive impact indicates that mathematics self-efficacy is strongly associated with mathematical literacy performance which supports the previous observations (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999; OECD Publications, 2004).

When the variable about school characteristics was considered, only *School Size* was found as significantly related to mathematical literacy. A positive association between *School Size* and mathematical literacy was observed in the study. The larger the school size, the higher the mean school mathematical literacy performance. This result is consistent with PISA results indicating that school size tends to be positively related to school performance, all other things equal (OECD Publications, 2004).

As the school climate variable, only *Student-Related Factors Affecting School Climate* was significantly and positively related to mathematical literacy. The more positive evaluations of student-related factors affecting school climate, the higher the mean school mathematical literacy performance. The findings of the previous studies (OECD Publications, 2004) are supported by this result that the relationship between school principals' perceptions of student-related factors affecting school climate and student performance in mathematics tends to be positive.

Overall, in the member countries of European Union, schools with higher average mathematics self-efficacy, larger school size, higher resource autonomy, and more positive evaluations of student-related factors affecting school climate have higher mathematical literacy performance than schools with lower average mathematics self-efficacy, smaller school size, lower resource autonomy, and less positive evaluations of student-related factors affecting school climate.

5.2.2.3 School Level Factors for Candidate Countries of European Union

The *Grade - Mathematical Literacy* slope and the *Mathematics Self-Efficacy - Mathematical Literacy* slope were two coefficients included in the hierarchical linear model of the candidate countries of European Union that each of the two coefficients had one significant school level factor (cross-level interaction).

The first interaction provides observation that *Academic Selectivity* is negatively related to the *Grade Level*. The result indicates that in schools with lower academic selectivity, grade level of the students has more of an impact on mathematical literacy. If the student is attended a grade level, and the school has low academic selectivity, the impact of grade level may be stronger than a student at the same grade level in a school with higher academic selectivity. In other words, grade level of the students has more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity.

The second interaction provides observation that *Academic Selectivity* is negatively related to the *Mathematics Self-Efficacy*. The result indicates that in schools with lower academic selectivity, mathematics self-efficacy has more of an impact on mathematical literacy. If the student has an average level of mathematics self-efficacy, and the school has low academic selectivity, the impact of mathematics self-efficacy may be stronger than a student has the same average level of mathematics self-efficacy in a school with higher academic selectivity. In other words, mathematics self-efficacy levels of the students has more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity.

Overall, these two cross-level interactions indicate that both the grade level of the students and the students' mathematics self-efficacy levels have more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity.

When the school level variables significantly related to mathematical literacy in the candidate countries of European Union were considered, three school level factors were obtained: average mathematics self-efficacy, academic selectivity, and mathematics activities.

The *Average Mathematics Self-Efficacy* impacted the mathematical literacy performance of the schools. This positive impact indicates that mathematics self-efficacy is strongly associated with mathematical literacy performance which supports the previous observations (Cooper & Robinson, 1991; Hackett & Betz, 1989; Hall & Ponton, 2005; O'Brien, Martinez-Pons & Kopala, 1999; OECD Publications, 2004).

Among the school level factors about admittance policies and instructional context, *Academic Selectivity* and *Mathematics Activities* were found as significantly related to student performance in mathematics. The association between *Academic Selectivity* and mathematical literacy measure was found as positive indicating the higher the academic selectivity at school, the higher the mean school mathematical literacy. This provides support for the findings of the previous studies (Lee, & Bryk, 1989; OECD Publications, 2004) that the prevalence of some of the attributes of academic selectivity, including the use of students' academic record or recommendations from feeder schools tend to be positively related to performance, but only weakly and not statistically significantly. Actually, more selective schools may also perform better simply because they do not accept poorly performing students, and not necessarily because they provide better services. On the other hand, *Mathematics Activities* was significantly but negatively associated with the mathematical literacy performance. That is, the more mathematics activities offered at school, the lower the mean school mathematical literacy performance. In fact, this negative impact was not consistent with the previous studies (OECD Publications, 2004) that schools' offering of activities to promote student engagement with mathematics, such as mathematics competitions, mathematics clubs or computer clubs related to mathematics, tend to have a positive impact over and above all other factors. However, it is found that schools' offerings of activities to promote the engagement with mathematics depend highly on the socio-economic characteristics (OECD Publications, 2004). Further studies are needed to examine this negative relationship and investigate the possible reasons such as the effect of socio-economic characteristics.

Overall, in the candidate countries of European Union, schools with higher average mathematics self-efficacy, higher academic selectivity, and fewer mathematics activities offered have higher mathematical literacy performance than schools with lower average mathematics self-efficacy, lower academic selectivity, and more mathematics activities offered.

5.3 Conclusions

The present study aimed to gain a more complete understanding of 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 through the Programme for International Student Assessment (PISA) 2003.

The conclusions of the results were presented in this section of the dissertation. The results of the present study were summarized in this section in two main parts as the similarities and the differences between the results of Turkey, member and candidate countries of European Union models.

5.3.1 Similarities between the Results of the Three Models

(1) The *Grade* and *Disciplinary Climate in Mathematics Lessons* slopes were significantly related to mathematical literacy and randomly varying across schools in Turkey, member and candidate countries of European Union.

(2) *Grade Level* of the students was significantly and positively related to mathematical literacy performance in all three cultural settings. That is, students from higher grade levels performed significantly higher than the students from lower grade levels on the mathematical literacy assessment.

(3) The magnitude of the relationship between *Grade Level* and mathematical literacy performance significantly varies from school to school in all three cultural settings. In other words, grade level influenced mathematical literacy performance more in some schools than in other schools across Turkey, member and candidate countries of European Union.

(4) *Disciplinary Climate in Mathematics Lessons* was found as a significant factor having a positive impact on mathematical literacy performance of the students in all three cultural settings. This result indicates that students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in mathematics lessons on the

mathematical literacy assessment in Turkey, member and candidate countries of European Union.

(5) The magnitude of the relationship between *Disciplinary Climate in Mathematics Lessons* and mathematical literacy performance significantly varies from school to school in all three cultures. In other words, disciplinary climate in mathematics lessons influenced mathematical literacy performance more in some schools than in other schools in Turkey, member and candidate countries of European Union.

(6) The *Socio-Economic and Cultural Status* was found as not statistically significant with respect to the relation with mathematical literacy measure in Turkey, member and candidate countries of European Union.

(7) The *Cultural Possessions of the Family* was found as not statistically significant with respect to the association with mathematical literacy measure in Turkey, member and candidate countries of European Union.

(8) *Home Educational Resources* was significantly and positively related to mathematical literacy performance in all three cultures. That is, students having more educational resources at their home performed higher than the students having fewer educational resources at home on the mathematical literacy assessment in Turkey, member and candidate countries of European Union.

(9) The *Attitudes towards School* was found as not statistically significant with respect to the impact on mathematical literacy performance in Turkey, member and candidate countries of European Union.

(10) The *Instrumental Motivation in Mathematics Lessons* was found as not statistically significant with respect to the relationship with the mathematical literacy performance in Turkey, member and candidate countries of European Union.

(11) The *Mathematics Self-Efficacy* was significantly and positively related to mathematical literacy measure in all three cultural settings. Students having higher levels of mathematics self-efficacy performed higher than students having lower levels of mathematics self-efficacy on the mathematical literacy assessment in Turkey, member and candidate countries of European Union.

(12) *Mathematics Anxiety* was significantly but negatively related to mathematical literacy in all three cultural settings. Thus, students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment in Turkey, member and candidate countries of European Union.

(13) *Mathematics Self-Concept* was significantly and positively related to mathematical literacy performance in all three cultures. In other words, students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment in Turkey, member and candidate countries of European Union.

(14) The *Memorisation Strategies* was found as significantly and negatively related to mathematical literacy performance in all three cultural settings. Students having more preferences for memorisation learning strategy performed lower on the mathematical literacy assessment in Turkey, member and candidate countries of European Union.

(15) The *Competitive Learning* was found as not statistically significant with respect to the relationship with the mathematical literacy performance in Turkey, member and candidate countries of European Union.

(16) The *Cooperative Learning* was found as not statistically significant with respect to the relationship with the mathematical literacy performance in Turkey, member and candidate countries of European Union.

(17) The *Average Mathematics Self-Efficacy* impacted the mathematical literacy performance of the schools in all three cultural settings. This positive impact indicates that mathematics self-efficacy is strongly associated with mathematical literacy performance in Turkey, member and candidate countries of European Union.

(18) The *School Type* was found as not statistically significant with respect to the relationship with the mathematical literacy performance in Turkey, member and candidate countries of European Union.

(19) The *Use of Assessments* was not statistically significant in terms of the relationship with the mathematical literacy performance in Turkey, member and candidate countries of European Union.

(20) The *Ability Grouping between Mathematics Classes* was found as not statistically significant with respect to the impact on mathematical literacy performance in Turkey, member and candidate countries of European Union.

(21) The *Mathematics Extension Courses* was found as not statistically significant in terms of the relationship with the mathematical literacy performance in Turkey, member and candidate countries of European Union.

(22) The *Resource Autonomy* was not statistically significant in terms of the relationship with the mathematical literacy performance in all models of Turkey, member and candidate countries of European Union.

(23) The *Curricular Autonomy* was not statistically significant in terms of the relationship with the mathematical literacy performance in all models of Turkey, member and candidate countries of European Union.

(24) The *Quality of School's Educational Resources* was not statistically significant with respect to the impact on the mathematical literacy measure in all models of Turkey, member and candidate countries of European Union.

(25) The *Teacher Shortage* was found as not statistically significant with respect to the impact on mathematical literacy performance in all models of Turkey, member and candidate countries of European Union.

(26) The *Student Morale and Commitment* was not statistically significant with respect to the relationship with the mathematical literacy measure in all models of Turkey, member and candidate countries of European Union.

(27) The *Teacher Morale and Commitment* was not statistically significantly related to the mathematical literacy performance in all models of Turkey, member and candidate countries of European Union.

(28) The *Teacher-Related Factors Affecting School Climate* was not statistically significant in terms of the association with the mathematical literacy performance in all models of Turkey, member and candidate countries of European Union.

5.3.2 Differences between Results of the Three Models

(1) The *Mathematics Self-Efficacy* slope was significantly related to mathematical literacy and randomly varying across schools in candidate countries of European Union besides the *Grade* and *Disciplinary Climate in Mathematics Lessons* slopes.

(2) The magnitude of the relationship between *Mathematics Self-Efficacy* and mathematical literacy performance significantly varies from school to school only in candidate countries of European Union. In other words, mathematics self-efficacy influenced mathematical literacy performance more in some schools than in other schools in candidate countries of European Union.

(3) The association between *Gender* of the students and mathematical literacy performance was found as significant and positive indicating that male students performed significantly higher than the female students on the mathematical literacy assessment in Turkey. On the contrary, the association between gender of the

students and mathematical literacy performance was found as not statistically significant in the member and candidate countries of European Union.

(4) *Highest Parental Occupational Status* was significantly and positively associated with the mathematical literacy measure in the member and candidate countries of European Union. That is, students who have parents with higher occupational status performed higher than the students having parents with lower occupational status on the mathematical literacy assessment in the member and candidate countries of European Union. On the other hand, the relationship between highest parental occupational status and mathematical literacy measure was not statistically significant in Turkey.

(5) *Highest Educational Level of Parents* had a significant but negative impact on student mathematics performance in candidate countries of European Union. In other words, students who have parents with higher educational level performed lower on the mathematical literacy assessment in the candidate countries of European Union. The impact of highest educational level of parents was found as not statistically significant both in Turkey and member countries of European Union.

(6) *Computer Facilities at Home* was significantly and positively related to the mathematical literacy measure in the member and candidate countries of European Union. That is, students having more computer facilities at their home performed higher than the students having fewer computer facilities at their home on the mathematical literacy assessment in the member and candidate countries of European Union. Nevertheless, the relationship between computer facilities at home and mathematical literacy measure was not statistically significant in Turkey.

(7) A negative association between *Student-Teacher Relations* and mathematical literacy was observed only in Turkey. Students having better student-teacher relations at school performed lower on the mathematical literacy assessment. This relationship between student-teacher relations at school and mathematical literacy performance was not statistically significant in the member and candidate countries of European Union.

(8) The relationship between *Sense of Belonging at School* and mathematical literacy measure was found as positive in Turkey. Students in Turkey having positive feelings about their school performed higher on the mathematical literacy assessment. On the contrary, a negative association between sense of belonging at school and mathematical literacy was observed in the member countries of European Union. Students in the member countries of European Union having positive feelings about their school performed lower on the mathematical literacy assessment. On the other hand, the impact of sense of belonging at school on mathematical literacy performance was not statistically significant in the candidate countries of European Union.

(9) *Interest in Mathematics* was negatively associated with the mathematical literacy measure in the member and candidate countries of European Union. Students having higher interest in mathematics performed lower on the mathematical literacy assessment. However, this relation between interest in mathematics and mathematical literacy performance was not statistically significant in Turkey.

(10) *Control Strategies* had a positive association with the mathematical literacy indicating students having more preferences for control strategies as learning strategy performed higher on the mathematical literacy assessment only in Turkey. On the other hand, the impact of mathematics self-concept on mathematical literacy performance was found as not statistically significant in member and candidate countries of European Union.

(11) *Elaboration Strategies* had a negative association with the mathematical literacy indicating students having more preferences for elaboration strategies as learning strategy performed lower on the mathematical literacy assessment in Turkey and member countries of European Union. Nevertheless, the relationship between elaboration strategies and mathematical literacy performance was not statistically significant in the candidate countries of European Union.

(12) *Teacher Support in Mathematics Lessons* was significantly but negatively related to mathematical literacy measure in the member and candidate countries of European Union. Thus, students having more support from their teachers in mathematics lessons performed lower than students having less support from their teachers in mathematics lessons on the mathematical literacy assessment in the member and candidate countries of European Union. However, this association was not statistically significant in Turkey.

(13) The *Disciplinary Climate in Mathematics Lessons – Mathematical Literacy* slope was the only coefficient included in the hierarchical linear model of Turkey that had two significant school level factors (cross-level interaction). However, none of the school level factors were significantly related to a student level slope, thus, there was no cross-level interaction in the hierarchical linear model of the member countries of European Union. On the other hand, the *Grade - Mathematical Literacy* slope and the *Mathematics Self-Efficacy - Mathematical Literacy* slope were two coefficients included in the hierarchical linear model of the candidate countries of European Union that each of the two coefficients had one significant school level factor (cross-level interaction).

(14) The first interaction in the model of Turkey provides observation that *School Size* is positively related to the *Disciplinary Climate in Mathematics Lessons*. In other words, disciplinary climate in mathematics lessons has more of an influence on mathematical literacy in schools with larger school size than in schools with smaller school size. The second interaction in the model of Turkey provides observation that *Mathematics Student-Teacher Ratio* is negatively related to the *Disciplinary Climate in Mathematics Lessons*. That is, disciplinary climate in mathematics lessons has more of an influence on mathematical literacy in schools with smaller mathematics student-teacher ratio than in schools with larger mathematics student-teacher ratio. Overall, these two cross-level interactions in the model of Turkey indicate that disciplinary climate in mathematics lessons has more of an impact on mathematical literacy skills of the students in schools with larger school size and with smaller mathematics student-teacher ratio than in schools with smaller school size and larger mathematics student-teacher ratio.

(15) The first interaction provides observation in the model of European Union candidate countries that *Academic Selectivity* is negatively related to the *Grade Level*. In other words, grade level of the students has more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity. The second interaction in the model of European Union Candidate Countries provides observation that *Academic Selectivity* is negatively related to the *Mathematics Self-Efficacy*. That is, mathematics self-efficacy levels of the students have more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity. Overall, these two cross-level interactions in the model of candidate countries of European Union indicate that both the grade level of the students and the students' mathematics self-efficacy levels have more of an influence on mathematical literacy in schools with lower academic selectivity than in schools with higher academic selectivity.

(16) A positive association between *School Size* and mathematical literacy was observed in the both models of Turkey and member countries of European Union. That is, the larger the school size, the higher the mean school mathematical literacy performance in Turkey and member countries of European Union. However, the impact of school size on mathematical literacy performance was not statistically significant in candidate countries of European Union.

(17) *Proportion of Females Enrolled at School* was positively related to mathematical literacy in the model of Turkey. The larger the proportion of females enrolled at school, the higher the mean school mathematical literacy performance in Turkey. On the other hand, the relationship between proportion of females enrolled at school and mathematical literacy was not statistically significant in the models of member and candidate countries of European Union.

(18) The *Total Student-Teacher Ratio* had negative impacts on mathematical literacy in the model of Turkey. Thus, the larger the total student-teacher ratio at school, the lower the mean school mathematical literacy performance in Turkey. On the other hand, the relationship between total student-teacher ratio and mathematical

literacy was not statistically significant in the models of member and candidate countries of European Union.

(19) The *Mathematics Student-Teacher Ratio* was significantly and negatively associated with mathematical literacy performance in the model of Turkey. In other words, the larger the mathematics student-teacher ratio at school, the lower the mean school mathematical literacy performance in Turkey. However, the impact of mathematics student-teacher ratio and mathematical literacy performance was found as not statistically significant in the models of member and candidate countries of European Union.

(20) *Academic Selectivity* was found as significantly and positively related to student performance in mathematics in the models of Turkey, and candidate countries of European Union. That is, in Turkey and candidate countries of European Union, schools having higher academic selectivity performed higher on the mathematical literacy assessment. On the other hand, this association between academic selectivity and mathematical literacy was not statistically significant in the model of member countries of European Union.

(21) *Mathematics Activities* was significantly but negatively associated with the mathematical literacy performance in the model of candidate countries of European Union. In other words, the more mathematics activities offered at school, the lower the mean school mathematical literacy performance in the candidate countries of European Union. However, the impact of mathematics activities on mathematical literacy measure was found as not statistically significant both in Turkey and member countries of European Union models.

