Analyzing Turkey's Data from TIMSS 2007 to Investigate Regional Disparities in Eighth Grade Science Achievement

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ANALYZING TURKEY'S DATA FROM TIMSS 2007 TO INVESTIGATE REGIONAL DISPARITIES IN EIGHTH GRADE SCIENCE ACHIEVEMENT

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Abstract

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Dissertation by Ebru Erberber

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Turkey is expected to be a full member of the European Union (EU) by 2013. In the course of its integration into the EU, Turkey has been simultaneously facing access, quality, and equity issues in education. Over the past decade, substantial progress has been made on increasing the access. However, improving the country's low level of education quality and achieving equity in quality education across the regions continue to be a monumental challenge in Turkey. Most recently, results from the Trends in International Mathematics and Science Study (TIMSS) 2007 indicated that Turkey's educational achievement at the eighth grade, the end of compulsory primary education in Turkey, was far below that of other countries in the EU. Considering Turkey's long standing socioeconomic disparities between the western and eastern parts of the country, the challenges of improving overall education quality are coupled with the challenges of achieving equity in learning outcomes for students across the regions.

This dissertation used data from TIMSS 2007 to document the extent of Turkey's regional differences in science achievement at the eighth grade and to investigate factors associated with these differences. Findings from a series of analyses using hierarchical linear models suggested that attempts to increase Turkish students' achievement and close the achievement gaps between regions should target the students in the undeveloped regions, particularly in Southeastern Anatolia and Eastern Anatolia. Designing interventions to improve competency in Turkish and to compensate for the shortcomings of insufficient parental education, limited home educational resources, poor school climate for academic achievement, and inadequate instructional equipment and facilities might be expected to close the regional achievement gaps as well as raise the overall achievement level in Turkey.

To my parents: Ali and Veliye Erberber

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This dissertation is dedicated to my parents, Ali and Veliye Erberber, who taught me that education is the best asset one can attain. It was their unconditional love, generous care, never-ending confidence in me, and constant prayers that gave me the courage and strength to find my path, as well as move forward on it. I cannot thank them enough. In the form of a rough translation of a Turkish expression, “I would forever be indebted to them even if I carried them on my shoulders for the rest of my life”.

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Chapter 1

Introduction

Established after World War 1 less than a century ago in 1923, the secular Turkish Republic has progressed considerably since being founded from the remnants of the defeated Islamic Ottoman Empire. In particular, Turkey has experienced good economic growth and currently is a candidate for membership in the European Union (EU). According to the *Ninth Development Plan 2007-2013* prepared by the State Planning Organization, Turkey seeks to be a country that is part of the "information society, growing in stability, sharing more equitably, globally competitive and fully completed her coherence with European Union" by 2013 (DPT, 2006, p.11). However, results on international assessments such as TIMSS and PISA indicate that Turkey's educational achievement is far below that of other countries in the EU.

In the process of reaching its goals, the Turkish government will need to face quantity, quality, and equity issues in education, and in a simultaneous fashion, not at the expense of each other. Otherwise, it risks increasing existing socioeconomic disparities between various groups of society and among the seven regions and as a result, growth may be impeded. In-depth understanding of the differences across regions in learning outcomes is essential in developing strategies that will raise the national level of educational performance as well as close achievement gaps, most notably between the western and eastern regions. This dissertation used data from IEA's (International Association for the Evaluation of Educational Achievement) Trends in International Mathematics and Science Study (TIMSS) 2007 to examine the extent of Turkey's regional differences in student achievement for educational policy makers and to investigate factors associated with the differences.

Description of the Problem

Status of Quantity, Quality, and Equity of Education in Turkey

Turkey's economic performance is reasonably high by world standards. It is among the 20 largest economies of the world (World Bank, 2007) and aims to be in the top 10 economies by 2023, the 100th anniversary of its being founded. However, economic development alone has not necessarily resulted in higher quality living standards. The United Nations Development Programme's (UNDP) *Human Development Index*[1] (HDI) placed Turkey among "medium level HDI" countries and ranked it 84th among 177 countries, based on 2005 figures (UNDP, 2007). Turkey has been in the medium HDI category since 1972 (UNDP, 2001). Currently, the EU has twenty-seven member nations and three candidates for admission, including Turkey. All of the EU member and candidate states, except Turkey, are among "high level HDI" countries.

[1] The HDI is a composite index based on three basic dimensions of human development: 1) a long and healthy life as measured by life expectancy at birth; 2) educational attainment as measured by combination of the adult (ages 15 and older) literacy rate (two-thirds weight) and the combined gross enrollment ratio (one-third weight) for primary, secondary, and tertiary schools; and 3) a decent standard of living as measured by gross domestic product (GDP) per capita in purchasing power parity terms in US dollars.

When education, health, and economic components of the index are examined separately, it is evident that Turkey's medium HDI level mainly results from its low level on the education index (ranking 104^{th}) compared with its life expectancy index and GDP index (ranking 84^{th} and 67^{th}, respectively).

Turkey, with a population of 70.5 million, has a large proportion of young people. There are 11 million students in primary education which is comprised of grades 1 through 8 for ages 6-14 (Demirer et al., 2008). Given the size of the student population in primary school, access and quality in education have always been a challenge for the Ministry of National Education (MoNE). Prompted by the global call of *Education for All* (World Conference on Education for All, 1990), compulsory primary education was increased from 5 to 8 years in 1997. Over the past decade, in addition to this fundamental reform, important educational projects targeting school access were successfully implemented. These initiatives included a girls' education campaign, distribution of free textbooks in primary and secondary schools, construction of new classrooms by private sources, busing students to schools in rural areas, and providing access to free boarding schools in primary education (Aydagul, 2007). These projects ensured school attendance of children, especially girls, at least through the end of compulsory education.

In 2007, a decade after the reform, the net enrollment ratio had increased significantly from 85% to 97% for primary school children and the 11% ratio gap between girls and boys decreased to 2% (MoNE, 2008). Unfortunately, enrollment ratios for noncompulsory schooling are still low, especially in preschool. Based on 2005 figures, the gross schooling rate for preschool was 20% for the 4-5 age group (DPT, 2006). The government has set targets for increasing the enrollment ratio to 50% in preschool by 2013 (DPT, 2006), the same year Turkey aims to have a full membership in the EU.