(22) *Quality of School's Physical Infrastructure* was significantly and positively related to mathematical literacy in the model of Turkey. The mean school mathematical literacy performance was higher in schools where the quality of physical infrastructure is better in Turkey. On the other hand, the impact of quality of school's physical infrastructure on mathematical literacy measure was found as not

statistically significant in the models of member and candidate countries of European Union.

(23) *Student-Related Factors Affecting School Climate* was significantly and positively related to mathematical literacy performance in the model of European Union countries. The more positive evaluations of student-related factors affecting school climate, the higher the mean school mathematical literacy performance in the member countries of European Union. However, the association between student-related factors affecting school climate and mathematical literacy performance was not statistically significant both in the models of Turkey, and candidate countries of European Union.

5.4 Implications

Actually, schools need to provide appropriate and equitable opportunities for a diverse student body. The relative success with which they do this is an important criterion for judging the performance of education systems. Identifying the characteristics of poorly performing students and schools can also help educators and policy-makers determine priorities for policy. Similarly, identifying the characteristics of high performing students and schools can assist policy-makers in promoting high levels of overall performance.

As known, the results of the present study are associative in nature, but these results provide some suggestions for improving mathematics education in Turkey based on the results of the comparison with the member and candidate countries of European Union. Therefore, the implications of the present research in accordance with the conclusions which are indeed the suggestions identified as important were presented in this section of the dissertation.

(1) Grade level influenced mathematical literacy performance more in some schools than in other schools across Turkey, member and candidate countries of European Union. Therefore, the reasons for the differences among schools should be exained and necessary and appropriate arrangements and applications should be provided to set equitable opportunities among schools.

(2) Disciplinary climate in mathematics lessons influenced mathematical literacy performance more in some schools than in other schools in Turkey, member and candidate countries of European Union. Therefore, the reasons for the differences among schools should be examined and necessary and appropriate arrangements and applications should be provided to set equitable opportunities among schools.

(3) Students having more preferences for memorisation learning strategy performed lower on the mathematical literacy assessment in Turkey, member and candidate countries of European Union. Thus, preferences for memorisation strategies as a learning strategy should be avoided especially for the domain of mathematics education.

(4) Students who have more positive disciplinary climate in their mathematics lessons performed higher than the students who have more negative disciplinary climate in mathematics lessons on the mathematical literacy assessment in Turkey, member and candidate countries of European Union. Thus, disciplinary climate problems in classroom management courses should be emphasized in teacher education programs and in-service teacher training programs.

(5) Students having higher levels of mathematics self-efficacy performed higher than students having lower levels of mathematics self-efficacy on the mathematical literacy assessment in Turkey, member and candidate countries of European Union. That's why, efficacy - enhancing instructional strategies especially for mathematics education should be designed for students. Moreover, learning environment conducive to fostering mathematics self-efficacy in students should be created since mathematics self-efficacy is strongly associated with mathematical literacy performance in Turkey, member and candidate countries of European Union.

(6) Students having more educational resources at their home performed higher than the students having fewer educational resources at home on the mathematical literacy assessment in Turkey, member and candidate countries of European Union. An important objective for public policy may therefore be to support parents, particularly those whose own educational attainment is limited, in order to create

appropriate home environment for their children that enhance their children's learning.

(7) Students having higher levels of mathematics anxiety performed lower than the students having lower levels of mathematics anxiety on the mathematical literacy assessment in Turkey, member and candidate countries of European Union. Therefore, instructional strategies and learning environment conducive to reducing the mathematics anxiety levels of the students should be designed. Furthermore, mathematics anxiety reduction programs are strongly recommended throughout the country since students in Turkey reported feeling most concerned in the degree to which students feel anxiety when dealing with mathematics.

(8) Students having more positive self-concept in mathematics performed higher on the mathematical literacy assessment in Turkey, member and candidate countries of European Union. Thus, instructional strategies and learning environment conducive to fostering mathematics self-concept in students should be designed and created.

(9) Male students performed significantly higher than the female students on the mathematical literacy assessment in Turkey. Therefore, the reasons for the differences among male and female students should be examined and necessary and appropriate arrangements and applications should be provided to set equitable opportunities among genders.

(10) Students having better student-teacher relations at school performed lower on the mathematical literacy assessment in Turkey. To the extent that the teacher encouragement offered is effective, it could be expected that performance will be higher in classes that receive more support than in other classes. So, learning environment conducive to fostering student-teacher relations for all students with the regardless of less able students or more successful students should be designed and created.

(11) Students in Turkey having positive feelings about their school performed higher on the mathematical literacy assessment. Correspondingly, students' perceptions of belonging at school should be improved by the teachers and school administrators as well as parents.

(12) Students having more preferences for control strategies as learning strategy performed higher on the mathematical literacy assessment in Turkey. Therefore, preferences for control strategies as a learning strategy should be improved especially for the domain of mathematics education.

(13) Although the association between elaboration strategies and mathematical literacy performance was expected as positive on the basis of the previous literature, students having more preferences for elaboration strategies as learning strategy performed lower on the mathematical literacy assessment in Turkey and member countries of European Union. Actually, students' preferences about all learning situations should be improved by the efforts of the teachers.

(14) In Turkey, the two cross-level interactions indicate that disciplinary climate in mathematics lessons has more of an impact on mathematical literacy skills of the students in schools with larger school size and with smaller mathematics student-teacher ratio than in schools with smaller school size and larger mathematics student-teacher ratio. Thus, necessary and appropriate arrangements and applications should be provided to set equitable opportunities among schools.

(15) The larger the school size, the higher the mean school mathematical literacy performance in Turkey and member countries of European Union. Moreover, the larger the proportion of females enrolled at school, the higher the mean school mathematical literacy performance in Turkey. So, all these results should be considered by the school administrators, and policy makers as well as parents of the students.

(16) The larger the total student-teacher ratio and mathematics student-teacher ratio at school, the lower the mean school mathematical literacy performance in Turkey. Smaller classes are valued by parents and teachers because they may allow students to receive more individual attention from their teachers and reduce the disadvantage of managing large number of students and their work. However, the predominance of teacher costs in educational expenditure means that reducing class size leads to sharp increases in the costs of education. Therefore, these results should be considered by the school administrators, and policy makers as well as parents of the students.

(17) In Turkey and candidate countries of European Union, schools having higher academic selectivity performed higher on the mathematical literacy assessment. Although academic selectivity of the schools is appeared as an important issue, necessary and appropriate arrangements and applications should be provided to set equitable opportunities among the schools and the students.

(18) The mean school mathematical literacy performance was higher in schools where the quality of physical infrastructure is better in Turkey. Actually, the school principals in Turkey frequently reported that the quality of their school's physical infrastructure and their supply and quality of educational resources hindered learning. Thus, the physical infrastructure of the schools should be in the quality to set possibility for a good education and also additional educational resources should be provided to enhance the students' learning at the schools.

(19) Since the parents of the children are one of the key aspects of the students' learning and education, the awareness of the parents about the importance of their children's education should be ensured. The public policy should support parents, particularly those whose own educational attainment is limited, in order to facilitate their interactions both with their children and with their children's schools in ways that enhance their children's learning.

(20) The teachers also play an essential role in the students' learning and education. Therefore, pre-service and in-service teachers should be trained about the ways of improving the necessary skills of the students needed in their educations such as their self-efficacy levels, self-concept perceptions, learning strategies, and perceptions of belonging at school. Furthermore, teachers should encourage effective ways of learning including goal setting, strategy selection, and control and evaluation of the learning process.

5.5 Limitations of the Study

The present study aimed to gain a more complete understanding of 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 through PISA 2003 project. Since hierarchical linear modeling technique was used as a multilevel analysis technique, the present study is an associational in nature. Thus, this study does not give much information about the causes and effects of the relationships obtained.

The measurement of the variables used can be a limitation of the present study. Since the validity and reliability of the measurement were considered and provided in the PISA project, the students and the school principals answering the questionnaires could have given unreliable responses. If a variable is measured incorrectly, then the relationships with both mathematical literacy measure and the other variables are distorted and this distortion impacts the magnitude of the coefficients, standard errors, and hypothesis tests.

The next limitation can be stated as the lack of teacher data in PISA 2003 project. A great deal of variance was accounted for or reduced by the addition of student and school level variables based on the results of the study. However, a great deal of variance still exists in some cases. The teaching patterns and activities in a classroom could help to dictate a great deal of what is going on in the classroom, what is learned and understood by the students, etc. Therefore, how much of the unaccounted variance would have been absorbed by teacher level information is actually unknown.

The change in the degrees of freedom from the four research questions (from one and two to three and four) can be also a limitation of the study. The change in the degrees of freedom (i.e., from 158 to 128 in Turkey) reduces the validity of the results. Because the random variation in the first two research questions and the last two research questions were tested on different samples essentially.

Since applications of hierarchical linear modeling are fairly recent in educational research, little is known about the consequences of violating the assumptions (i.e., non-normality). As there were some variables having skewed distributions (having skewness and kurtosis values exceeding the range of ± 2), there is a possibility that the coefficients and standard errors were distorted.

Model specification is also another limitation of the study. It was not possible to examine bi-directional relationships as in the structural equation modeling due to the nature of the hierarchical linear modeling technique. Besides the bi-directional relationships (i.e., Ma's (1997) bi-directional relationship of attitude and achievement), interactions that have been observed in previous studies (i.e., motivation and control strategies) were not considered in the models of the study. Actually, the interactions and bi-directional relationships are important to examine because they provide information concerning how the variables relate and influence performance.

And lastly, the school level variables did not influence the vast majority of the student level factors. This was mainly due to the fact that most of the student level factors were observed to be not randomly varying and were fixed before the school level variables could be examined. This lack of random variation may be due to the small within school sample size.

5.6 Recommendations for Further Researchers

The present study aimed to gain a more complete understanding of 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 through PISA 2003 project. Since hierarchical linear modeling technique was used as a multilevel analysis technique, the present study is an associational in nature and it does not give much information about the causes and effects of the relationships obtained. Therefore, several observations need further investigation. Correspondingly, the recommendations for further researchers were presented in this section of the dissertation.

Two observations in Turkey were the varying influence among schools of grade level of the students and disciplinary climate in mathematics lessons. The next step appears to be trying to determine what factors may be influential in the variability among schools. Moreover, other data files of Turkey need to be examined to see if these two factors vary with the same sample or other samples.

More in-depth research is needed to examine the reasons of the relationships obtained in the present study. In Turkey, further studies should be conducted to explore the underlying reasons of the relationships between mathematical literacy performance and the included student level factors: grade level, gender of the students, home educational resources, student-teacher relation at school, sense of belonging at school, mathematics self-efficacy, mathematics anxiety, mathematics self-concept, control strategies, elaboration strategies, memorisation strategies, and disciplinary climate in mathematics lessons.

Especially, factors that may be influential in the relationships between mathematical literacy and the student level factors such as student-teacher relations at school, and elaboration strategies should be searched since the negative impacts of student-teacher relations at school and elaboration strategies on mathematical literacy performance were found as surprising.

Furthermore, further studies should be conducted in Turkey to investigate the underlying reasons of the relationships between mathematical literacy performance and the included school level factors: school size, proportion of females enrolled at school, total student-teacher ratio, mathematics student-teacher ratio, academic selectivity, and quality of school’s physical infrastructure.

There were also unexpected relationships obtained in the member and candidate countries of European Union. These surprising associations may also need further investigation: negative impact of highest educational level of parents on mathematical literacy performance, negative impact of sense of belonging at school on mathematical literacy performance, negative impact of interest in mathematics on mathematical literacy performance, negative impact of elaboration strategies on mathematical literacy performance, and negative impact of teacher support in mathematics lessons on mathematical literacy performance.

As previously stated, the present study used the student and school level variables and mathematical literacy as an outcome variable obtained from PISA 2003 project. It will be very useful and informative to conduct the same research on the repeating PISA projects such as the cycles of 2006, 2009 and 2012. Therefore, all the results of the present study will be tested again on the different samples selected from the participating countries and on the different variables included in these cycles of the PISA project. Thus, this replication study is able to give more precise and supportive conclusions about the associations of the student and school level factors with the mathematical literacy performance.

Several questions for future research studies are provided from the results of the present study. In the end, it is hoped that the present study and all the studies that will develop from it help to illuminate the human and physical resource allocations that influence the mathematical literacy.

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APPENDIX A

THE PARTICIPATING COUNTRIES IN PISA 2000 and 2003

A.1 Participating Countries in PISA 2000

OECD Countries Participating in PISA 2000	*Non-OECD Countries Participating in PISA 2000*	*Countries where the Assessment will be Completed in 2002*
Australia	Brazil	Albania
Austria	Latvia	Argentina
Belgium	Liechtenstein	Bulgaria
Canada	Russian Federation	Chile
Czech Republic		China
Denmark		Hong-Kong
Finland		Indonesia
France		Israel
Germany		Lithuania
Greece		Macedonia
Hungary		Peru
Iceland		Romania
Ireland		Thailand
Italy		
Japan		
Korea		
Luxembourg		
Mexico		
Netherlands		
New Zealand		
Norway		
Poland		
Portugal		
Spain		
Sweden		
Switzerland		
United Kingdom		
United States		

A.2 Participating Countries in PISA 2003

OECD Countries	*Partner Countriesin PISA 2003*	*Partner Countries in Other PISA Assessments*
Australia	Brazil	Albania
Austria	Hong-Kong	Argentina
Belgium	Indonesia	Azerbaijan
Canada	Latvia	Bulgaria
Czech Republic	Liechtenstein	Chile
Denmark	Macao-China	Colombia
Finland	Russian Federation	Crotia
France	Serbia and Montenegro	Estonia
Germany	Thailand	Israel
Greece	Tunisia	Jordan
Hungary	Uruguay	Kazakhstan
Iceland		Krygyz Republic
Ireland		Lithuania
Italy		Macedonia
Japan		Peru
Korea		Qatar
Luxembourg		Romania
Mexico		Slovenia
Netherlands		Chinese Taipei
New Zealand		
Norway		
Poland		
Portugal		
Slovak Republic		
Spain		
Sweden		
Switzerland		
Turkey		
United Kingdom		
United States		

APPENDIX B

SUMMARY OF THE ASSESSMENT AREAS IN PISA 2003 (OECD Publications, 2003, p. 15-17)

Table B.1.1 Summary of the Assessment Areas in PISA 2003

Assessment Area	***Mathematics***	***Reading***	***Science***	***Problem Solving***
Definition and its distintive features	The capacity to identify and understand the role that mathematics plays in the world, to make well-founded judgements and to use and engage with mathematics in ways that meet the needs of that individual's life as a constructive, concerned and reflective citizen.	The capacity to understand, use and reflect on written texts, in order to achieve one's goals, to develop one's knowledge and potential and to participate in society.	The capacity to use scientific knowledge, to identify questions and to draw evidence-based conclusions in order to understand and help make decisions about the natural world and the changes made to it through human activity.	The capacity to use cognitive processes to confront and resolve real, cross-disciplinary situations where the solution path is not immediately obvious and where the literacy domains or curricular areas that might be applicable are not within a single domain of mathematics, science and reading.
Content dimension	Clusters of relevant mathematical areas and concepts: ♣ Quantity; ♣ Space and shape; ♣ Change and relationships; and ♣ Uncertainty.	The form of reading materials: ♣ Continuous materials including different kinds of prose such as narration, exposition and argumentation; and ♣ Non-continuous texts including graphs, forms and lists.	Areas of scientific knowledge and concepts: ♣ Biodiversity; ♣ Forces and movement; and ♣ Physiological change.	The problem type covering the problem solving processes: ♣ Including decision making, system analysis and design; ♣ Trouble shooting applied in specific problem context, usually distinct from the classroom setting or school's curricula; and ♣ Involving personal life, work and leisure, and community and society.

SUMMARY OF THE ASSESSMENT AREAS IN PISA 2003 (Continued)

Table B.1.1 Summary of the Assessment Areas in PISA 2003 (Continued)

Assessment Area	***Mathematics***	***Reading***	***Science***	***Problem Solving***
Process dimension	"Competency clusters" define skills needed for mathematics: ♣ Reproduction (simple mathematical operations); ♣ Connections (bringing together ideas to solve straightforward problems); and ♣ Reflection (wider mathematical thinking)	Type of reading task or process: ♣ Retrieving information; ♣ Interpreting texts; and ♣ Reflection and evaluation of texts.	The ability to use scientific knowledge and understanding, to acquire, interpret and act on evidence: ♣ Describing, explaining and predicting scientific phenomena; ♣ Understanding scientific investigation; and ♣ Interpreting scientific evidence and conclusions.	The problem solving processes which involve: ♣ Understanding the nature of the problem; ♣ Characterising it; ♣ Representing it; ♣ Solving it; ♣ Reflecting on it; and ♣ Communicating its results.
Situation dimension	Situations vary according to their distance from individuals' lives. In order of closeness: ♣ Personal; ♣ Educational and occupational; ♣ Local and broader community; and ♣ Scientific.	The use for which the text constructed: ♣ Private (e.g., personal letter); ♣ Public (e.g., an official document); ♣ Occupational (e.g., a report); and ♣ Educational (e.g., school related reading).	The context of science, focusing on uses in relation to: ♣ Life and health; ♣ The Earth and the environment; and ♣ Technology.	The situations or problem context constructed from: ♣ Students's real life setting in which the problem types will be applied.

APPENDIX C

EXAMPLES OF THE QUESTIONS IN THE MATHEMATICAL LITERACY ASSESSMENT IN PISA 2003

C.1 Mathematics Unit 8 – Reaction Time

(OECD Publications, 2003, p. 75, 76)

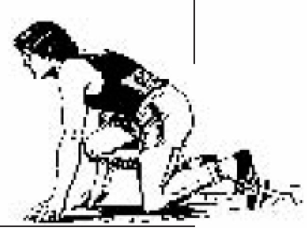
Mathematics Unit 8

REACTION TIME

In a sprinting event, the "reaction time" is the time interval between the starter's gun firing and the athlete leaving the starting block. The "final time" includes both this reaction time, and the running time.