Besides challenges in improving the *quantity* of education, both in terms of enrollment ratios and years of schooling, Turkey also faces issues of improving the *quality* of education provided to its children. Students' low achievement results in both international and national assessments show that improving student learning clearly remains a challenge for Turkey. TIMSS 2007 is the most recent study in which Turkey assessed its mathematics and science achievement in an international context among 49 countries and performance was low in comparison to the 12 EU member countries[2] that participated in the study at the eighth grade. Turkish eighth grade students had significantly lower average achievement in mathematics than the students in all of the 12 EU countries (Mullis, Martin, & Foy, 2008, chapter 1). On the science test, Turkey's average science achievement was similar to three EU countries, namely, Romania, Malta, and Cyprus and lower than the others (Martin, Mullis, & Foy, 2008, chapter 1).

Even more disturbing than Turkey's low ranking is the finding that 41% of Turkish students performed below the *Low International Benchmark* on the mathematics scale indicating they did not demonstrate a grasp of even basic computational skills. On

[2] These countries included Bulgaria, Cyprus, the Czech Republic, Hungary, Italy, Lithuania, Malta, Romania, Slovenia, and Sweden. England and Scotland participated in TIMSS 2007 as separate entities, thus they were counted as two separate EU states, not as the United Kingdom.

the science scale, 29% performed below the *Low International Benchmark* signifying that they did not know even basic facts from the life and physical sciences. Only 5% of the students reached the *Advanced International Benchmark* in mathematics (Mullis, Martin, et al., 2008, chapter 2) and 3% in science (Martin et al., 2008, chapter 2). These small percentages of students demonstrating competence on TIMSS 2007 suggest that high quality education remains a privilege provided only for a small fraction of Turkish students.

OECD's (Organisation for Economic Co-operation and Development) Programme for International Students Assessment (PISA) 2006 results presented a similarly dismal picture. PISA 2006 focused on the science literacy of 15-year-olds. Most of the Turkish students who participated in the assessment were in ninth-grade. Among 30 OECD countries in the study, Turkey ranked at the bottom, above only Mexico. Almost half of the Turkish students (46.6%) performed at or below the lowest proficiency level of the science literacy scale (OECD, 2007a).

The grim picture of the results from international assessments corresponds to national test results. In 2005, the Ministry of National Education sampled primary school students nation-wide at grades 4 through 8 and tested their achievement in four primary subjects —mathematics, science, social studies, and Turkish. The results of the test, the OBBS (*Ogrenci Basari Belirleme Sinavi* [Student Achievement Determination Test]) revealed that the level of primary curriculum attainment was unsatisfactory across the country. For all grades and subjects, except Turkish, the average score for correct answers was 50% or less (MoNE, 2007). The 2005 results showed no change from 2002 when OBBS was first conducted, confirming the disappointing picture revealed by the initial test results.

Mandated by the government's *Urgent Action Plan* issued in 2003 (DPT), the ministry initiated major curriculum reforms to improve the quality of learning and teaching in the nation. These reforms included development, implementation, and assessment of new curricula in primary education. The curriculum reforms are expected to promote constructivist ways of teaching where students' learning is put at the center of instruction (MoNE, 2005). Rapid implementation of the new curriculum began after a year of pilot study. In the 2005/06 academic year, the new curriculum for grades 1 to 5 started to be taught in schools while the curriculum for grade 6 was piloted. During the following two years, piloting for grades 7 and 8 was finalized. The new curriculum for grades 6 to 8 was put into practice in the academic years 2006/07, 2007/08, and 2008/09, respectively. The effects of the new curriculum may be reflected in the TIMSS 2011 results (Demirer et al., 2008).

The national tests of primary curriculum attainment, OBBS, illustrated not only the low level of average student performance at the national level but also Turkey's regional *equity* issues in learning outcomes (see Figure 1.1 for the map of Turkey). The results from OBBS showed that students in the least socioeconomically developed regions, namely the Eastern Anatolia and Southeastern Anatolia regions, performed less well than their peers in more developed regions (MoNE, 2007).

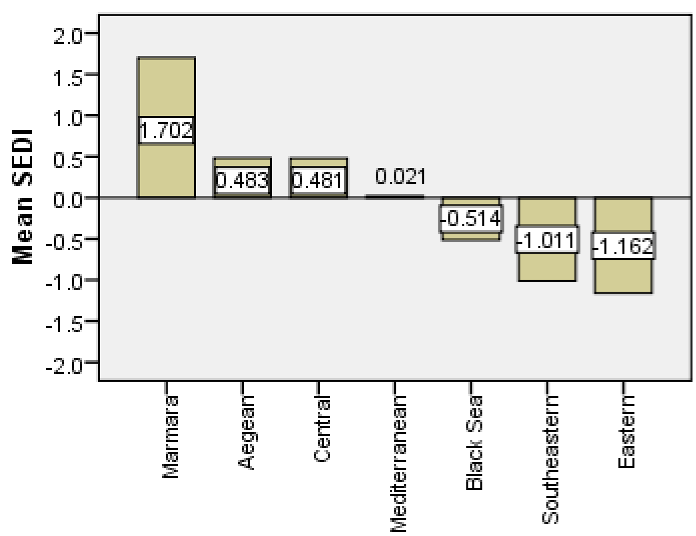
Figure 1.1. Geographic Regions of Turkey

Status of Regional Socioeconomic Imbalances in Turkey

Regional differences in student achievement on the OBBS were only an echo of disparities in regional development in Turkey. Socioeconomic development inequalities among the regions of the country have long been a significant national problem. Turkey's Human Development Report of 2001 compared 1975 and 1997 scores on the *Human Development Index* for regions of the country and stated that "Turkey is progressing, but with persistent inequality" (UNDP, 2001, p.3). A recent study by the State Planning Organization revealed that the regional disparities are wide (Dincer, Ozaslan, & Kavasoglu, 2003). This study used the *Socioeconomic Development Index* (SEDI), based on 2003 figures, to measure socioeconomic development status at a national level as well as a regional level. The SEDI included the three components of the United Nations' HDI among other social and economic indicators. In total, the SEDI is based on 58 variables selected from socioeconomic measures including indicators of demography, employment, education, health, infrastructure, manufacturing, construction, agriculture, and finance.