The following table gives the reaction time and the final time of 8 runners in a 100 metre sprint race.

Lane	Reaction time (sec)	Final time (sec)
1	0.147	10.09
2	0.136	9.99
3	0.197	9.87
4	0.180	Did not finish the race
5	0.210	10.17
6	0.216	10.04
7	0.174	10.08
8	0.193	10.13



Mathematics Example 8.1

Identify the Gold, Silver and Bronze medallists from this race. Fill in the table below with the medallists' lane number, reaction time and final time.

Medal	*Lane*	*Reaction time (sec)*	*Final time (sec)*
Gold			
Silver			
Bronze			

Scoring and comments on Mathematics Example 8.1

Full Credit

Code 1:

Medal	***Lane***	***Reaction time (sec)***	***Final time (sec)***
Gold	3	0.197	9.87
Silver	2	0.136	9.99
Bronze	6	0.216	10.04

No Credit

Code 0: Other answers.

Item type: *Open constructed-response*
Competency cluster: *Reproduction*
Overarching idea: *Quantity*
Situation: *Scientific*

Mathematics Example 8.2

To date, no humans have been able to react to a starter's gun in less than 0.110 second.

If the recorded reaction time for a runner is less than 0.110 second, then a false start is considered to have occurred because the runner must have left before hearing the gun.

If the Bronze medallist had a faster reaction time, would he have had a chance to win the Silver medal? Give an explanation to support your answer.

Scoring and comments on Mathematics Example 8.2

Full Credit

Code 1: Answers which specify "yes", with an adequate explanation. For example:

- Yes. If he had a reaction time 0.05 sec faster, he would have equalled second place.
- Yes, he would have a chance to win the Silver medal if his reaction time were less than or equal to 0.166 sec.
- Yes, with the fastest possible reaction time he would have done a 9.93, which is good enough for the Silver medal.

No Credit

Code 0: Other answers, including answers which specify "yes" without an adequate explanation.

Item type: *Open constructed-response*

Competency cluster: *Connections*

Overarching idea: *Quantity*

Situation: *Scientific*

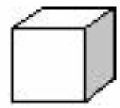
C.2 Mathematics Unit 9 – Building Blocks

(OECD Publications, 2003, p. 78 - 81)

Mathematics Unit 9

BUILDING BLOCKS

Susan likes to build blocks from small cubes like the one shown in the following diagram:



Small cube

Susan has lots of small cubes like this one. She uses glue to join cubes together to make other blocks.

First, Susan glues eight of the cubes together to make the block shown in Diagram A:

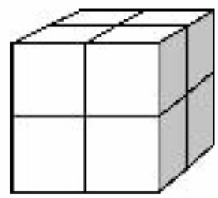


Diagram A

Then Susan makes the solid blocks shown in Diagram B and Diagram C below:

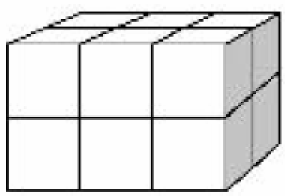


Diagram B

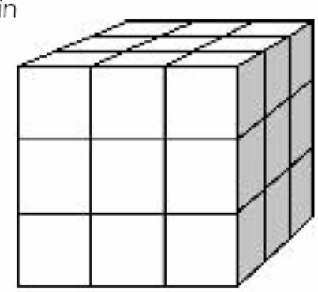


Diagram C

Mathematics Example 9.1

How many small cubes will Susan need to make the block shown in Diagram B?

Answer: ______________________ cubes.

Scoring and comments on Mathematics Example 9.1

Full Credit

Code 1: Answers which specify 12 cubes.

No Credit

Code 0: Other answers.

Item type: *Open constructed-response*
Competency cluster: *Reproduction*
Overarching idea: *Space and shape*
Situation: *Personal*

Mathematics Example 9.2

How many small cubes will Susan need to make the solid block shown in Diagram C?

Answer: ______________________ cubes.

Scoring and comments on Mathematics Example 9.2

Full Credit

Code 1: Answers which specify 27 cubes.

No Credit

Code 0: Other answers.

Item type: *Open constructed-response*
Competency cluster: *Reproduction*
Overarching idea: *Space and shape*
Situation: *Personal*

Mathematics Example 9.3

Susan realises that she used more small cubes than she really needed to make a block like the one shown in Diagram C. She realises that she could have glued small cubes together to look like Diagram C, but the block could have been hollow on the inside.

What is the minimum number of cubes she needs to make a block that looks like the one shown in Diagram C, but is hollow?

Answer: ______________________ cubes.

Scoring and comments on Mathematics Example 9.3

Full Credit

Code 1: Answers which specify 26 cubes.

No Credit

Code 0: Other answers.

Item type: *Open constructed-response*
Competency cluster: *Connections*
Overarching idea: *Space and shape*
Situation: *Personal*

Mathematics Example 9.4

Now Susan wants to make a block that looks like a solid block that is 6 small cubes long, 5 small cubes wide and 4 small cubes high. She wants to use the smallest number of cubes possible, by leaving the largest possible hollow space inside the block.

What is the minimum number of cubes Susan will need to make this block?

Answer: ______________________ cubes.

Scoring and comments on Mathematics Example 9.4

Full Credit

Code 1: Answers which specify 96 cubes.

No Credit

Code 0: Other answers.

Item type: *Open-Constructed Response*
Competency cluster: *Reflection*
Overarching idea: *Space and shape*
Situation: *Personal*

C.3 Mathematics Unit 10 – Drug Concentration

(OECD Publications, 2003, p. 82 - 84)

Mathematics Unit 10

DRUG CONCENTRATIONS

Mathematics Example 10.1

A woman in hospital receives an injection of penicillin. Her body gradually breaks the penicillin down so that one hour after the injection only 60% of the penicillin will remain active.

This pattern continues: at the end of each hour only 60% of the penicillin that was present at the end of the previous hour remains active.

Suppose the woman is given a dose of 300 milligrams of penicillin at 8 o'clock in the morning.

Complete this table showing the amount of penicillin that will remain active in the woman's blood at intervals of one hour from 0800 until 1100 hours.

Time	0800	0900	1000	1100
Penicillin (mg)	300			

Scoring and comments on Mathematics Example 10.1

Full Credit

Code 2: Answers which include all three correct table entries, such as:

Time	0800	0900	1000	1100
Penicillin (mg)	300	180	108	64.8 or 65

Partial Credit

Code 1: Answers which include one or two correct table entries.

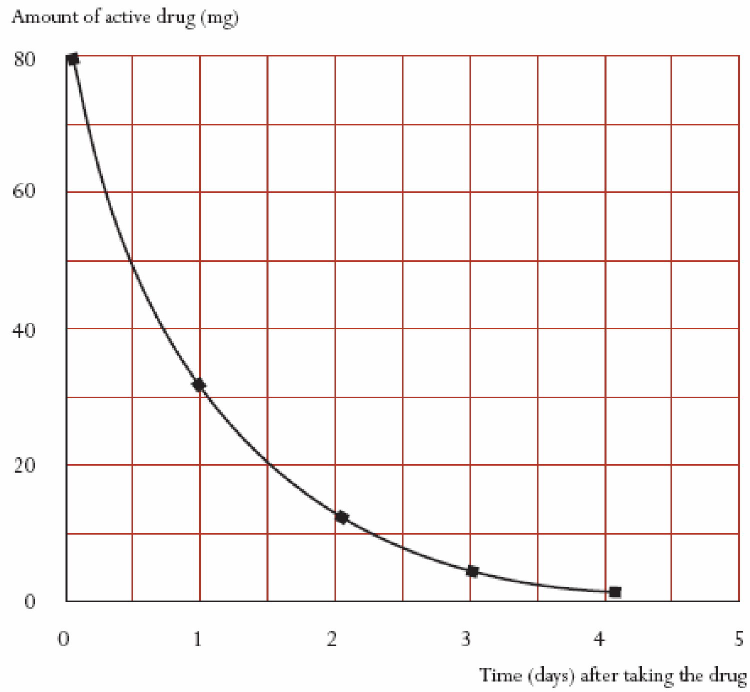
No Credit

Code 0: Other answers.

Item type: *Open constructed-response*
Competency cluster: *Connections*
Overarching idea: *Change and relationships*
Situation: *Scientific*

Mathematics Example 10.2

Peter has to take 80 mg of a drug to control his blood pressure. The following graph shows the initial amount of the drug, and the amount that remains active in Peter's blood after one, two, three and four days.



How much of the drug remains active at the end of the first day?

A. 6 mg.

B. 12 mg.

C. 26 mg.

D. 32 mg.

Scoring and comments on Mathematics Example 10.2

Full Credit

Code 1: Response D: 32 mg.

No Credit

Code 0: Other responses.

Item type: *Multiple-choice*
Competency cluster: *Reproduction*
Overarching idea: *Change and relationships*
Situation: *Scientific*

Mathematics Example 10.3

From the graph for the previous question it can be seen that each day, about the same proportion of the previous day's drug remains active in Peter's blood.

At the end of each day which of the following is the approximate percentage of the previous day's drug that remains active?

A. 20%.

B. 30%.

C. 40%.

D. 80%.

Scoring and comments on Mathematics Example 10.3

Full Credit

Code 1: Response C: 40%.

No Credit

Code 0: Other responses.

Item type: *Multiple-choice*
Competency cluster: *Connections*
Overarching idea: *Change and relationships*
Situation: *Scientific*

APPENDIX D

D.1 SCALE RELIABILITIES FOR TURKEY, MEMBER AND CANDIDATE COUNTRIES OF EUROPEAN UNION (OECD Publications, 2005, p. 410)

Table D.1.1 Scale Reliabilities for Turkey, Member and Candidate Countries of European Union

	Combined	Quantity	Space and Shape	Change and Relationship	Uncertainty
Turkey	0.91	0.86	0.89	0.89	0.89
Member Countries of European Union					
Austria	0.92	0.83	0.91	0.89	0.89
Belgium	0.93	0.86	0.91	0.90	0.91
Denmark	0.90	0.84	0.89	0.90	0.85
Finland	0.89	0.81	0.86	0.87	0.86
Germany	0.93	0.87	0.91	0.91	0.91
Greece	0.89	0.84	0.87	0.86	0.86
Ireland	0.91	0.83	0.90	0.90	0.88
Italy	0.91	0.86	0.90	0.90	0.89
Luxembourg	0.90	0.82	0.89	0.90	0.88
Netherlands	0.93	0.88	0.92	0.92	0.90
Portugal	0.90	0.84	0.88	0.89	0.88
Spain	0.89	0.83	0.87	0.88	0.87
Sweden	0.90	0.85	0.89	0.89	0.88
United Kingdom	0.92	0.85	0.91	0.91	0.88
Candidate Countries of European Union					
Czech Republic	0.91	0.83	0.88	0.89	0.88
Hungary	0.90	0.84	0.87	0.90	0.88
Poland	0.90	0.84	0.88	0.89	0.88
Slovak Republic	0.91	0.84	0.89	0.89	0.88
Latvia	0.89	0.85	0.88	0.90	0.87

D.2 ESTIMATES FOR INTER-CODER RELIABILITY FOR TURKEY, MEMBER AND CANDIDATE COUNTRIES OF EUROPEAN UNION (OECD Publications, 2005, p. 223)

Table D.2.1 Estimates for Inter-Coder Reliability for Turkey, Member and Candidate Countries of European Union

	I = 8 & M = 1		I = 16 & M = 1		I = 24 & M = 1	
	ρ_3	ρ_4	ρ_3	ρ_4	ρ_3	ρ_4
Turkey	0.998	0.715	0.999	0.834	1.000	0.883
Member Countries of European Union						
Austria	0.980	0.758	0.988	0.862	0.992	0.904
Belgium	0.979	0.758	0.988	0.862	0.991	0.903
Denmark	0.948	0.634	0.974	0.781	0.985	0.845
Finland	0.987	0.684	0.992	0.812	0.994	0.866
Germany	0.970	0.753	0.981	0.857	0.985	0.899
Greece	0.962	0.720	0.977	0.836	0.983	0.884
Ireland	0.950	0.689	0.970	0.816	0.978	0.869
Italy	0.976	0.713	0.985	0.832	0.989	0.881
Luxembourg	0.975	0.724	0.983	0.838	0.987	0.885
Netherlands	0.960	0.728	0.976	0.843	0.983	0.894
Portugal	0.993	0.704	0.995	0.826	0.996	0.876
Spain	0.959	0.700	0.975	0.822	0.981	0.873
Sweden	0.969	0.757	0.981	0.861	0.986	0.902
United Kingdom	0.980	0.739	0.987	0.849	0.991	0.893
Candidate Countries of European Union						
Czech Republic	0.979	0.772	0.988	0.871	0.992	0.910
Hungary	0.967	0.727	0.979	0.840	0.984	0.886
Poland	0.988	0.760	0.993	0.863	0.995	0.904
Slovak Republic	0.971	0.732	0.981	0.843	0.985	0.888
Latvia	0.936	0.710	0.951	0.821	0.957	0.866

*I: number of items & M: number of coders

APPENDIX E

DISTRIBUTION OF ITEMS BY THE DIMENSIONS OF THE PISA FRAMEWORK FOR THE ASSESSMENT OF MATHEMATICS (OECD Publications, 2004, p. 334)

Table E.1.1 Distribution of Items by the Dimensions of the Framework for the Assessment of Mathematics

	Number of Items	***Number of Multiple Choice Items***	***Number of Complex Multiple Choice Items***	***Number of Closed Constructed Response Items***	***Number of Open Constructed Response Items***	***Number of Short Response Items***
Distribution of mathematics items by "overarching ideas"						
Space and Shape	20	4	4	6	4	2
Change and Relationships	22	1	2	4	11	4
Quantity	23	4	2	2	1	14
Uncertainty	20	8	3	1	5	3
Total	85	17	11	13	21	23
Distribution of mathematics items by competency cluster						
Reproduction	26	7	0	7	3	9
Connection	40	5	9	4	9	13
Reflection	19	5	2	2	9	1
Total	85	17	11	13	21	23

DISTRIBUTION OF ITEMS BY THE DIMENSIONS OF THE PISA FRAMEWORK FOR THE ASSESSMENT OF MATHEMATICS (Continued)

Table E.1.1 Distribution of Items by the Dimensions of the Framework for the Assessment of Mathematics (Continued)

	Number of Items	***Number of Multiple Choice Items***	***Number of Complex Multiple Choice Items***	***Number of Closed Constructed Response Items***	***Number of Open Constructed Response Items***	***Number of Short Response Items***
Distribution of mathematics items by situations or contexts						
Personal	18	5	3	1	3	6
Educational / Occupational	20	2	4	6	2	6
Public	29	8	2	4	8	7
Scientific	18	2	2	2	8	4
Total	85	17	11	13	21	23

APPENDIX F

DESCRIPTIVE STATISTICS FOR STUDENT AND SCHOOL LEVEL VARIABLES FOR TURKEY

F.1 Descriptive Statistics for Student Level Variables for Turkey

Table F.1.1 Distribution of Grade of the Students in Turkey

	Frequency	*Percent (%)*
7^{th} Grade	27	0.6
8^{th} Grade	92	1.9
9^{th} Grade	191	3.9
10^{th} Grade	2 863	59.0
11^{th} Grade	1 670	34.4
12^{th} Grade	12	0.2
Total	4 855	100.0

Table F.1.2 Distribution of Gender of the Students in Turkey

	Frequency	*Percent (%)*
Female	2 090	43.0
Male	2 765	57.0
Total	4855	100.0

Table F.1.3 Descriptive Statistics of the Student Background Variables for Turkey

	Highest Parental Occupational Status	*Highest Educational Level of Parents*	*Socio-Economic and Cultural Status*	*Computer Facilities at Home*	*Cultural Possessions of the Family*	*Home Educational Resources*
Mean	41.900	2.840	-0.961	-1.199	-0.105	-0.370
Median	45.000	2.000	-1.070	-1.676	-0.309	-0.624
Mode	49.000	1.000	-1.382	-1.676	-1.276	0.677
Standard Deviation	15.333	1.868	1.076	0.856	0.938	1.205
Variance	235.103	3.489	1.158	0.733	0.881	1.451
Minimum	16.000	0.000	-4.565	-1.676	-1.276	-4.299
Maximum	88.000	6.000	2.220	1.051	1.347	0.677
Skewness	0.462	0.359	0.403	1.615	0.035	-0.982
Kurtosis	-0.210	-1.232	-0.122	1.255	0.070	0.424

Table F.1.4 Descriptive Statistics of the School Climate Variables for Turkey

	Attitudes towards School	*Student-Teacher Relations at School*	*Sense of Belonging at School*
Mean	0.148	0.163	-0.434
Median	0.202	-0.152	-0.638
Mode	0.202	0.381	-0.924
Standard Deviation	1.069	1.100	0.875
Variance	1.143	1.210	0.766
Minimum	-3.145	-0.090	-3.383
Maximum	2.526	2.855	2.218
Skewness	0.429	0.357	0.517
Kurtosis	-0.018	-0.066	0.138

Table F.1.5 Descriptive Statistics of the Self-Related Cognitions in Mathematics Variables for Turkey

	Interest in Mathematics	*Instrumental Motivation in Mathematics*	*Mathematics Self-Efficacy*	*Mathematics Anxiety*	*Mathematics Self-Concept*
Mean	0.558	0.232	-0.166	0.339	0.018
Median	0.643	0.098	-0.273	0.404	-0.033
Mode	0.973	0.098	-0.109	0.658	-0.511
Standard Deviation	1.059	0.975	1.059	1.020	0.981
Variance	1.121	0.951	1.122	1.040	0.963
Minimum	-1.783	-2.378	-3.890	-2.478	-2.122
Maximum	2.373	1.745	2.531	2.697	2.416
Skewness	-0.234	-0.266	0.078	-0.232	0.196
Kurtosis	-0.410	-0.322	1.710	0.672	-0.025