Figure 1.2 displays average SEDI scores for each region compared to the country mean of zero. The index figures indicate that the socioeconomic disparities are particularly pronounced between the west and the east of Turkey. The Marmara region that includes Istanbul —the demographic and economic heart of the country— had the highest index score and is the most developed region of the country. The Aegean and Central Anatolia (including the capital city of Ankara) regions are the next most developed regions, with very close SEDI scores, above the national average. The index score for the Mediterranean region is at the country's average and it is below average for the Black Sea, Southeastern Anatolia, and Eastern Anatolia regions.

Figure 1.2. SEDI Rankings by Regions of Turkey



Note. Data are from Dincer, Ozaslan, & Kavasoglu (2003).

Purpose of the Study

Socioeconomic disparities between the western and eastern parts of Turkey gained more attention after the start of membership negotiations with the EU in 2005. One of the important goals of the EU is to reduce regional gaps in order to achieve economic and social cohesion not only within the EU but also in its territories (Loewendahl, 2005). OECD's economic survey of Turkey (2006) suggested that "improved education quality in the poorest regions would contribute to reducing these [regional] disparities while also encouraging faster growth of the economy as a whole" (p.158). OECD's latest review of educational policies in the country (2007b) also highlighted the striking socioeconomic disparities among Turkey's regions. Their report recommended that Turkey make education a key instrument for socioeconomic cohesion. To reach this goal, the report also recommended that Turkey strive toward providing equal educational opportunities for all people, establishing priorities for efficient use of existing resources, and continuing to narrow socioeconomic gaps among regions.

The aim of this study was to determine the extent to which science achievement inequalities exist across the seven regions of Turkey and to explore potential reasons for why such educational inequalities might exist. A better understanding of the differences in student learning outcomes between developed and undeveloped regions may be useful to regional policy makers in their efforts to formulate region-specific development strategies. Identifying constraints and differences in achievement may also inform educational policy to better allocate available resources.

This dissertation study used Turkey's TIMSS 2007 eighth grade science achievement data as well as the background data collected from students, teachers, and school principals about contextual factors that may affect learning outcomes. Characteristics of the student sample allowed for the investigation of regional disparities in student outcomes. Turkey's sample of students from TIMSS 2007 is nationally representative and stratified by the seven regions of the country (Olson, Martin, & Mullis, 2008, Appendix B). Further, TIMSS 2007 results (Martin et al., 2008, chapter 5) demonstrated that almost all of the content assessed by the TIMSS 2007 science test was included in Turkey's science curriculum and intended to be taught to all students in the country by the end of eighth grade. In this study, the analytic method of Hierarchical Linear Modeling (HLM) was employed at the school level and the students-within-school level to examine the relative effects of home and school factors associated with regional differences in achievement.

Research Questions

The research questions investigated in this dissertation were as follows:

1. What is the science achievement profile of eighth grade Turkish students across the seven geographic regions of Turkey?
2. What student background factors contribute to regional disparities in science achievement in Turkey?
3. What school context factors contribute to regional disparities in science achievement in Turkey?

Importance of the Study

Turkey's aim to become a member of the EU has led to a series of legal and social reforms, including major ones in education. These major educational reforms were:

- increasing the years of compulsory primary education,
- providing greater access to schooling,
- narrowing the gender gap in enrollment, and
- revising the school curricula.

Even though significant progress has been made in increasing years of schooling and the enrollments, the quality of education in the country as well as the disparities in educational quality by region continue to be a concern. To have sustainable human development and successfully complete its accession process with the EU by 2013, Turkey needs to simultaneously improve educational quantity, quality, and equity.

The government's decision to participate in TIMSS 2007 demonstrates its interest in gathering evidence about students' achievement in comparison to other nations in the world. Also, the Ministry of National Education is undertaking national assessments that measure curriculum attainment every three years to monitor national trends in students' learning in primary education. The purpose of this dissertation was to contribute to the discussion in Turkey about the best strategies for improving the overall level of student performance in compulsory primary education and eliminating the achievement inequalities among its regions.

Studies using nationally representative samples and aiming to understand factors pertinent to regional student outcome differences are scarce in Turkey, mainly because of lack of data. The curriculum achievement tests, OBBS, were the first large-scale assessments in primary education that provided empirical evidence on regional achievement disparities. However, national reports of OBBS are limited to descriptive analyses of the data and do not include comprehensive analysis of contextual variables related to regional disparities in learning outcomes. Further, the data from OBBS are not readily available for use by researchers.[3] Therefore, the little information published about factors influencing educational achievement in Turkey is based only on small-scale local studies analyzing a limited number of predictors of student achievement.

Turkey's nationally representative student sample stratified by region from TIMSS 2007 provided an important and unique opportunity to conduct research on Turkey's education system. This dissertation capitalized on the characteristics of this sample as well as on the extensive contextual information TIMSS collected. It was the first attempt using a nationally representative sample to investigate the factors related to science achievement differences across regions in Turkey. Providing timely empirical information about the current picture of regional achievement disparities and the factors that are associated with these disparities could potentially be very helpful to policy makers, in the course of integration into the EU.

[3] Access to the OBBS database may be granted with a special permission from MoNE (S. T. Basaran of MoNE, personal communication, June 23, 2008).

Chapter 2

Literature Review

This study was conducted to examine regional disparities in the science achievement of Turkish students at eighth grade, which is the end of compulsory education in Turkey. Keeping the focus of the study in mind, the following chapter is divided into three sections. The first section provides an overview of the historical and current context of primary education (currently grades 1 to 8) in Turkey, including a summary of significant reforms in primary education. It also gives a profile of Turkish eighth grade students' science achievement drawn from national and international studies. The second section describes the main characteristics of Turkey's seven geographic regions, outlines the past and contemporary human development issues facing the regions, and explains the origins of the regional disparities. The third and last section reviews literature on student and school factors related to improved science achievement for students.