Table F.1.6 Descriptive Statistics of the Learning and Instruction Variables for Turkey

	Control Strategies	*Elaboration Strategies*	*Memorisation Strategies*	*Competitive Learning*	*Cooperative Learning*
Mean	0.277	0.446	0.101	0.683	0.332
Median	0.073	0.500	-0.080	0.615	0.439
Mode	0.073	0.841	-0.121	0.615	0.439
Standard Deviation	1.163	1.092	0.985	0.991	1.126
Variance	1.353	1.193	0.970	0.982	1.267
Minimum	-3.478	-3.262	-3.483	-2.844	-3.134
Maximum	2.711	3.263	3.292	2.450	2.742
Skewness	-0.005	-0.181	-0.298	0.036	-0.043
Kurtosis	0.558	1.685	2.674	0.072	0.633

Table F.1.7 Descriptive Statistics of the Classroom Climate Variables for Turkey

	Teacher Support in Mathematics Lessons	*Disciplinary Climate in Mathematics Lessons*
Mean	0.402	-0.087
Median	0.368	0.063
Mode	2.100	0.079
Standard Deviation	1.023	0.925
Variance	1.046	0.856
Minimum	-2.920	-2.738
Maximum	2.100	2.353
Skewness	-0.093	0.088
Kurtosis	0.005	0.769

F.2 Descriptive Statistics for School Level Variables for Turkey

Table F.2.1 Descriptive Statistics of the Control Variable for Turkey

	Average Mathematics Self-Efficacy
Mean	-0.198
Median	-0.272
Mode	-1.286
Standard Deviation	0.506
Variance	0.256
Minimum	-1.286
Maximum	2.080
Skewness	1.778
Kurtosis	5.290

Table F.2.2 Distribution of School Type for Turkey

	Frequency	*Percent (%)*
Public	154	96.6
Private	5	3.1
Total	159	100.0

Table F.2.3 Descriptive Statistics of the School Characteristics Variables for Turkey

	School Size	*Proportion of Females Enrolled at School*
Mean	1 081.080	0.422
Median	854.000	0.448
Mode	1 081.000	0.442
Standard Deviation	809.347	0.193
Variance	655 042.969	0.037
Minimum	30.000	0.000
Maximum	4 541.000	1.000
Skewness	1.217	0.056
Kurtosis	1.987	1.371

Table F.2.4

Descriptive Statistics of the Indicators of School Resources Variables for Turkey

	Total Student-Teacher Ratio	*Mathematics Student-Teacher Ratio*
Mean	21.699	175.484
Median	21.699	169.333
Mode	21.699	175.483
Standard Deviation	11.370	93.108
Variance	129.285	8 669.035
Minimum	1.667	30.000
Maximum	70.000	623.500
Skewness	1.606	2.034
Kurtosis	3.702	5.930

Table F.2.5 Distribution of Use of Assessments for Turkey

	Frequency	*Percent (%)*
Less than 20	113	71.1
Between 20 and 39	37	23.3
More than 40	9	5.7
Total	159	100.0

Table F.2.6 Distribution of Academic Selectivity for Turkey

	Frequency	*Percent (%)*
Not Considered	64	40.3
At Least One Considered	69	43.4
At Least One High Priority	8	5.0
At Least One Prerequisite	18	11.3
Total	159	100.0

Table F.2.7

Distribution of Ability Grouping between Mathematics Classes for Turkey

	Frequency	*Percent (%)*
Not for All Classes	33	20.8
For Some Classes	62	39.0
For All Classes	64	40.3
Total	159	100.0

Table F.2.8 Distribution of Mathematics Extension Courses for Turkey

	Frequency	*Percent (%)*
0	55	34.6
1	53	33.3
2	51	32.1
Total	159	100.0

Table F.2.9 Distribution of Mathematics Activities for Turkey

	Frequency	*Percent (%)*
0	106	66.7
1	45	28.3
2	1	0.6
3	7	4.4
Total	159	100.0

Table F.2.10 Distribution of Resource Autonomy for Turkey

	Frequency	*Percent (%)*
0	49	30.8
1	33	20.8
2	66	41.5
3	3	1.9
5	1	0.6
6	7	4.4
Total	159	100.0

Table F.2.11 Distribution of Curricular Autonomy for Turkey

	Frequency	*Percent (%)*
0	3	1.9
1	10	6.3
2	64	40.3
3	45	28.3
4	37	23.3
Total	159	100.0

Table F.2.12 Descriptive Statistics of the School Resources Variables for Turkey

	Teacher Shortage	*Quality of school's Physical Infrastructure*	*Quality of School's Educational Resources*
Mean	1.735	-1.078	-1.333
Median	1.521	-1.124	-1.393
Mode	3.193	-2.310	-1.833
Standard Deviation	1.020	1.005	0.955
Variance	1.040	1.009	0.911
Minimum	-1.203	-2.310	-3.226
Maximum	3.193	1.488	2.200
Skewness	-0.206	0.279	0.279
Kurtosis	-0.301	-0.746	0.608

Table F.2.13 Descriptive Statistics of the School Climate Variables for Turkey

	Student Morale and Commitment	*Teacher Morale and Commitment*	*Student-Related Factors Affecting School Climate*	*Teacher-Related Factors Affecting School Climate*
Mean	-0.252	-0.464	-0.395	-0.887
Median	-0.532	-0.571	-0.200	-0.861
Mode	-0.532	-0.571	0.390	-0.624
Standard Deviation	1.205	1.219	1.452	1.252
Variance	1.452	1.485	2.107	1.568
Minimum	-2.766	-2.809	-3.611	-4.208
Maximum	2.588	1.650	2.613	2.489
Skewness	0.205	-0.001	-0.236	0.429
Kurtosis	-0.444	-0.636	-0.603	0.663

APPENDIX G

DESCRIPTIVE STATISTICS FOR STUDENT AND SCHOOL LEVEL VARIABLES FOR EUROPEAN UNION COUNTRIES

G.1 Descriptive Statistics for Student Level Variables for European Union Countries

Table G.1.1 Distribution of Grade of the Students in European Union Countries

	Frequency	*Percent (%)*
7th Grade	32	0.6
8th Grade	264	5.1
9th Grade	2 058	40.1
10th Grade	2 199	42.9
11th Grade	392	7.6
12th Grade	184	3.6
Total	5 129	100.0

Table G.1.2 Distribution of Gender of the Students in European Union Countries

	Frequency	*Percent (%)*
Female	2 531	49.3
Male	2 597	50.6
Missing	1	0.1
Total	5 129	100.0

Table G.1.3 Descriptive Statistics of the Student Background Variables for European Union Countries

	Highest Parental Occupational Status	*Highest Educational Level of Parents*	*Socio-Economic and Cultural Status*	*Computer Facilities at Home*	*Cultural Possessions of the Family*	*Home Educational Resources*
Mean	49.417	4.251	0.199	0.015	0.128	0.106
Median	50.000	4.000	0.081	-0.309	0.677	0.131
Mode	51.000	6.000	1.051	-1.276	0.677	1.503
Standard Deviation	16.723	1.604	0.869	1.019	0.890	0.987
Variance	279.659	2.571	0.754	1.038	0.810	0.975
Minimum	16.000	0.000	-1.676	-1.276	-4.299	-3.397
Maximum	90.000	6.000	1.051	1.347	0.677	2.579
Skewness	0.261	-0.784	-0.799	0.032	-1.773	-0.312
Kurtosis	-0.632	-0.118	-0.236	-1.418	3.540	-0.129

Table G.1.4 Descriptive Statistics of the School Climate Variables for European Union Countries

	Attitudes towards School	*Student-Teacher Relations at School*	*Sense of Belonging at School*
Mean	-0.006	-0.094	0.099
Median	-0.281	-0.152	0.089
Mode	-0.281	0.381	0.489
Standard Deviation	0.988	0.983	0.986
Variance	0.975	0.966	0.972
Minimum	-3.145	-3.090	-3.383
Maximum	2.526	2.855	2.218
Skewness	0.467	0.182	0.222
Kurtosis	0.324	0.718	-0.220

Table G.1.5 Descriptive Statistics of the Self-Related Cognitions in Mathematics Variables for European Union Countries

	Interest in Mathematics	*Instrumental Motivation in Mathematics*	*Mathematics Self-Efficacy*	*Mathematics Anxiety*	*Mathematics Self-Concept*
Mean	-0.097	-0.141	0.028	-0.063	0.015
Median	0.029	0.098	-0.109	0.127	-0.033
Mode	-0.319	0.098	-0.109	0.127	0.488
Standard Deviation	0.980	0.997	0.940	1.002	0.990
Variance	0.960	0.994	0.883	1.004	0.979
Minimum	-1.783	-2.378	-3.890	-2.478	-2.122
Maximum	2.373	1.745	2.531	2.697	2.416
Skewness	0.061	0.008	0.426	-0.273	0.021
Kurtosis	0.034	-0.307	1.536	0.451	-0.076

Table G.1.6 Descriptive Statistics of the Learning and Instruction Variables for European Union Countries

	Control Strategies	*Elaboration Strategies*	*Memorisation Strategies*	*Competitive Learning*	*Cooperative Learning*
Mean	0.010	-0.117	-0.036	-0.108	-0.017
Median	0.073	-0.173	-0.121	-0.152	0.061
Mode	0.073	-0.511	-0.121	-0.812	0.439
Standard Deviation	0.985	0.972	0.968	0.983	0.987
Variance	0.970	0.944	0.937	0.966	0.973
Minimum	-3.478	-3.262	-3.483	-2.844	-3.134
Maximum	2.711	3.263	3.292	2.450	2.742
Skewness	0.181	-0.117	-0.242	-0.066	0.003
Kurtosis	1.342	1.707	2.379	0.892	1.293

Table G.1.7 Descriptive Statistics of the Classroom Climate Variables for European Union Countries

	Teacher Support in Mathematics Lessons	*Disciplinary Climate in Mathematics Lessons*
Mean	-0.121	0.014
Median	-0.092	0.079
Mode	0.131	0.079
Standard Deviation	1.052	1.048
Variance	1.107	1.098
Minimum	-2.920	-2.738
Maximum	2.100	2.353
Skewness	-0.171	0.067
Kurtosis	0.393	0.138

G.2 Descriptive Statistics for School Level Variables for European Union Countries

Table G.2.1 Descriptive Statistics of the Control Variable for European Union Countries

	Average Mathematics Self-Efficacy
Mean	0.009
Median	-0.034
Mode	-1.522
Standard Deviation	0.415
Variance	0.172
Minimum	-1.522
Maximum	1.452
Skewness	0.109
Kurtosis	1.391

Table G.2.2 Distribution of School Type for European Union Countries

	Frequency	*Percent (%)*
Public	143	75.7
Private	46	24.3
Total	189	100.0

Table G.2.3 Descriptive Statistics of the School Characteristics Variables for European Union Countries

	School Size	*Proportion of Females Enrolled at School*
Mean	683.136	0.487
Median	600.000	0.490
Mode	683.136	0.487
Standard Deviation	446.516	0.183
Variance	199 376.583	0.033
Minimum	54.000	0.000
Maximum	2 428.000	1.000
Skewness	1.392	-0.150
Kurtosis	2.657	2.715

Table G.2.4 Descriptive Statistics of the Indicators of School Resources Variables for European Union Countries

	Total Student-Teacher Ratio	*Mathematics Student-Teacher Ratio*
Mean	12.282	94.626
Median	11.895	84.778
Mode	12.282	94.626
Standard Deviation	4.581	58.205
Variance	20.989	3 387.765
Minimum	3.606	14.500
Maximum	41.745	416.000
Skewness	1.878	2.151
Kurtosis	9.178	7.022

Table G.2.5 Distribution of Use of Assessments for European Union Countries

	Frequency	*Percent (%)*
Less than 20	35	18.5
Between 20 and 39	115	60.8
More than 40	39	20.6
Total	189	100.0

Table G.2.6 Distribution of Academic Selectivity for European Union Countries

	Frequency	*Percent (%)*
Not Considered	91	48.1
At Least One Considered	54	28.6
At Least One High Priority	16	8.5
At Least One Prerequisite	28	14.8
Total	189	100.0

Table G.2.7 Distribution of Ability Grouping between Mathematics Classes for European Union Countries

	Frequency	*Percent (%)*
Not for All Classes	58	30.7
For Some Classes	66	34.9
For All Classes	65	34.4
Total	189	100.0

Table G.2.8 Distribution of Mathematics Extension Courses for European Union Countries

	Frequency	*Percent (%)*
0	23	12.2
1	105	55.6
2	61	32.3
Total	189	100.0

Table G.2.9 Distribution of Mathematics Activities for European Union Countries

	Frequency	*Percent (%)*
0	73	38.6
1	75	39.7
2	25	13.2
3	16	8.5
Total	189	100.0

Table G.2.10 Distribution of Resource Autonomy for European Union Countries

	Frequency	*Percent (%)*
0	3	1.6
1	49	25.9
2	40	21.2
3	11	5.8
4	45	23.8
5	13	6.9
6	28	14.8
Total	189	100.0

Table G.2.11 Distribution of Curricular Autonomy for European Union Countries

	Frequency	*Percent (%)*
0	13	6.9
1	7	3.7
2	25	13.2
3	37	19.6
4	107	56.6
Total	189	100.0

Table G.2.12 Descriptive Statistics of the School Resources Variables for European Union Countries

	Teacher Shortage	*Quality of school's Physical Infrastructure*	*Quality of School's Educational Resources*
Mean	-0.177	0.032	0.141
Median	-0.175	0.032	0.101
Mode	-1.203	1.488	0.265
Standard Deviation	0.979	0.981	0.977
Variance	0.959	0.963	0.955
Minimum	-1.203	-2.310	-3.226
Maximum	3.193	1.488	2.200
Skewness	0.890	-0.306	-0.187
Kurtosis	0.671	-0.170	1.036

Table G.2.13

Descriptive Statistics of the School Climate Variables for European Union Countries

	Student Morale and Commitment	*Teacher Morale and Commitment*	*Student-Related Factors Affecting School Climate*	*Teacher-Related Factors Affecting School Climate*
Mean	0.053	-0.051	0.170	0.104
Median	0.019	-0.571	0.090	0.104
Mode	0.019	-0.571	-0.480	-0.135
Standard Deviation	0.935	0.970	1.019	0.999
Variance	0.875	0.941	1.038	0.997
Minimum	-2.766	-2.179	-2.871	-3.425
Maximum	2.588	1.650	2.613	2.489
Skewness	-0.061	0.174	0.280	0.171
Kurtosis	0.257	-0.613	0.473	1.216

APPENDIX H

DESCRIPTIVE STATISTICS FOR STUDENT AND SCHOOL LEVEL VARIABLES FOR EUROPEAN UNION CANDIDATE COUNTRIES

H.1 Descriptive Statistics for Student Level Variables for European Union Candidate Countries

Table H.1.1

Distribution of Grade of the Students in European Union Candidate Countries

	Frequency	*Percent (%)*
7th Grade	32	0.7
8th Grade	228	5.2
9th Grade	2 830	64.0
10th Grade	1 299	29.4
11th Grade	18	0.4
Missing	12	0.3
Total	4 419	100.0

Table H.1.2

Distribution of Gender of the Students in European Union Candidate Countries

	Frequency	*Percent (%)*
Female	2 225	50.4
Male	2 194	49.6
Total	4 419	100.0

Table H.1.3 Descriptive Statistics of the Student Background Variables for European Union Candidate Countries

	Highest Parental Occupational Status	*Highest Educational Level of Parents*	*Socio-Economic and Cultural Status*	*Computer Facilities at Home*	*Cultural Possessions of the Family*	*Home Educational Resources*
Mean	49.580	4.407	0.051	-0.510	0.342	0.169
Median	50.000	4.000	-0.016	-0.747	0.380	0.677
Mode	51.000	4.000	-0.348	-1.676	1.347	0.677
Standard Deviation	15.513	1.148	0.836	1.062	0.913	0.882
Variance	240.664	1.317	0.700	1.129	0.834	0.778
Minimum	16.000	0.000	-3.691	-1.676	-1.276	-4.299
Maximum	90.000	6.000	2.343	1.051	1.347	0.677
Skewness	0.349	-0.050	0.098	0.229	-0.439	-1.909
Kurtosis	-0.365	-0.282	-0.081	-1.425	-0.941	4.087

Table H.1.4 Descriptive Statistics of the School Climate Variables for European Union Candidate Countries

	Attitudes towards School	*Student-Teacher Relations at School*	*Sense of Belonging at School*
Mean	-0.020	-0.171	-0.183
Median	-0.281	-0.152	-0.290
Mode	-0.281	0.381	-0.638
Standard Deviation	0.900	0.894	0.866
Variance	0.810	0.799	0.749
Minimum	-3.145	-3.090	-2.844
Maximum	2.526	2.855	2.218
Skewness	0.428	0.352	0.558
Kurtosis	0.527	1.168	0.165

Table H.1.5 Descriptive Statistics of the Self-Related Cognitions in Mathematics Variables for European Union Candidate Countries

	Interest in Mathematics	*Instrumental Motivation in Mathematics*	*Mathematics Self-Efficacy*	*Mathematics Anxiety*	*Mathematics Self-Concept*
Mean	-0.024	-0.013	0.188	0.020	-0.065
Median	0.029	0.098	0.063	0.127	-0.033
Mode	-0.319	0.098	-0.109	0.127	-0.511
Standard Deviation	0.847	0.845	0.958	0.869	0.869
Variance	0.718	0.714	0.918	0.754	0.755
Minimum	-1.783	-2.378	-3.890	-2.478	-2.122
Maximum	2.373	1.745	2.531	2.697	2.416
Skewness	0.060	0.063	0.585	-0.282	0.140
Kurtosis	0.129	0.224	0.752	1.218	0.459

Table H.1.6 Descriptive Statistics of the Learning and Instruction Variables for European Union Candidate Countries