Context of Primary Education in Turkey

Turkey is located at the crossroads of two continents between southeastern Europe and southwestern Asia. It was established in 1923 by Mustafa Kemal Ataturk, who built on the remains of the Islamic Ottoman Empire. During the decade following its founding, Turkey underwent radical social and political transformations. These changes were in the direction of moving from a theocratic monarchy to a secular state and included abolishing the Islamic caliphate, replacing the Sheria (Islamic law) by the secular Civil Code (adapted from the Swiss Civil Code), establishing civil rights including women's right to vote, adopting the Latin alphabet instead of Arabic script, and mandating Turkish as the common language in education (Aydagul, 2002). Immediate educational reforms included unifying the public, private, religious, and minority/foreign schools under the Ministry of National Education [MoNE] and adopting five years of compulsory primary education. Although five years of compulsory schooling began in 1924 in many schools, the duration of primary schooling in rural schools was three years until 1939. Five years of primary schooling was mandated in *all* schools in 1961 (Eurydice, 2006).

During the initial time of tremendous transformation, MoNE invited John Dewey, as an influential American philosopher and educator, to observe and give advice on how to improve the Turkish education system. Dewey compiled his suggestions for improving Turkey's education system in a report in 1924. Turan (2000) reviewed the report and documented that Dewey recommended Turkey implement the following reforms:

- increase the funding of education,
- improve teacher training using progressive pedagogical methods,
- enhance the physical conditions of the schools, and
- develop schools as community centers connected to local life and adapt the curriculum to local conditions so that it is connected to students' life.

Dewey also explained that schools in Turkey should be in service of *all* citizens in the state, not only for the elites of the society. To develop a society where individuals had independence of judgment, the ability to think scientifically, and an understanding of how to cooperate for the common purposes of the society, he advised that "the mass of citizens must be educated for intellectual participation in the political, economic, and cultural growth of the country, and not simply certain leaders" (Turan, 2000, p.550).

Last but not least, Dewey warned about the danger of MoNE becoming rigidly bureaucratic and tightly centralized, thus neglecting the local dimension of education and ignoring the issues of remote areas. He pointed out the distinction between unity and uniformity in education, and advised that MoNE should concentrate its activities to unify the education system and avoid activities that would prevent local communities from taking responsibilities in the education system. That is, MoNE should become "the center to prepare education development plans, the intellectual and moral leader and inspirer of Turkish education" (p.548). He recommended encouraging diversity in the education system to allow schools to become adapted to varying local conditions and interests.

In 2008, eighty-five years after the founding of the Republic, the total population in Turkey reached 70 million with almost 90% of its adults (aged 15 and above) being literate (UNDP, 2007). However, the nation still faces some of the same educational issues articulated by Dewey, and on an increased scale. In the initial years after its founding, the total population of Turkey was 13 million (Hosgor, 2004) with a strikingly low literacy rate —less than 10% at the time (MoNE, 2005). In the academic year 1923/24, when the Republic was founded, the ministry educated less than half a million primary school students in 5,000 schools with, on average, two teachers per school. In the 2007/08 academic year, the number of students in primary education approached the total population size of the young Republic with 11 million students in 35,000 schools (MoNE, 2008).

MoNE, which has a firmly centralized and bureaucratic structure, remains the sole governing body of the education system (OECD, 2006). MoNE plans, delivers, and monitors all education services and activities including developing and overseeing the national curriculum for preschool, primary, and secondary education. The ministry is also responsible for developing educational policy, opening preprimary, primary, secondary educational institutions, and providing educational materials. MoNE carries out its activities centrally in the capital city, Ankara, and at the local level through provincial and district organizations (MoNE, 2005). Gershberg (2005) documented that, using the OECD Education Database 1998, 94% of all education decisions in Turkey are made at the central level and 6% at the school level. He concluded that Turkey's education system is "more centralized than all members of the European Union it hopes to join" (p.1).

In Turkey, primary education is eight years long, compulsory for children aged 6-14, and free of charge in public schools. Preschool education includes children between ages 3-6, but unlike primary education it is optional (Demirer et al., 2008). There are serious concerns about Turkish children's access to preprimary education, because it provides the basis for primary education. According to data from the UNESCO Institute for Statistics (2008), in 2000, the gross enrollment ratio[4] for preprimary school was dramatically low (6%) and, in 2006, it had increased only to 13%. As shown in Figure 2.1, a 13% gross schooling ratio for preprimary schooling is the lowest ratio among the EU member and candidate states and lags far behind the 85% average.[5]

In addition to Turkey's already low enrollment ratio for preprimary school, there are considerable regional differences in preprimary schooling opportunities. Figure 2.2 presents gross enrollment ratios for preprimary education in Turkey and the regions, ordered by their socioeconomic development index (SEDI) score that was presented in Figure 1.2 in Chapter 1. As shown in the figure, schooling rates in preprimary education for students who are 48-72 months-old range from 22% in the Aegean region (the second most socioeconomically developed region) to 11% in Eastern Anatolia (the least socioeconomically developed region).