	Control Strategies	*Elaboration Strategies*	*Memorisation Strategies*	*Competitive Learning*	*Cooperative Learning*
Mean	-0.017	0.177	0.028	-0.060	0.038
Median	0.073	0.163	-0.121	-0.152	0.061
Mode	0.073	0.163	-0.121	-0.453	0.439
Standard Deviation	0.825	0.779	0.832	0.818	0.809
Variance	0.681	0.607	0.691	0.669	0.655
Minimum	-3.478	-3.262	-3.483	-2.844	-3.134
Maximum	2.711	3.263	3.292	2.450	2.742
Skewness	0.570	0.351	0.046	0.145	0.352
Kurtosis	1.514	2.382	2.507	1.499	2.069

Table H.1.7 Descriptive Statistics of the Classroom Climate Variables for European Union Candidate Countries

	Teacher Support in Mathematics Lessons	*Disciplinary Climate in Mathematics Lessons*
Mean	-0.092	0.096
Median	-0.092	0.079
Mode	0.131	0.079
Standard Deviation	0.921	0.986
Variance	0.848	0.972
Minimum	-2.920	-2.738
Maximum	2.100	2.353
Skewness	-0.055	0.058
Kurtosis	0.545	0.217

H.2 Descriptive Statistics for School Level Variables for European Union Candidate Countries

Table H.2.1 Descriptive Statistics of the Control Variable for European Union Candidate Countries

	Average Mathematics Self-Efficacy
Mean	0.137
Median	0.058
Mode	-0.432
Standard Deviation	0.493
Variance	0.244
Minimum	-1.971
Maximum	1.913
Skewness	0.197
Kurtosis	2.438

Table H.2.2 Distribution of School Type for European Union Candidate Countries

	Frequency	*Percent (%)*
Public	170	91.9
Private	15	8.1
Total	185	100.0

Table H.2.3 Descriptive Statistics of the School Characteristics Variables for European Union Candidate Countries

	School Size	*Proportion of Females Enrolled at School*
Mean	515.237	0.494
Median	499.000	0.502
Mode	512.469	0.595
Standard Deviation	263.089	0.142
Variance	69 215.842	0.020
Minimum	25.000	0.000
Maximum	1 517.000	0.949
Skewness	0.739	-1.010
Kurtosis	0.688	3.979

Table H.2.4 Descriptive Statistics of the Indicators of School Resources Variables for European Union Candidate Countries

	Total Student-Teacher Ratio	*Mathematics Student-Teacher Ratio*
Mean	13.520	118.035
Median	13.652	117.411
Mode	13.895	117.411
Standard Deviation	3.510	46.127
Variance	12.323	2 127.732
Minimum	1.563	7.143
Maximum	21.750	299.333
Skewness	-0.384	0.799
Kurtosis	0.812	1.677

Table H.2.5

Distribution of Use of Assessments for European Union Candidate Countries

	Frequency	*Percent (%)*
Less than 20	35	18.9
Between 20 and 39	116	62.7
More than 40	34	18.4
Total	185	100.0

Table H.2.6

Distribution of Academic Selectivity for European Union Candidate Countries

	Frequency	*Percent (%)*
Not Considered	56	30.3
At Least One Considered	62	33.5
At Least One High Priority	18	9.7
At Least One Prerequisite	49	26.5
Total	185	100.0

Table H.2.7 Distribution of Ability Grouping between Mathematics Classes for European Union Candidate Countries

	Frequency	*Percent (%)*
Not for All Classes	55	29.7
For Some Classes	70	37.8
For All Classes	60	32.4
Total	185	100.0

Table H.2.8 Distribution of Mathematics Extension Courses for European Union Candidate Countries

	Frequency	*Percent (%)*
0	11	5.9
1	53	28.6
2	121	65.4
Total	185	100.0

Table H.2.9

Distribution of Mathematics Activities for European Union Candidate Countries

	Frequency	*Percent (%)*
0	10	5.4
1	79	42.7
2	72	38.9
3	24	13.0
Total	185	100.0

Table H.2.10

Distribution of Resource Autonomy for European Union Candidate Countries

	Frequency	*Percent (%)*
0	1	0.5
2	6	3.2
3	29	15.7
4	54	29.2
5	18	9.7
6	77	41.6
Total	185	100.0

Table H.2.11

Distribution of Curricular Autonomy for European Union Candidate Countries

	Frequency	*Percent (%)*
1	6	3.2
2	30	16.2
3	37	20.0
4	112	60.5
Total	185	100.0

Table H.2.12 Descriptive Statistics of the School Resources Variables for European Union Candidate Countries

	Teacher Shortage	*Quality of school's Physical Infrastructure*	*Quality of School's Educational Resources*
Mean	-0.129	0.083	-0.381
Median	-0.175	0.146	-0.370
Mode	-0.516	0.446	-0.853
Standard Deviation	0.738	0.844	0.901
Variance	0.544	0.713	0.813
Minimum	-1.203	-2.310	-3.226
Maximum	3.193	1.488	2.200
Skewness	0.787	-0.268	0.065
Kurtosis	2.387	0.040	0.786

Table H.2.13 Descriptive Statistics of the School Climate Variables for European Union Candidate Countries

	Student Morale and Commitment	*Teacher Morale and Commitment*	*Student-Related Factors Affecting School Climate*	*Teacher-Related Factors Affecting School Climate*
Mean	-0.370	0.038	0.184	0.318
Median	0.019	0.244	0.197	0.372
Mode	0.019	-0.571	0.090	0.116
Standard Deviation	0.827	0.815	0.930	0.916
Variance	0.684	0.664	0.866	0.838
Minimum	-2.766	-1.775	-3.611	-2.704
Maximum	1.355	1.650	2.613	2.489
Skewness	-0.123	-0.292	-0.679	-0.138
Kurtosis	-0.696	-0.535	1.735	0.804

APPENDIX K

DISTRIBUTION OF GRADE AND GENDER OF THE STUDENTS WITH RESPECT TO EACH COUNTRY AS THE MEMBER AND CANDIDATE COUNTRIES OF EUROPEAN UNION

K.1 MEMBER COUNTRIES OF EUROPEAN UNION

K.1.1 Distribution of Selected Students for Each Country

Table K.1.1

Distribution of Selected Students for Each Country in the European Union

	Frequency	*Percent (%)*
Austria	19	10.1
Belgium	23	12.2
Denmark	9	4.8
Finland	9	4.8
Germany	15	7.9
Greece	9	4.8
Ireland	9	4.8
Italy	22	11.6
Luxembourg	4	2.1
Netherlands	6	3.2
Portugal	7	3.7
Spain	23	12.2
Sweden	11	5.8
United Kingdom	23	12.2
Total	189	100.0

K.1.2 Distribution of Grade and Gender of the Students for Austria

Table K.1.2.1 Distribution of Grade of the Students in Austria

	Frequency	*Percent (%)*
8^{th} Grade	5	1.0
9^{th} Grade	255	52.1
10^{th} Grade	229	46.8
Total	489	100.0

Table K.1.2.2 Distribution of Gender of the Students in Austria

	Frequency	*Percent (%)*
Female	212	43.4
Male	277	56.6
Total	489	100.0

K.1.3 Distribution of Grade and Gender of the Students for Belgium

Table K.1.3.1 Distribution of Grade of the Students in Belgium

	Frequency	*Percent (%)*
8^{th} Grade	18	2.5
9^{th} Grade	248	35.0
10^{th} Grade	441	62.2
11^{th} Grade	2	0.3
Total	709	100.0

Table K.1.3.2 Distribution of Gender of the Students in Belgium

	Frequency	*Percent (%)*
Female	294	41.5
Male	415	58.5
Total	709	100.0

K.1.4 Distribution of Grade and Gender of the Students for Denmark

Table K.1.4.1 Distribution of Grade of the Students in Denmark

	Frequency	*Percent (%)*
8th Grade	15	9.9
9th Grade	131	86.2
10th Grade	6	3.9
Total	152	100.0

Table K.1.4.2 Distribution of Gender of the Students in Denmark

	Frequency	*Percent (%)*
Female	72	47.4
Male	80	52.6
Total	152	100.0

K.1.5 Distribution of Grade and Gender of the Students for Finland

Table K.1.5.1 Distribution of Grade of the Students in Finland

	Frequency	*Percent (%)*
8th Grade	27	11.2
9th Grade	214	88.8
Total	241	100.0

Table K.1.5.2 Distribution of Gender of the Students in Finland

	Frequency	*Percent (%)*
Female	125	51.9
Male	116	48.1
Total	241	100.0

K.1.6 Distribution of Grade and Gender of the Students for Germany

Table K.1.6.1 Distribution of Grade of the Students in Germany

	Frequency	*Percent (%)*
7th Grade	8	2.4
8th Grade	36	10.9
9th Grade	200	60.8
10th Grade	84	25.5
11th Grade	1	0.3
Total	329	100.0

Table K.1.6.2 Distribution of Gender of the Students in Germany

	Frequency	*Percent (%)*
Female	173	52.6
Male	155	47.1
Missing	1	0.3
Total	329	100.0

K.1.7 Distribution of Grade and Gender of the Students for Greece

Table K.1.7.1 Distribution of Grade of the Students in Greece

	Frequency	*Percent (%)*
7th Grade	2	2.7
8th Grade	8	10.8
9th Grade	37	50.0
10th Grade	23	31.1
11th Grade	4	5.4
Total	74	100.0

Table K.1.7.2 Distribution of Gender of the Students in Greece

	Frequency	*Percent (%)*
Female	32	43.2
Male	42	56.8
Total	74	100.0

K.1.8 Distribution of Grade and Gender of the Students for Ireland

Table K.1.8.1 Distribution of Grade of the Students in Ireland

	Frequency	*Percent (%)*
8th Grade	2	0.9
9th Grade	142	60.7
10th Grade	55	23.5
11th Grade	35	15.0
Total	234	100.0

Table K.1.8.2 Distribution of Gender of the Students in Ireland

	Frequency	*Percent (%)*
Female	132	56.4
Male	102	43.6
Total	234	100.0

K.1.9 Distribution of Grade and Gender of the Students for Italy

Table K.1.9.1 Distribution of Grade of the Students in Italy

	Frequency	*Percent (%)*
7th Grade	1	0.2
8th Grade	2	0.3
9th Grade	44	7.0
10th Grade	562	89.5
11th Grade	19	3.0
Total	628	100.0

Table K.1.9.2 Distribution of Gender of the Students in Italy

	Frequency	*Percent (%)*
Female	326	51.9
Male	302	48.1
Total	628	100.0

K.1.10 Distribution of Grade and Gender of the Students for Luxembourg

Table K.1.10.1 Distribution of Grade of the Students in Luxembourg

	Frequency	*Percent (%)*
8th Grade	95	21.7
9th Grade	247	56.5
10th Grade	95	21.7
Total	437	100.0

Table K.1.10.2 Distribution of Gender of the Students in Luxembourg

	Frequency	*Percent (%)*
Female	209	47.8
Male	228	52.2
Total	437	100.0

K.1.11 Distribution of Grade and Gender of the Students for Netherlands

Table K.1.11.1 Distribution of Grade of the Students in Netherlands

	Frequency	*Percent (%)*
8th Grade	8	4.9
9th Grade	47	28.8
10th Grade	108	66.3
Total	163	100.0

Table K.1.11.2 Distribution of Gender of the Students in Netherlands

	Frequency	*Percent (%)*
Female	83	50.9
Male	80	49.1
Total	163	100.0

K.1.12 Distribution of Grade and Gender of the Students for Portugal

Table K.1.12.1 Distribution of Grade of the Students in Portugal

	Frequency	*Percent (%)*
7th Grade	21	11.4
8th Grade	26	14.1
9th Grade	67	36.2
10th Grade	71	38.4
Total	185	100.0

Table K.1.12.2 Distribution of Gender of the Students in Portugal

	Frequency	*Percent (%)*
Female	104	56.2
Male	81	43.8
Total	185	100.0

K.1.13 Distribution of Grade and Gender of the Students for Spain

Table K.1.13.1 Distribution of Grade of the Students in Spain

	Frequency	*Percent (%)*
8th Grade	14	2.2
9th Grade	152	23.3
10th Grade	485	74.5
Total	651	100.0

Table K.1.13.2 Distribution of Gender of the Students in Spain

	Frequency	*Percent (%)*
Female	335	51.5
Male	316	48.5
Total	651	100.0

K.1.14 Distribution of Grade and Gender of the Students for Sweden

Table K.1.14.1 Distribution of Grade of the Students in Sweden

	Frequency	*Percent (%)*
8th Grade	8	2.8
9th Grade	274	97.2
Total	282	100.0

Table K.1.14.2 Distribution of Gender of the Students in Sweden

	Frequency	*Percent (%)*
Female	136	48.2
Male	146	51.8
Total	282	100.0

K.1.15 Distribution of Grade and Gender of the Students for United Kingdom

Table K.1.15.1 Distribution of Grade of the Students in United Kingdom

	Frequency	*Percent (%)*
10th Grade	40	7.2
11th Grade	331	59.6
12th Grade	184	33.2
Total	555	100.0

Table K.1.15.2 Distribution of Gender of the Students in United Kingdom

	Frequency	*Percent (%)*
Female	298	53.7
Male	257	46.3
Total	555	100.0

K.2 CANDIDATE COUNTRIES OF EUROPEAN UNION

K.2.1 Distribution of Selected Students for Each Country

Table K.2.1 Distribution of Selected Students for Each Candidate Country in the European Union

	Frequency	*Percent (%)*
Czech Republic	1 058	23.9
Hungary	711	16.1
Latvia	867	19.6
Poland	782	17.7
Slovakia	1 001	22.7
Total	4 419	100.0

K.2.2 Distribution of Grade and Gender of the Students for Czech Republic

Table K.2.2.1 Distribution of Grade of the Students in Czech Republic

	Frequency	*Percent (%)*
7th Grade	1	0.1
8^{th} Grade	19	1.8
9^{th} Grade	464	43.9
10^{th} Grade	574	54.3
Total	1 058	100.0

Table K.2.2.2 Distribution of Gender of the Students in Czech Republic

	Frequency	*Percent (%)*
Female	525	49.6
Male	533	50.4
Total	1 058	100.0

K.2.3 Distribution of Grade and Gender of the Students for Hungary

Table K.2.3.1 Distribution of Grade of the Students in Hungary

	Frequency	*Percent (%)*
7th Grade	14	2.0
8th Grade	46	6.5
9th Grade	464	65.3
10th Grade	187	26.3
Total	711	100.0

Table K.2.3.2 Distribution of Gender of the Students in Hungary

	Frequency	*Percent (%)*
Female	366	51.5
Male	345	48.5
Total	711	100.0

K.2.4 Distribution of Grade and Gender of the Students for Latvia

Table K.2.4.1 Distribution of Grade of the Students in Latvia

	Frequency	*Percent (%)*
7th Grade	8	0.9
8th Grade	122	14.1
9th Grade	677	78.1
10th Grade	47	5.4
11th Grade	1	0.1
Missing	12	1.4
Total	867	100.0

Table K.2.4.2 Distribution of Gender of the Students in Latvia

	Frequency	*Percent (%)*
Female	449	51.8
Male	418	48.2
Total	867	100.0

K.2.5 Distribution of Grade and Gender of the Students for Poland

Table K.2.5.1 Distribution of Grade of the Students in Poland

	Frequency	*Percent (%)*
7th Grade	4	0.5
8th Grade	19	2.4
9th Grade	756	96.7
10th Grade	3	0.4
Total	782	100.0

Table K.2.5.2 Distribution of Gender of the Students in Poland

	Frequency	*Percent (%)*
Female	408	52.2
Male	374	47.8
Total	782	100.0

K.2.6 Distribution of Grade and Gender of the Students for Slovakia

Table K.2.6.1 Distribution of Grade of the Students in Slovakia

	Frequency	*Percent (%)*
7th Grade	5	0.5
8th Grade	22	2.2
9th Grade	469	46.9
10th Grade	488	48.8
11th Grade	17	1.7
Total	1 001	100.0

Table K.2.6.2 Distribution of Gender of the Students in Slovakia

	Frequency	*Percent (%)*
Female	477	47.7
Male	524	52.3
Total	1 001	100.0

APPENDIX L

HIERARCHICAL LINEAR MODELING ASSUMPTIONS
NORMALITY ASSUMPTION

L.1 Assumption Tests for Turkey

L.1.1 The Homogeneity of Variance Assumption

The homogeneity of variance was tested using the H statistic which analyzes the assumption of equal variance across schools. The H statistic was not significant (χ^2 = 140.77, df = 127, p-value = 0.191) indicating that the variances across schools were equal to each other.

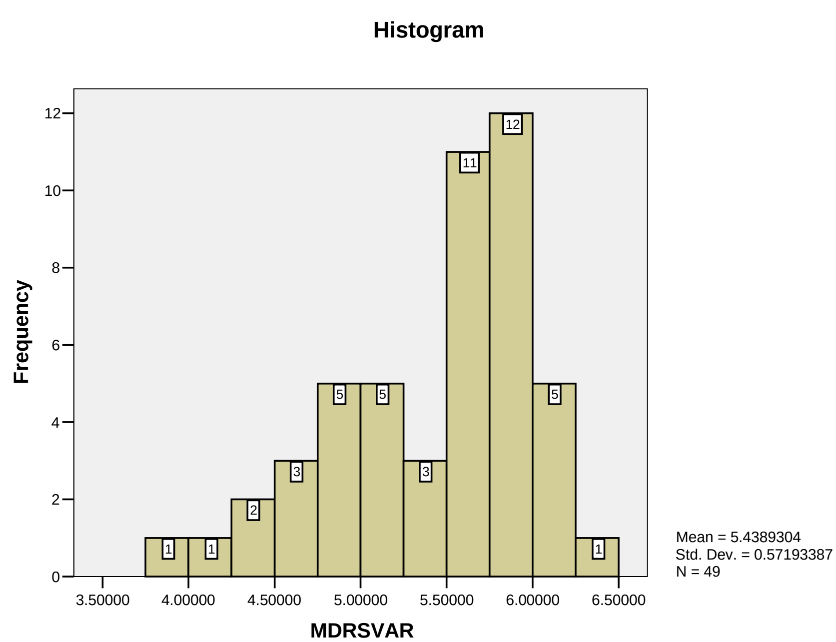


Figure L.1 Histogram of MDRSVAR for Turkey

L.1.2 Normality Assumption of Random Coefficients

Plots of the three random coefficients empirical bayes estimates (*Grade, Memorisation Strategies*, and *Disciplinary Climate in Mathematics Lessons)* were found to be normally distributed.