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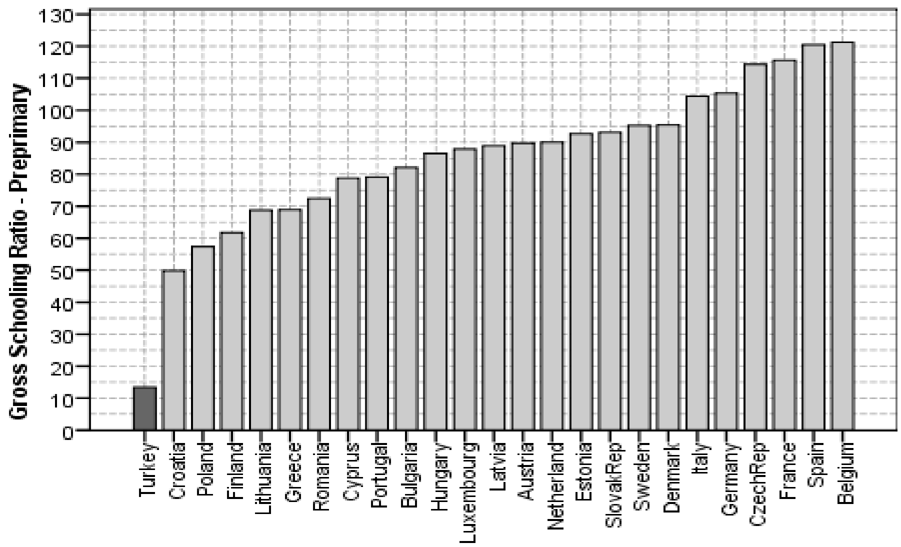
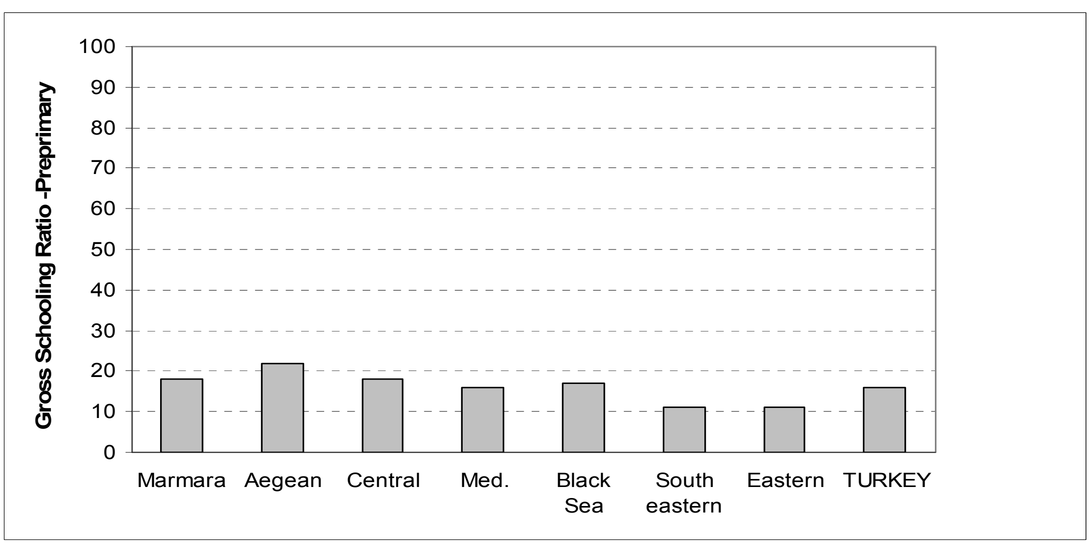
[4] Gross schooling ratio (enrollment rate) is obtained by dividing the total number of students, regardless of age, enrolled in preprimary education by the total population in the theoretical age group (official preprimary school age). By definition, the gross schooling ratio can exceed 100 percent.
[5] As of 2008, the EU had 27 member nations and three candidates, including Turkey. UNESCO's database did not include 2006 figures for four member states (Malta, Ireland, Slovenia, and United Kingdom) and one candidate state, Macedonia. Therefore, the average was calculated for 25 countries.

Figure 2.1. Gross Schooling Ratio for Preprimary Education in 2006 in EU Member and Candidate States



Note. Data are from UNESCO Institute for Statistics database (2008).

Figure 2.2. Gross Schooling Ratio for Preprimary Education in 2004 in Turkey and Its Regions



Note. Data are from MoNE (2005, p. 27-28).

Two recent reports prepared for the European Commission highlight the importance of preprimary education in combating educational disadvantages. As a result, the Commission identified preprimary education as a priority theme for cooperation between EU states in 2009-2010 (EACEA, 2009). Wobmann and Schutz (2006) state that "an extensive system of early education in terms of both duration and universal enrolment" (p.19) is a promising approach to raise equality of educational opportunity. *Early Childhood Education and Care in Europe* (EACEA, 2009) recommends that EU states invest more in preprimary education as an effective way of establishing the foundation for increasing equity of student outcomes and overall skill levels.

Basic Education Program

Since the late 1900s, Turkey has made significant progress toward improving primary schooling access for its students. Even considering the low access ratios in preprimary school, substantial progress in addressing educational enrollment ratios has been made after the expansion of compulsory primary education from three to five and then to eight years. About a decade ago, when the *Eight-year Compulsory Basic Education Law* (Law no. 4306) was enacted in 1997, five-year elementary schools were merged with three-year lower secondary schools and the Basic Education Program was developed.

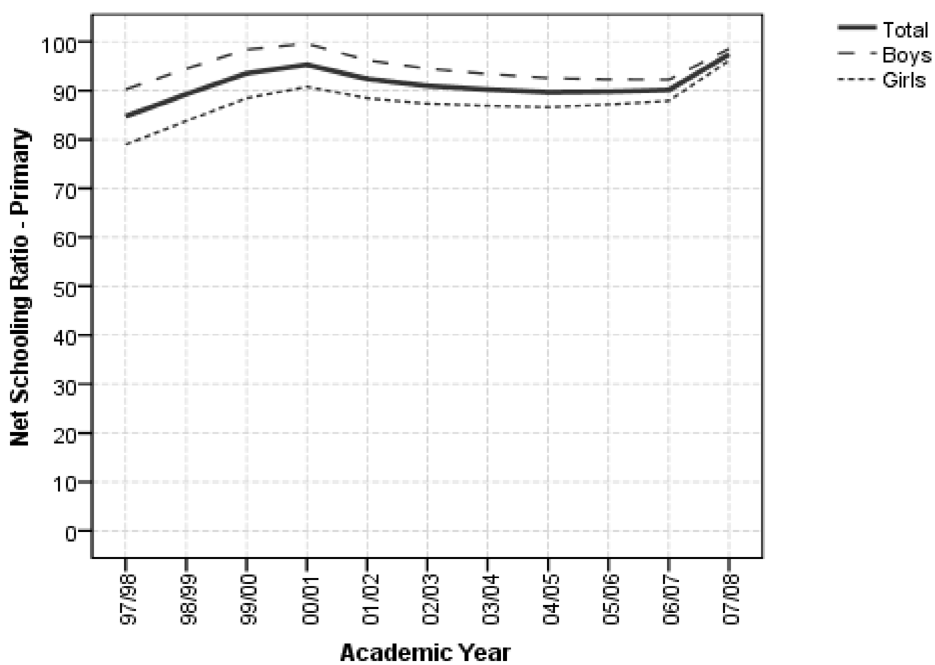
Two main objectives of the Basic Education Program were expanding primary education for children aged 6-14 and increasing the quality of their education (MoNE, 2005). A primary goal of the program was to reduce poverty for the poorest portion of the population; those people in remote rural areas as well as the ones who recently migrated to urban settings, but have a low standard of living. The government also considered the Basic Education Program as part of the strategy to improve social cohesion by diminishing existing socioeconomic disparities. Extending compulsory education to eight years was thought to enhance equal educational opportunities (Dulger, 2004). MoNE initiated a series of actions to expand the quantity (i.e., enrollment) and quality of primary education for all children, including girls and students from low income families. The projects that targeted expanding primary education coverage included:

- constructing new schools and classrooms in rural areas,
- expanding busing and boarding school capacities in remote areas without schools,
- supplying free education materials such as textbooks and uniforms to poor students, and
- implementing educational campaigns in selected disadvantaged provinces (e.g., "Haydi Kizlar Okula! [Come on Girls, Let's go to School!]).

Activities designed to improve the quality of primary schooling included providing in-service training for teachers and principals, enhancing information and communication technology (ICT) by providing educational materials and computers to schools in rural areas, and switching from double-shift to full-day education (UNESCO, 2004).

The Basic Education Program resulted in an unprecedented expansion in primary schooling. The results were remarkable and immediate. Overall, the program substantially reduced net enrollment disparities between girls and boys in primary school. As presented in Figure 2.3, the net enrollment ratio[6] in primary education in 1997 was 85% and ratio gap between girls and boys was 11% (79% vs. 90%) (MoNE, 2008). In 2007, a decade after the primary education reform, the enrollment ratio had substantially increased to 97% and the ratio gap between girls and boys had declined to 2% (96% vs. 98%).

Figure 2.3. Net Schooling Ratio by Academic Year for Primary Education in Turkey Since Developing the Basic Education Program



Note. Data are from MoNE (2008).

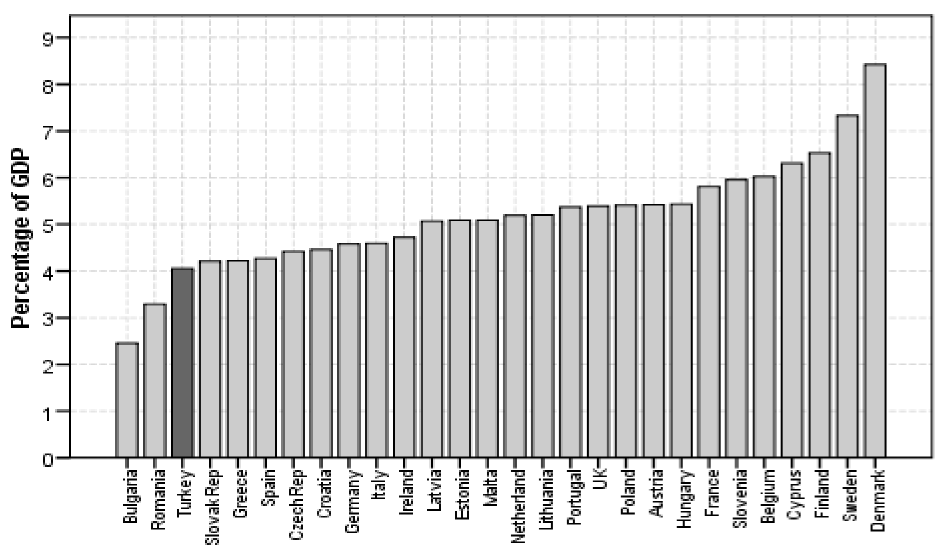
[6] Net schooling ratio (enrollment rate) is obtained by dividing the total number of students in a theoretical age group (official primary school age which is 6-14) enrolled in primary education by the total population in that theoretical age group.

To support the objective of increasing primary education quality, the government's *Urgent Action Plan 2003* (DPT, 2003) initiated massive and rapid curriculum revisions and transformation of teaching from teacher-centered practices to constructivist and student-centered practices (MoNE, 2005). The new primary education curriculum was developed in all core subjects, including science, piloted for a year in randomly selected schools, and then put into practice. Specifically, the new curriculum began to be taught in 2005 for grades 1-5 and began in 2006, 2007, and 2008 for grades 6 through 8, respectively (Demirer et al., 2008).

The development, implementation, and assessment of new science curricula were included among the curriculum reform efforts. Currently, in grades 1 to 3, science is taught in combination with social studies under the course name "life study", while in grades 4 to 8 science and social studies are taught separately. In 2005, the new science curriculum was implemented at grades 4 and 5 and then, in the next three years, the new curriculum was put into practice at grades 6 through 8. Another aspect of the curriculum reforms was to increase the instructional time intended for science teaching. The teaching time devoted to science was increased from three lesson hours (40 minutes each) to four lesson hours per week in order to keep up with global trends in science teaching and to allocate more time for constructivist ways of teaching. This change meant an increase from 10% to 13% of total instructional time allocated to science.

The Basic Education Program also had a significant impact on public spending on education. In 1987, a decade before the introduction of the *Basic Education Law* of 1997, Turkey's public spending on primary, secondary, and tertiary education was 1.2% of its gross domestic product (GDP) (UNESCO Institute for Statistics, 2008). By 2004, the figure had risen to 4.1%. Turkey's Defense Minister in 2004 noted that "for the first time, our defense budget was not the highest but the second highest item. Our national education budget outnumbered our defense budget." ("Education Budget", 2004). Despite the increase in public spending on education, Turkey's figure still lags behind most of the EU member and candidate countries (see Figure 2.4) among which Denmark and Sweden had the highest figures (8.4% and 7.3%).

Figure 2.4. Public Expenditure on Education as a Percentage of GDP in 2004 in EU Member and Candidate States



Note. Data are from UNESCO Institute for Statistics database (2008). The database did not include 2004 figures for member state Luxembourg and candidate state Macedonia.