Table L.1 Skewness and Kurtosis Values of the EB Estimates of Random Coeffficients for Turkey

	EBGRADE	EBMEMOR	EBCLIMATE
Skewness	0.009	0.303	0.072
Kurtosis	0.648	-0.121	-0.137

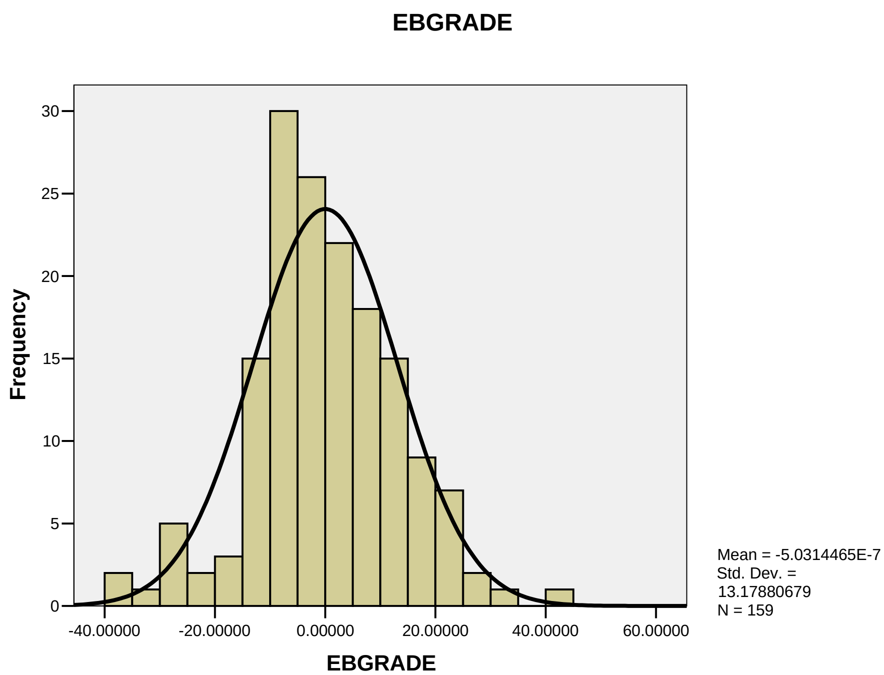


Figure L.2 Histogram of Grade EB Estimates for Turkey

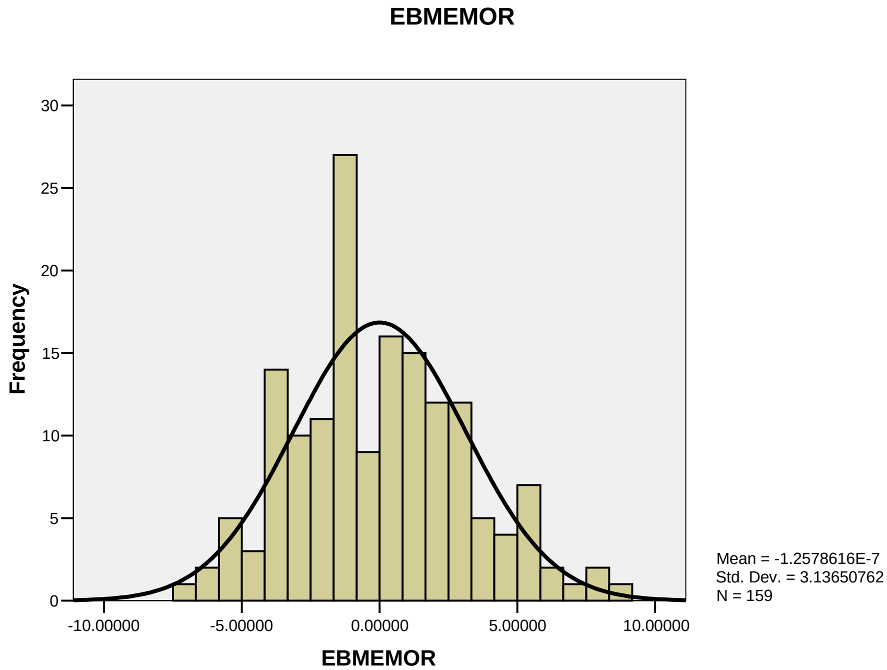


Figure L.3 Histogram of Memorisation Strategies EB Estimates for Turkey

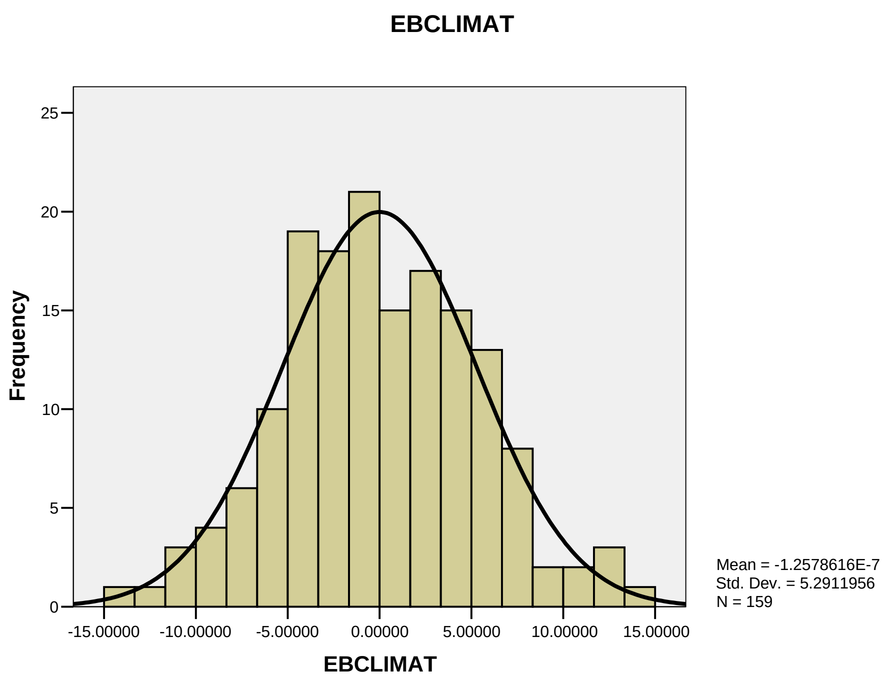


Figure L.4 Histogram of Disciplinary Climate in Mathematics Lessons EB Estimates for Turkey

L.1.3 Normality Assumption for School Level Residuals

For the normality assumption, the units in the residual file were used. In the residual file, there were variables CHIPCT and MDIST. If q level-1 coefficients were modeled, MDIST would be the Mahalanobis distance (i.e., the standardized squared distance of a unit from the center of a v-dimensional distribution, where v is the number of random effects per unit). Essentially, MDIST provides a single, summary measure of the distance of a unit's EB estimates, B^*_{qj}, from its "fitted value", $\hat{\gamma}_{q0}$ + $\sum \hat{\gamma}_{qs} W_{sj}$. CHPICT are expected values of the order statistics for a sample of size J selected from a population that is distributed $\chi^2(v)$. If the normality assumption is true, then the Mahalanobis distances should be distributed approximately $\chi^2(v)$. Analogous to univariate normal probability plotting, a Q-Q plot of MDIST versus CHIPCT can be constructed. If the Q-Q plot resembles a 45 degree line, it means that there is an evidence that the random effects are distributed v-variate normal. In addition, the plot will help to detect outlying units (i.e., units with large MDIST values well above the 45 degree line). In fact, it should be noted that such plots are good diagnostic tools only when the level-1 sample sizes are at least moderately large (Raudenbush, Bryk, Cheong, & Congdon, 2001, p. 44).

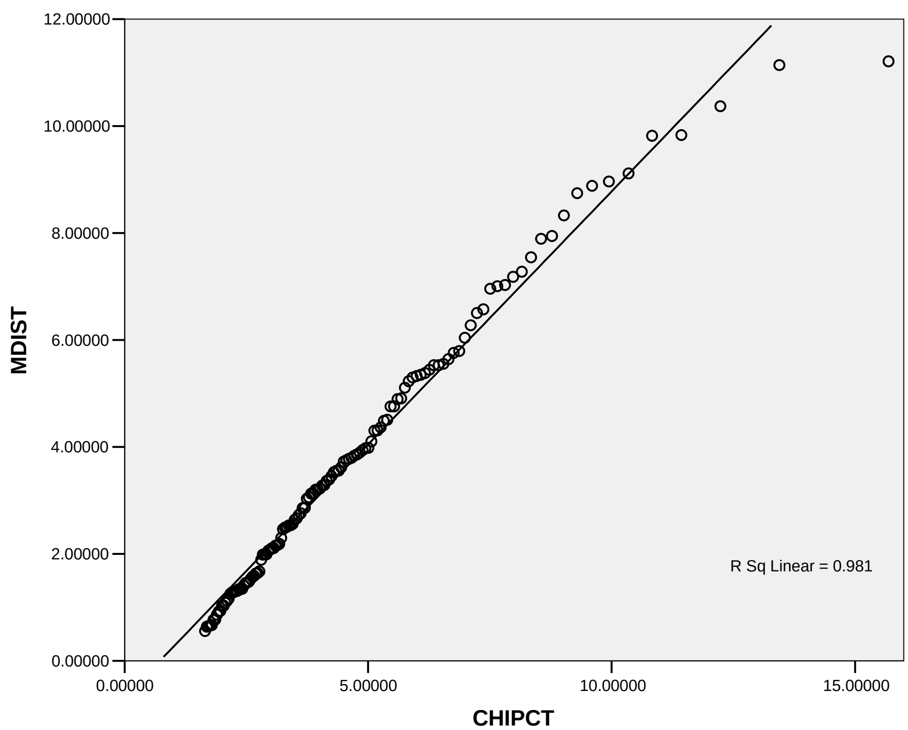


Figure L.5 Plot of MDIST versus CHIPCT for Turkey

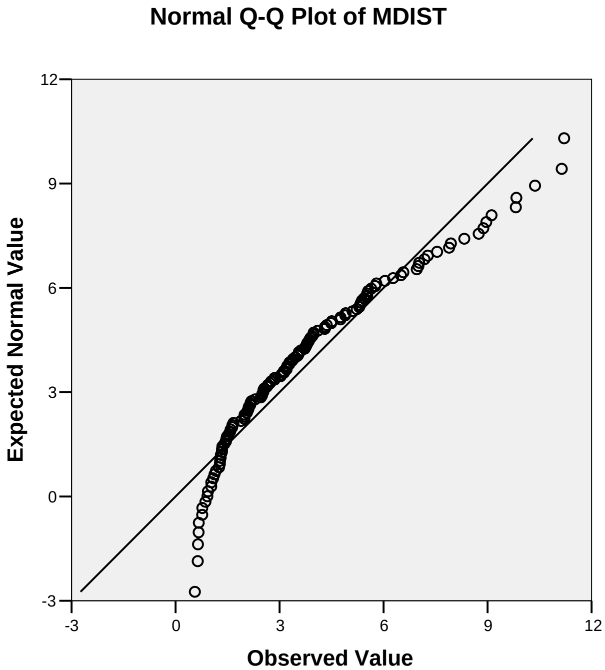


Figure L.6 Q-Q Plot of MDIST for Turkey

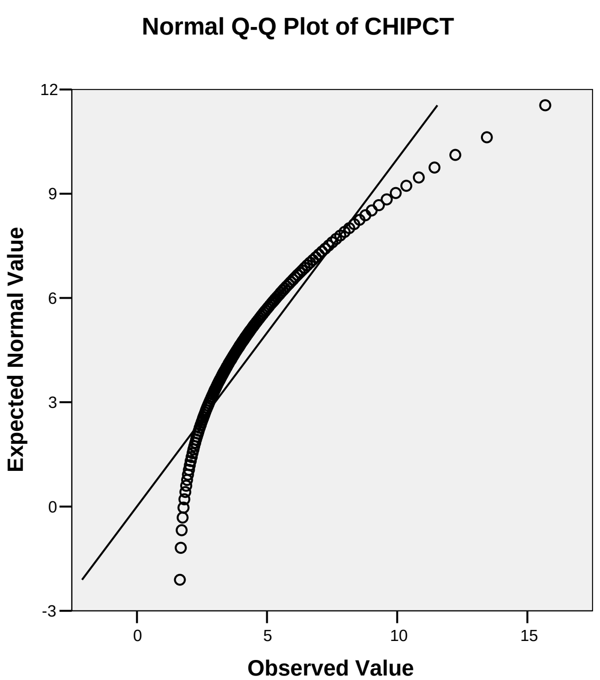


Figure L.7 Q-Q Plot of CHIPCT for Turkey

L.2 Assumption Tests for European Union Countries

L.2.1 The Homogeneity of Variance Assumption

The homogeneity of variance was tested using the H statistic which analyzes the assumption of equal variance across schools. The H statistic was significant (χ^2 = 308.27, df = 151, p-value = 0.000) indicating that the variances across schools were not equal to each other. Therefore an examination of the residual dispersion was warranted. A histogram indicated that two schools had lower than expected residual dispersion. A visual inspection of the data from these schools seems accurate, and the problem seems to be that the students within these schools are very homogenegous. A violation of the homogeneity of variance assumption is not a serious problem for estimating the school level coefficients or their standard errors.

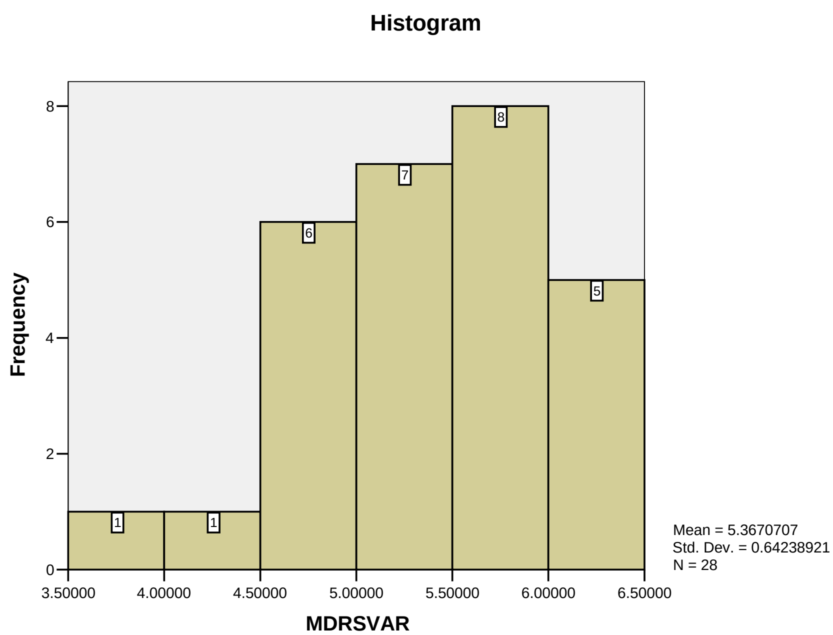


Figure L.8 Histogram of MDRSVAR for European Union Countries

L.2.2 Normality Assumption of Random Coefficients

Plots of the two random coefficients empirical bayes estimates (*Grade* and *Disciplinary Climate in Mathematics Lessons)* were found to be normally distributed.