Results from National and International Studies in Educational Achievement

The heart of the UNESCO's (United Nations Educational, Scientific and Cultural Organization) *Education for All* movement, launched in 1990 and restated in 2000, was to provide not only access to schooling but also school success for all children, regardless of gender, wealth, location, language, or ethnic origin (UNESCO, 2007). The movement emphasizes that efforts to improve school access and school success should go hand in hand. However, in Turkey, progress in school access took priority over the progress in quality of education. Eliminating illiteracy and raising the number of primary school graduates were the main goals in Turkey (Dulger, 2004). Consequently, improvement of school quality remains as a challenge in the country. Despite the government's tremendous efforts in increasing both quantity and quality in primary education, only school access has shown remarkable improvement.

Alarming evidence from international assessments such as TIMSS and PISA as well as national tests paints a disappointing picture of learning outcomes for Turkish students at the end of their compulsory education. Turkey participated in TIMSS first in 1999 at the eighth grade, and most recently in 2007. TIMSS 2007 provided information on Turkish eighth grade students' science achievement in an international arena (among 49 countries) and relative to the 12 EU countries. On the science test, Turkish students were outperformed by those in most of the EU countries.

Average science achievement of eighth grade students in Turkey was similar to the performance of their counterparts in Romania, Malta, and Cyprus (Martin et al., 2008, chapter 1). However, England, the top-performing country among the EU members, outperformed Turkey by almost one standard deviation[7] —542 versus 454 score points. In comparison to the five middle-income[8] EU countries, including Bulgaria, the Czech Republic, Hungary, Lithuania, and Romania, students in Turkey and Romania had the lowest achievement. A positive aspect of the results was that Turkish girls and boys performed similarly on the TIMSS 2007 science test.

On average, only 3% of the Turkish students reached the *Advanced International Benchmark* demonstrating a grasp of various complex topics and abstract concepts in science (Martin et al., 2008, chapter 2). In comparison, almost one third of Turkish students (29%) performed below the *Low International Benchmark*. That is, they did not demonstrate a grasp of even basic facts from the life and physical sciences. By contrast, in Slovenia and the Czech Republic, almost all students (97%), reached the *Low International Benchmark*. In Turkey, the tiny proportion of students showing competence in science and the high percentage of students lacking a grasp of even basic science facts documents the existence of severe gaps between Turkey and the EU countries in learning outcomes at the end of primary education.

[7] The TIMSS science scale was constructed to have an average of 500 score points and a standard deviation of 100 score points.
[8] GNI (Gross National Income) per capita of US$876-US$10,725 in 2005, based on World Bank classification (effective 1 July 2006).

Results from PISA were also disappointing for Turkey. PISA has been carried out by the OECD every 3 years since 2000. PISA measures 15-year-olds' literacy in reading, mathematics, and science. Each PISA cycle assesses one of the three subject domains in-depth and treats the other two as minor domains. PISA 2006 focused on science literacy and allowed achievement comparisons among 30 OECD countries. Performance of Turkish students, who were mostly in the ninth grade, was at the bottom (above only Mexico) and 76 score points below the mean score[9] among OECD countries (OECD, 2007a). Almost half of the Turkish students (46.6%) did not reach PISA's baseline proficiency level at which "students begin to demonstrate the science competencies that will enable them to participate actively in life situations related to science and technology" (p.52).

Results from the national tests at the end of primary education were just as unsatisfactory. In 2002, the Ministry of National Education began assessing curriculum achievement of primary school students nation-wide. The test, known as the OBBS (the *Ogrenci Basari Belirleme Sinavi* [Student Achievement Determination Test]), is administered every 3 years to a random sample of students in each of grades 4 through 8. It measures students' achievement in core subjects including science. Results obtained in 2002 and 2005 revealed not only that the science curriculum attainment at the end of primary education was poor throughout the country but also that student achievement mirrored the regional disparities in socioeconomic development (MoNE, 2002, 2007).

[9] In PISA 2006, the mean score for student performance in science across OECD countries was set at 500 score points and the standard deviation at 100 score points.

Table 2.1 presents the average percent correct scores for regions, ordered by their socioeconomic development index (SEDI) score that was presented in Figure 1.2 in Chapter 1. As shown in the table, the average science score of eighth grade students in the country was less than 50%. Moreover, the students in the least developed regions, namely Eastern Anatolia and Southeastern Anatolia, performed lower than their peers in more developed regions.

Table 2.1. *Average Percent Correct by Region for Eighth Grade Turkish Students on the Science Test of OBBS 2002 and 2005*

Region	**OBBS 2002**	**OBBS 2005**
1. Marmara	45%	47%
2. Aegean	48%	49%
3. Central Anatolia	46%	47%
4. Mediterranean	45%	49%
5. Black Sea	44%	48%
6. Southeastern Anatolia	42%	40%
7. Eastern Anatolia	43%	42%
TURKEY	45%	46%

Note. Data are from MoNE (2002, 2007). For both tests, two booklets (forms A and B) were administered. Above figures are from Booklet A. Figures from Booklet B were not available in the OBBS 2002 report. Booklet B figures in OBBS 2005 differed from Booklet A figures by 1% or less.

Even though the national tests, OBBS, represented a step forward to the goal of measuring the curriculum attainment of the nation's primary school students, the tests had limitations. OBBS administered the science test questions in two different booklets. Each student took either one form or the other. The booklets had 5 common questions, with each booklet including 15 multiple-choice questions at grades 4 and 5 and 20 at grades 6 to 8. No effort was made to equate the difficulty of the two booklets. Basing OBBS scores on a limited number of questions in a particular test booklet raises concerns about the coverage of the science subject domain, encompassing life and physical sciences. Also, only the percent correct metric was used for reporting the OBBS results. That is, the student achievement score on a specific subject domain was simply the percent of the number of correct responses to the test items in the domain.

The percent correct metric of the OBBS may seem to be a straightforward way to increase public understanding of the test results. However, it presents interpretation problems, because students' proficiency descriptions (i.e., what students know and are able to do) were not provided in communicating the test results. In contrast, TIMSS used Item Response Theory (IRT) scaling to summarize student performance on 214 items on the TIMSS 2007 science achievement scale and described students' knowledge and understandings at four score points on the scale (625, 550, 475, and 400) as the Advanced, High, Intermediate, and Low International Benchmarks, respectively. The descriptions of students' achievement at the international benchmarks help users of the test results understand the meaning of students' scores (Mullis, Erberber, & Preuschoff, 2008).