Table L.2 Skewness and Kurtosis Values of the EB Estimates of Random Coeffficients for European Union Countries

	EBGRADE	EBCLIMATE
Skewness	0.227	0.094
Kurtosis	1.389	0.011

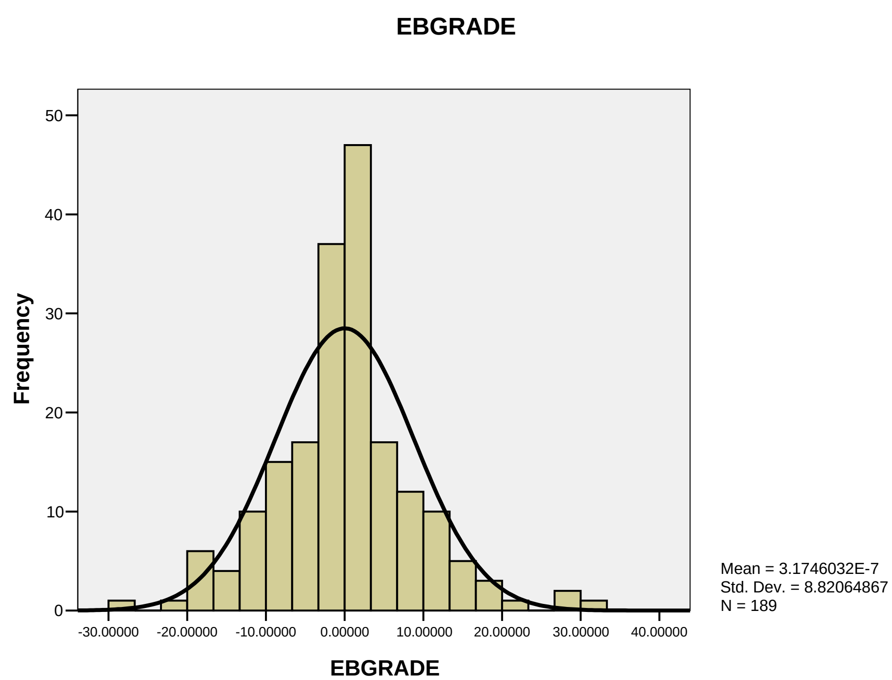


Figure L.9 Histogram of Grade EB Estimates for European Union Countries

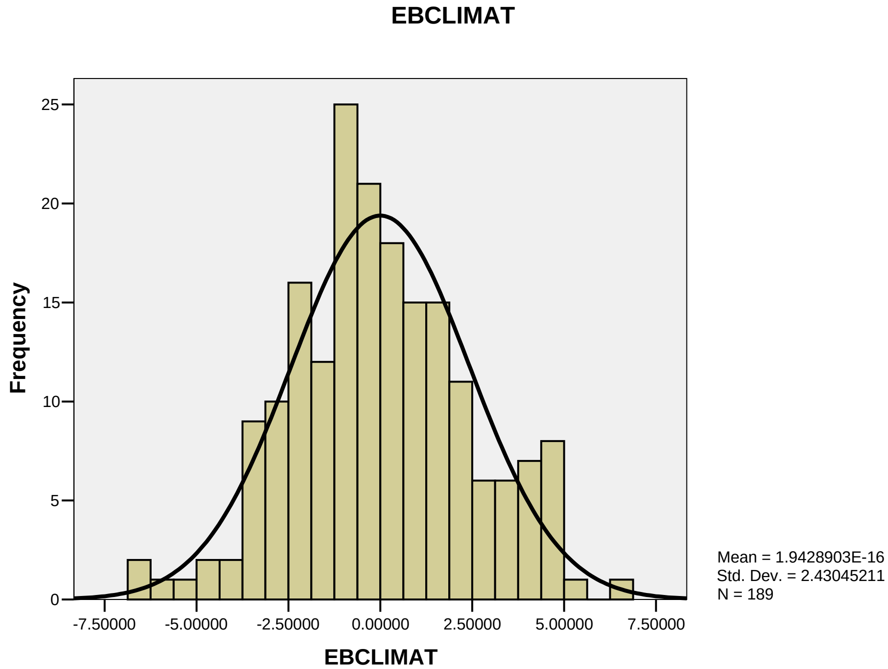


Figure L.10 Histogram of Disciplinary Climate in Mathematics Lessons EB Estimates for European Union Countries

L.2.3 Normality Assumption for School Level Residuals

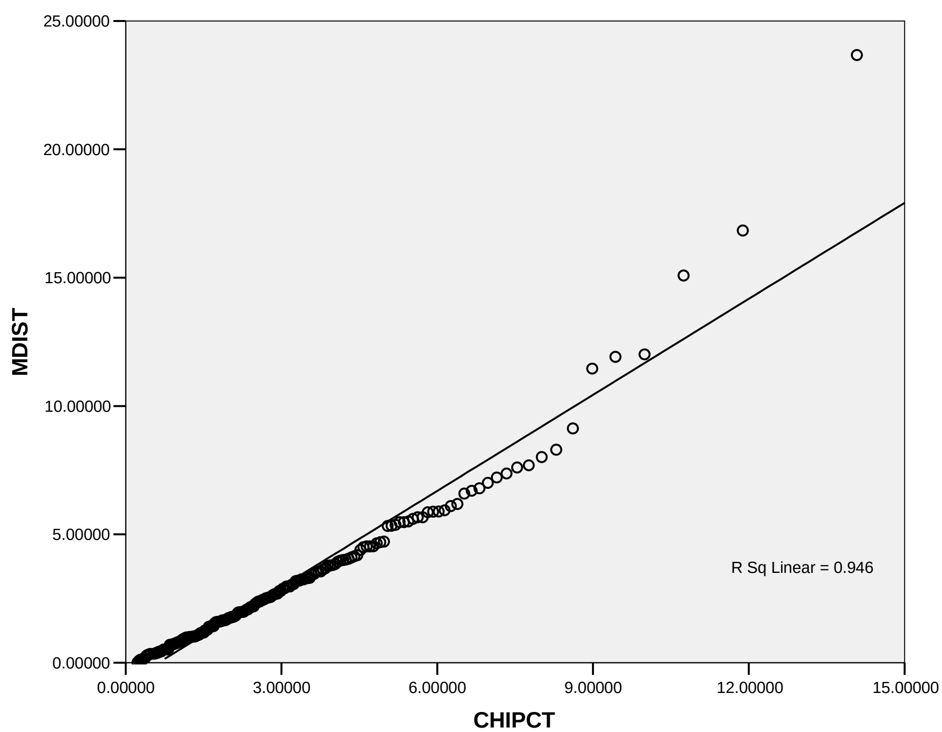


Figure L.11 Plot of MDIST versus CHIPCT for European Union Countries

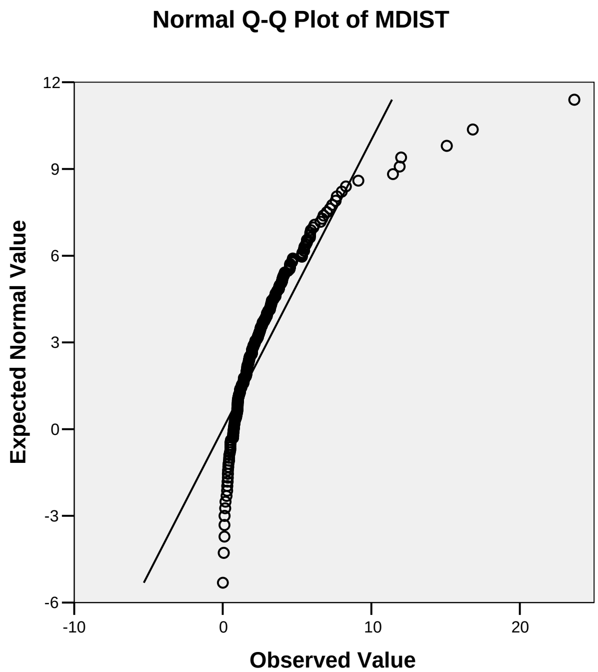


Figure L.12 Q-Q Plot of MDIST for European Union Countries

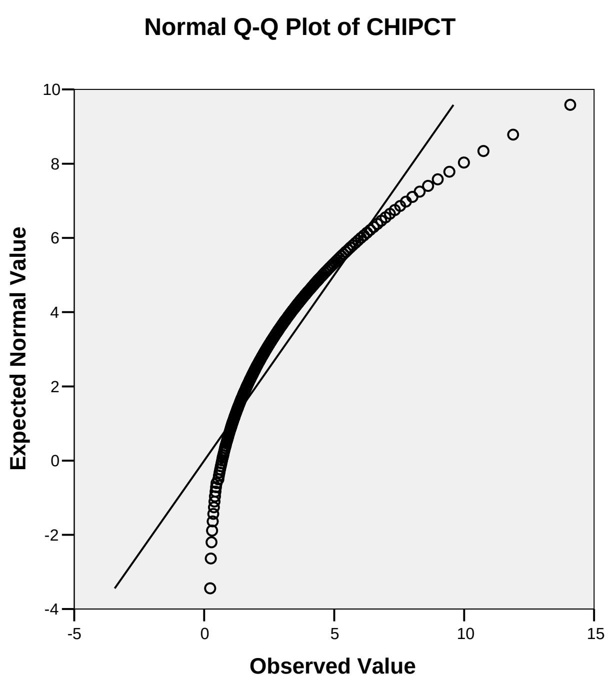


Figure L.13 Q-Q Plot of CHIPCT for European Union Countries

L.3 Assumption Tests for European Union Candidate Countries

L.3.1 The Homogeneity of Variance Assumption

The homogeneity of variance was tested using the H statistic which analyzes the assumption of equal variance across schools. The H statistic was significant (χ^2 = 157.99, df = 91, p-value = 0.000) indicating that the variances across schools were not equal to each other. Therefore an examination of the residual dispersion was warranted. A histogram indicated that three schools had lower than expected residual dispersion. A visual inspection of the data from these schools seems accurate, and the problem seems to be that the students within these schools are very homogenegous. A violation of the homogeneity of variance assumption is not a serious problem for estimating the school level coefficients or their standard errors.

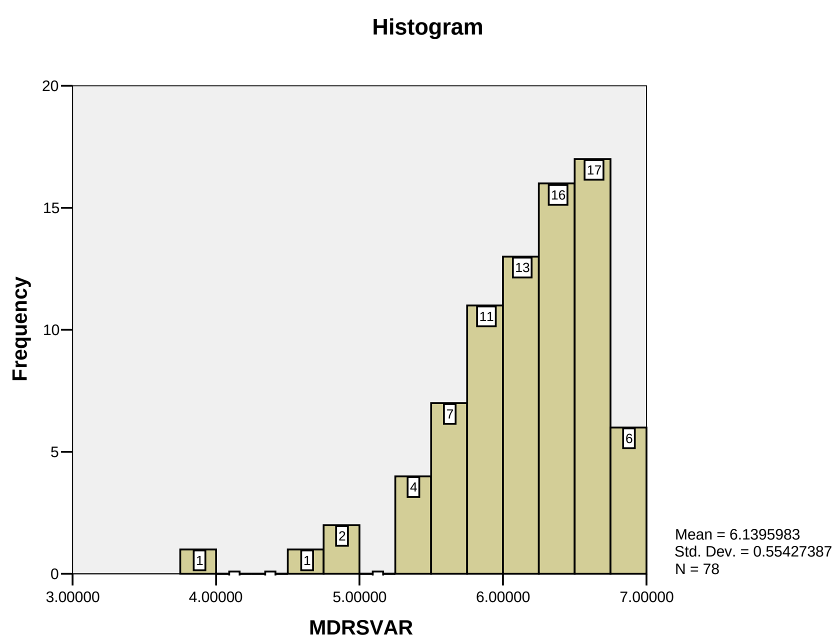


Figure L.14 Histogram of MDRSVAR for European Union Candidate Countries

L.3.2 Normality Assumption of Random Coefficients

Plots of the two random coefficients empirical bayes estimates (*Grade, Mathematics Self-Efficacy* and *Disciplinary Climate in Mathematics Lessons)* were found to be normally distributed.

Table L.3 Skewness and Kurtosis Values of the EB Estimates of Random Coeffficients for European Union Candidate Countries

	EBGRADE	EBSELFEFFI	EBCLIMATE
Skewness	0.021	-0.295	-0.121
Kurtosis	0.274	0.594	0.000

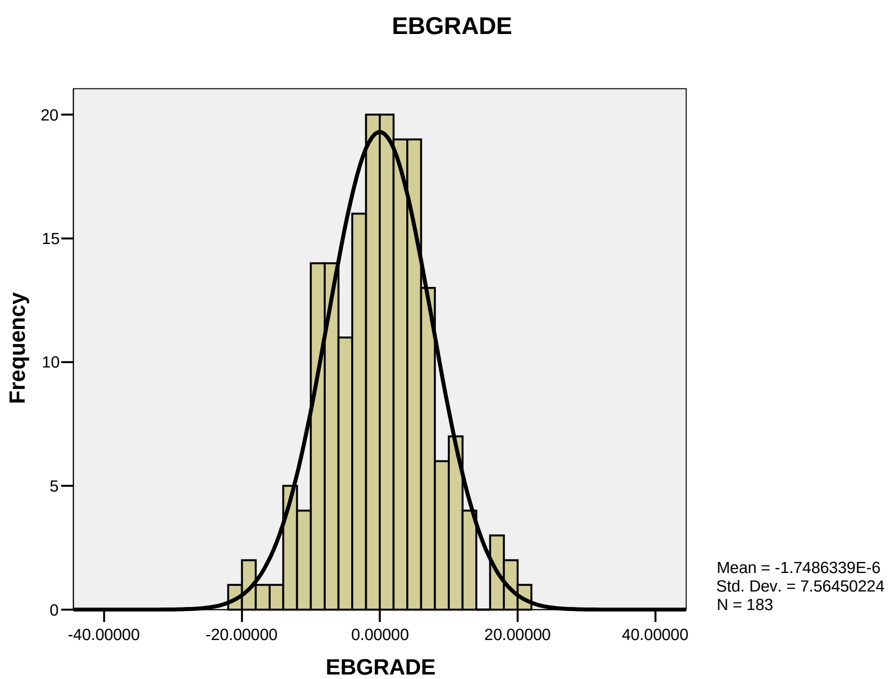


Figure L.15 Histogram of Grade EB Estimates for European Union Candidate Countries

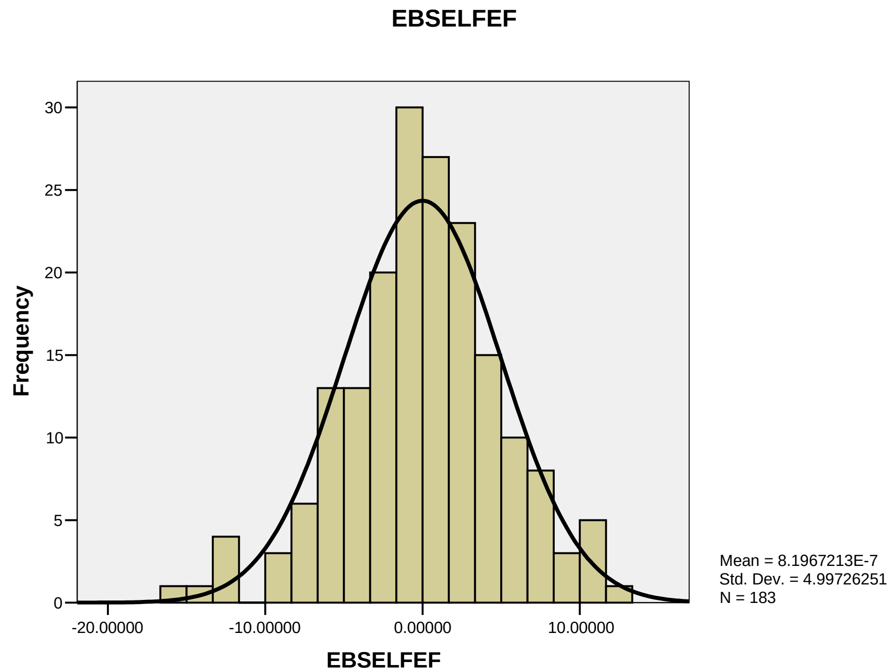


Figure L.16 Histogram of Mathematics Self-Efficacy EB Estimates for European Union Candidate Countries

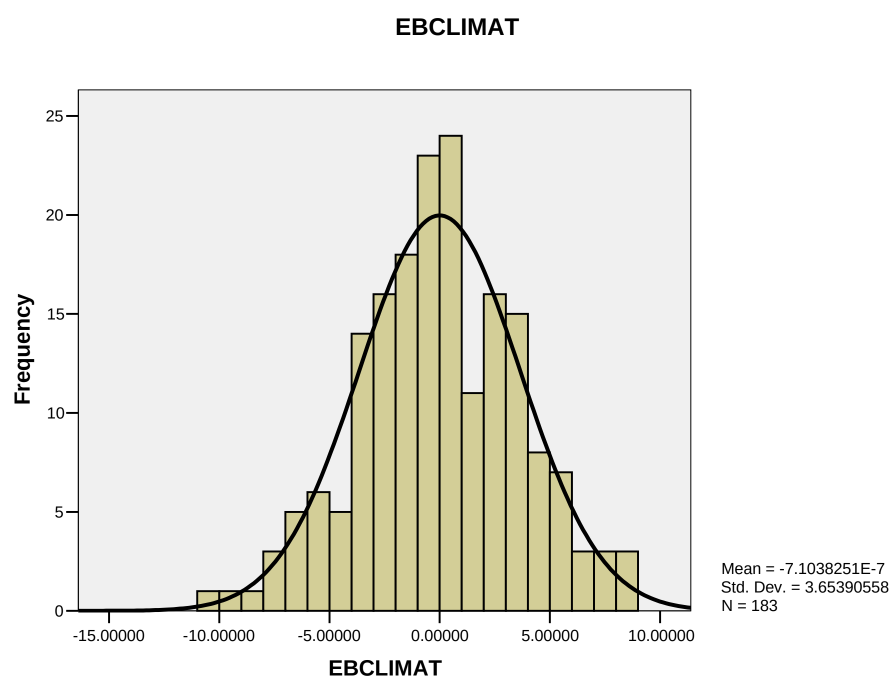


Figure L.17 Histogram of Disciplinary Climate in Mathematics Lessons EB Estimates for European Union Candidate Countries

L.3.3 Normality Assumption for School Level Residuals

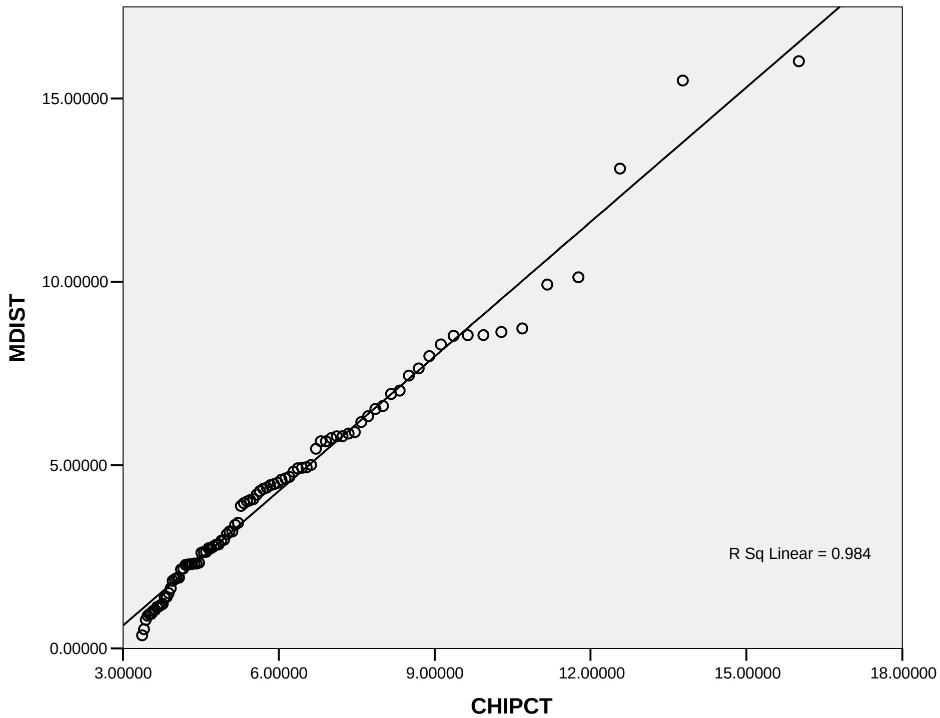


Figure L.18 Plot of MDIST versus CHIPCT for European Union Candidate Countries

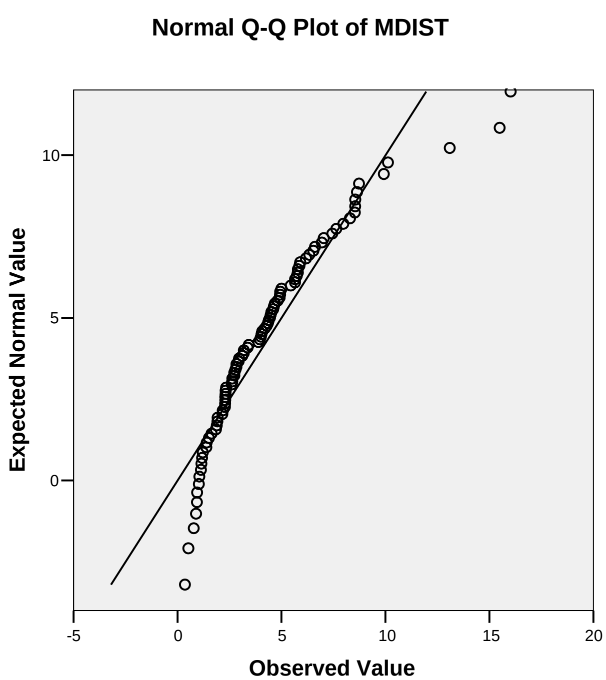


Figure L.19 Q-Q Plot of MDIST for European Union Candidate Countries

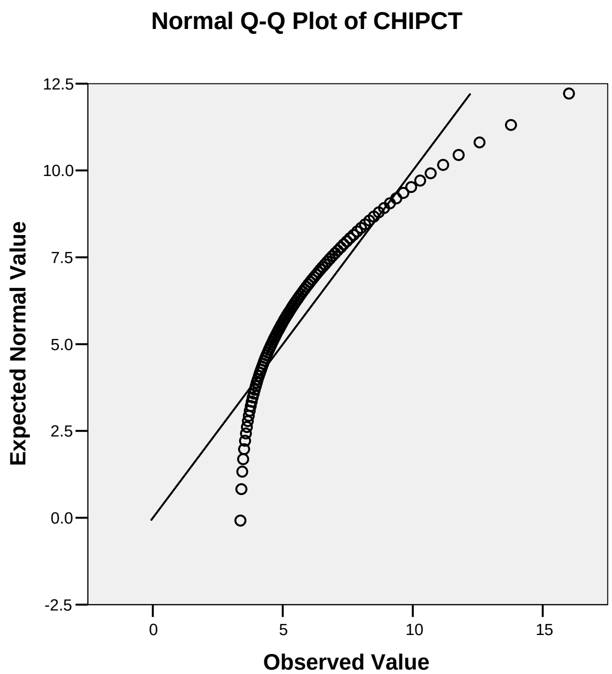


Figure L.20 Q-Q Plot of CHIPCT for European Union Candidate Countries

APPENDIX M

FINAL ESTIMATION OF FIXED EFFECTS OF FINAL FULL MODEL

M.1 Final Estimation of Fixed Effects of Final Full Model (Intercepts and Slopes as Outcomes Model of Turkey)

Table M.1.1 Final Estimation of Fixed Effects of Final Full Model for Turkey (Intercepts and Slopes as Outcomes Model)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Overall Mean Mathematical Literacy, γ_{00}	419.34	3.36	124.95	0.000
Mean of Mathematics Self-Efficacy, γ_{01}	114.66	7.36	15.52	0.000
School Size, γ_{02}	0.02	0.01	3.78	0.000
Proportion of Females Enrolled at School, γ_{03}	80.18	18.02	4.45	0.000
Total Student-Teacher Ratio, γ_{04}	-1.35	0.36	-3.73	0.000
Mathematics Student-Teacher Ratio, γ_{05}	-0.10	0.04	-2.26	0.030
Academic Selectivity, γ_{05}	8.09	3.82	2.12	0.035
Quality of School's Physical Infrastructure, γ_{06}	7.33	3.38	2.17	0.031
Grade, γ_{10}	21.56	2.88	7.50	0.000
Gender, γ_{20}	18.64	2.08	8.95	0.000
Home Educational Resources, γ_{30}	6.60	0.89	7.44	0.000
Student-Teacher Relations at School, γ_{40}	-6.98	0.92	-7.63	0.000
Sense of Belonging at School, γ_{50}	2.41	1.15	2.10	0.050
Mathematics Self-Efficacy, γ_{60}	17.68	1.18	14.96	0.000
Mathematics Anxiety, γ_{70}	-8.15	1.09	-7.46	0.000
Mathematics Self-Concept, γ_{80}	6.96	1.34	5.20	0.000
Control Strategies, γ_{90}	5.82	1.28	4.54	0.000
Elaboration Strategies, γ_{100}	-5.51	1.26	-4.36	0.000
Memorisation Strategies, γ_{110}	-4.27	1.25	-3.42	0.001
Disciplinary Climate in Mathematics Lessons, γ_{120}	7.21	1.28	5.62	0.000
School Size, γ_{121}	0.01	0.00	2.98	0.005
Mathematics Student-Teacher Ratio, γ_{122}	-0.04	0.02	-2.43	0.022

M.2 Final Estimation of Fixed Effects of Final Full Model

(Intercepts and Slopes as Outcomes Model of European Union Countries)

Table M.2.1 Final Estimation of Fixed Effects of Final Full Model for European Union Countries (Intercepts and Slopes as Outcomes Model)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Overall Mean Mathematical Literacy, γ_{00}	509.24	4.12	123.58	0.000
Mean of Mathematics Self-Efficacy, γ_{01}	58.02	10.18	5.70	0.000
School Size, γ_{02}	0.24	0.01	2.23	0.000
Student-Related Factors Affecting School Climate, γ_{03}	18.44	4.28	4.31	0.000
Grade, γ_{10}	32.17	2.46	13.06	0.000
Highest Parental Occupational Status, γ_{20}	0.45	0.05	8.53	0.000
Highest Educational Level of Parents, γ_{30}	-0.51	0.12	-4.37	0.000
Computer Facilities at Home, γ_{40}	3.96	1.17	3.37	0.002
Home Educational Resources, γ_{50}	5.77	1.10	5.25	0.000
Sense of Belonging at School, γ_{60}	-6.68	0.93	-7.21	0.000
Interest in Mathematics, γ_{70}	-4.63	1.28	-3.64	0.001
Mathematics Self-Efficacy, γ_{80}	22.85	1.17	19.52	0.000
Mathematics Anxiety, γ_{90}	-8.37	1.16	-7.21	0.000
Mathematics Self-Concept, γ_{100}	16.57	1.45	11.44	0.000
Elaboration Strategies, γ_{110}	-3.80	1.12	-3.39	0.001
Memorisation Strategies, γ_{120}	-6.20	1.04	-5.94	0.000
Teacher Support in Mathematics Lessons, γ_{130}	-4.37	0.95	-4.60	0.000
Disciplinary Climate in Mathematics Lessons, γ_{140}	5.47	1.02	5.39	0.000

M.3 Final Estimation of Fixed Effects of Final Full Model

(Intercepts and Slopes as Outcomes Model of European Union Candidate Countries)

Table M.3.1 Final Estimation of Fixed Effects of Final Full Model for European Union Candidate Countries (Intercepts and Slopes as Outcomes Model)

Fixed Effect	*Coefficient*	*Standard Error*	*T-Ratio*	*p-value*
Overall Mean Mathematical Literacy, γ_{00}	489.79	3.30	148.59	0.000
Mean of Mathematics Self-Efficacy, γ_{01}	93.83	7.76	12.10	0.000
Academic Selectivity, γ_{02}	13.50	3.14	4.30	0.000
Mathematics Activities, γ_{03}	-12.06	4.43	-2.73	0.009
Grade, γ_{10}	30.39	3.30	8.02	0.000
Academic Selectivity, γ_{11}	-6.41	2.95	-2.17	0.038
Highest Parental Occupational Status, γ_{20}	0.41	0.06	6.72	0.000
Computer Facilities at Home, γ_{30}	3.20	1.01	3.18	0.004
Home Educational Resources, γ_{40}	4.21	1.15	3.64	0.002
Interest in Mathematics, γ_{50}	-5.75	1.46	-3.94	0.001
Mathematics Self-Efficacy, γ_{60}	26.08	1.47	17.80	0.000
Academic Selectivity, γ_{61}	-3.91	1.13	-3.46	0.001
Mathematics Anxiety, γ_{70}	-11.99	1.43	-8.37	0.000
Mathematics Self-Concept, γ_{80}	18.34	1.73	10.63	0.000
Memorisation Strategies, γ_{90}	-9.30	1.19	-7.80	0.000
Teacher Support in Mathematics Lessons, γ_{100}	-5.88	1.11	-5.32	0.000
Disciplinary Climate in Mathematics Lessons, γ_{110}	3.66	1.20	3.07	0.004

VITA of Çiğdem İŞ GÜZEL

Personal Information:

Full Name: Çiğdem İŞ GÜZEL
Date and Place of Birth: January 22, 1977, Balıkesir, TURKEY
Marital Status: Married
Mailing Address: Karakusunlar Mah. 339. Sokak Erkam Apt.
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Work Experience:

September 2000- Present — **Middle East Technical University**
Research Assistant, Education Faculty, Secondary Science and Mathematics Education Department
- Co-instructor of Educational Statistics, Advanced Statistics, Test Construction, Item Response Theory and Undergraduate Internship Program
- Instructor of SPSS and LISREL computer package programs
- Responsible for preparation of all course materials for Educational Statistics and Advanced Statistics
- Department advisor for undergraduate and graduate students

August 2004-January 2005 — **Düzgün Publications**
Writer
- Responsible for preparing the mathematics course books for elementary classes I, II, III, IV and V and science course books for elementary classes IV and V based on the new elementary curriculum

November 2003-April 2004 — **City National Education Department**
Measurement and Evaluation Expert
- Evaluation of the exam questions used to measure students' level of knowledge in elementary, secondary and high schools

September 2003- January 2004 — **RtB Educational Solutions Ltd. Şti.**
Scenario Writer
- Responsible for the preparation of instructional materials for the mathematics curriculum of Malaysia Ministry of Education

November 2002-April 2003 — **City National Education Department**
Measurement and Evaluation Expert
- Evaluation of the exam questions used to measure students' level of knowledge in elementary, secondary and high schools

June 2000-August 2000 — **Özer Publications**
Writer
- Member of the writing committee of the high school mathematics course teacher's book III

March 2000-September 2000 — **Ministry of National Education - Educational Technologies Department**
Scenario Writer
- Responsible for the preparation of Mathematics III and IV television programs for the Open Secondary School Institution Program for the grade 10

Internship:

February 2000-June 2000 — **Mehmet Emin Resulzade Anatolian High School**
- Pre-service teacher for the second semester

September 1999-January 2000 — **Mehmet Emin Resulzade Anatolian High School**
- Pre-service teacher for the first semester

Publications:

July 2006 **Presented Paper**

İş Güzel, Ç., Berberoğlu, G. (2006). Factors affecting mathematical literacy in the 2003 Programme for International Student Assessment. *Paper presented at the 3rd International Conference on the Teaching of Mathematics, Istanbul,Turkey, June 30-July 5, 2006.*

July 2006 **Presented Paper**

İş Güzel, Ç., Iseri, A.İ. (2006). A cross-cultural comparison of factors affecting mathematical literacy of students in the 2003 Programme for International Student Assessment (PISA). *Paper presented at the 3rd International Conference on the Teaching of Mathematics, Istanbul,Turkey, June 30-July 5, 2006.*

December 2005 **Published Paper**

İş Güzel, Ç., Berberoğlu, G. (2005). An analysis of the Programme for International Student Assessment 2000 (PISA 2000) mathematical literacy data for Brazilian, Japanese and Norwegian students. *Studies in Educational Evaluation, 31,* 283-314.

September 2005 **Presented Paper**

İş Güzel, Ç., Berberoğlu, G., Akdağ, Z. A., Yayan, B. (2005). Factors explaining between school differences in the 2003 Programme for International Student Assessment (PISA) in Turkey. *Paper presented at the European Conference on Educational Research (ECER) 2005, Dublin, Ireland, September 07-10, 2005.*

September 2004 **Presented Paper**

İş Güzel, Ç., Berberoğlu, G. (2004). A cross-cultural comparison of factors affecting mathematical literacy of students in Programme for International Student Assessment (PISA 2000). *Paper presented at the 6th National Conference on Mathematics and Science, Istanbul,Turkey, September 09-11, 2004.*

July 2004 **Presented Paper**

Kiraz, E., İş Güzel, Ç., Aşçı, Z., Hardal, Ö. (2004). Designing an instruction vs. a designed instruction: Criticizing the quality of centralized instructional design approach. *Paper presented at the International Conference on Quality in Education in the Balkan Countries, Bulgaria, July 03, 04, 2004.*

June 2003 **MS Thesis**

İş, Ç. (2003). A cross-cultural comparison of factors affecting mathematical literacy of students in Programme for International Student Assessment (PISA 2000). Unpublished Master's Thesis, Middle East Technical University, Ankara, Turkey.

May 2001 **Presented Paper**

İş, Ç., Bulut, S. (2001). Use of concrete materials in mathematics education. *Paper presented at the Mathematics Activities 2001, Ankara,Turkey, May 24-26, 2001.*

Educational Information:

2003-Present **Middle East Technical University**

Program: Doctorate (PhD)

Major: Secondary Science and Mathematics Education
Mathematics Education

CGPA(4.00): 4.00

Projects:

- Advanced Statistics
  - Research projects on Third International Mathematics and Science Study (TIMSS) by using multivariate statistics and structural equation modeling with SPSS and LISREL computer package programs
- Item Response Theory
  - Research project on the cross-cultural differences of Turkish and Taiwanese students' responses to "Approaches to Study Inventory" with conduction of the item response theory and using BILOG and MULTILOG computer package programs
- Qualitative Research Methods in Education
  - A qualitative research project via interviews analyzing married women's experiences of the PhD program process at METU, and future career expectations.
  - A qualitative research project via observation in a classroom environment at METU where a method of teaching called drama is applied in order to develop a deep understanding of the method as a teaching methodology in education
- Critiques and Analyses of Research in Science and Mathematics Education
  - Quantitative research proposal about a cross-cultural comparison of factors affecting mathematical literacy of students in Programme for International Student Assessment (PISA)

- Instructional Design
  - Research project for the development of a new instructional design and its application on a course in the curriculum
- Psychology of Mathematics Education
  - Research project based on the interviews about the students' understanding of geometrical concepts in terms of Pirie and Kieren's Model of Mathematical Understanding; verbal and visual forms and under the effect of noise
  - Research project based on the interviews about the students' understanding of mathematical concepts in terms of semiotics system
- Computer Assisted Instruction
  - Design of a WebQuest about the multiple intelligences theory
  - Design of a personal web site (http://www.metu.edu.tr/~scigdem)

2000-2003 **Middle East Technical University**
Program: Graduate (MS)
Major: Secondary Science and Mathematics Education
Mathematics Education
CGPA(4.00): 3.57
Projects:

- Educational Statistics
  - Research projects using descriptive and inferential statistics
- Test Construction
  - Research project about the reliability and validity of a scale
- Research Methods in Education
  - Quantitative research proposal about the thoughts and beliefs of students on mathematical proofs
- Theories of Instruction
  - Research projects about the application of the instructional theories to the mathematical contents
- Lab Projects in Science and Mathematics Education
  - Development of a mathematical test and a questionnaire in order to conduct a quantitative research about the thoughts and beliefs of students on mathematical proofs
  - Application of the developed mathematical test and questionnaire to the preservice teachers

1995-2000 **Middle East Technical University**
Program: Undergraduate (BS)
Major: Secondary Science and Mathematics Education
Mathematics Education
CGPA(4.00): 2.67
Projects:

- Measurement and Evaluation
  - Research project on development of a mathematical test about Integrals; application to high school students; and calculating the reliability and validity of the test
- Geometry Concepts
  - Research reports concerning the application of teaching methods to the mathematical subjects including solid figures

- Teaching Methods
  - Literary review of the discovery learning method and in comparison to other teaching methods specifically in terms of its application to the mathematical topics
- Poster
  - Development of a poster about the interesting concepts and use of games in the mathematical subjects including solid figures

Languages Known:

- Good level of English
- Beginner level of German (3 years in Balıkesir Sırrı Yırcalı Anatolian High School)

Programming Languages Known:

MS Word, MS Excel, MS Powerpoint, MS Access, Frontpage, Html, ITEMAN, SPSS, BILOG, MULTILOG, LISREL and HLM

Interests:

Member of M.E.T.U. Mountaineering Society, member of Balıkesir Sırrı Yırcalı Anatolian High School (SYAL) Chorus, member of SYAL Folklore Team, member of SYAL Theatre Team, member of SYAL Basketball Team, member of SYAL Newspaper Team. Enjoy music, theater, movies, reading and traveling , swimming, playing games, photography.

References:

Prof. Dr. Giray Berberoglu (email :- giray@metu.edu.tr)