Socioeconomic Inequalities Across the Regions in Turkey

Because this dissertation study aimed to illustrate the extent of Turkey's regional disparities in learning outcomes as well as to investigate factors related to the differences, it was important to understand the setting that gave rise to existing and persistent inequalities in human development. This second section provides a brief description of the main characteristics of the different regions and summarizes the human development issues faced within the regions.

Historical and Geographic Background

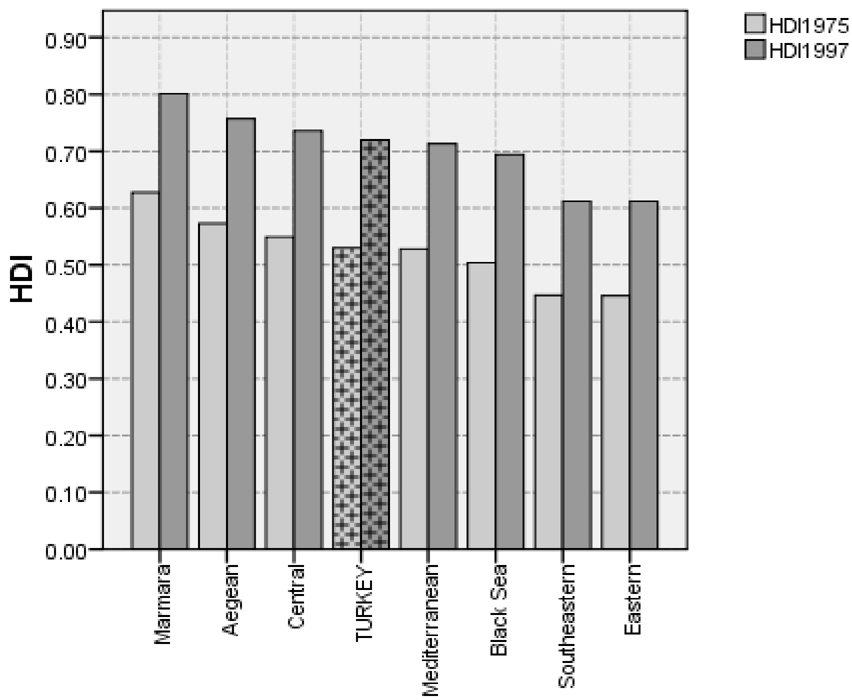
In 1941, educators and geographers in Turkey met in the First Congress of Turkish Geography in Ankara (Kocman & Sutgibi, 2004) in order to establish the objectives of geography education and prepare the content for the geography curriculum in grades 6 to 11 (Tas, 2005). Further, at the end of the congress, Turkey was divided into seven regions, based on the geographical characteristics of the regions (TNA, 1999). Because the country is centrally governed, the regions do not have separate administrative units. In the division process, factors such as climate, natural plant cover, and distribution of types of agriculture were considered. Four regions were given the names of the seas next to them: the Marmara, the Black Sea, the Aegean, and the Mediterranean. The other three regions were named according to their location in Anatolia —Central Anatolia, Eastern Anatolia, and Southeastern Anatolia.

Over time, geographic diversity translated into differences in socioeconomic development. Disparities became particularly pronounced between the densely populated and urbanized west and the rural east of Turkey. That is, the regions in the western part of the country are more developed compared to the regions in eastern Turkey. The Marmara region is the most developed region, followed by the Aegean and Central Anatolia. Development performance of the Mediterranean region is at the country average while the Eastern and Southeastern regions of Anatolia are the least developed.

Regional disparities in development have long been on the list of issues the country faces. According to the National Human Development Report 2001 (UNDP, 2001) comparing the regional scores on the United Nations' *Human Development Index* (HDI) for years 1975 and 1997, there was little change over that time. Figure 2.5 shows that despite the overall increase in the Turkish HDI score between 1975 to1997, regional inequalities remained and the HDI rank order of the regions had not changed at the end of those two decades.

The results of National Human Development Report 2001 were echoed in the results of a recent study by Turkey's State Planning Organization using figures from 2003 (Dincer et al., 2003). This study showed that large socioeconomic differences among the regions continued to exist. Dincer and his colleagues calculated the *Socioeconomic Development Index* (SEDI) for each of Turkey's 81 provinces, using more than 50 social and economic measures including indicators of demography, employment, education, health, infrastructure, manufacturing, construction, agriculture, and finance.

Figure 2.5. Turkey's Human Development Index by Region —1975 and 1997

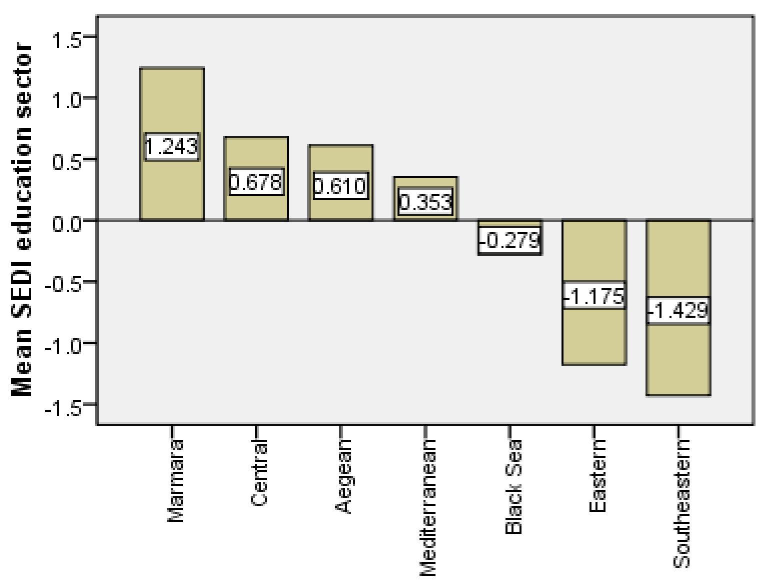


Note. Data are from the UNDP Human Development Report Turkey 2001 (UNDP, 2001, Table 2.1, p.21)

The regions' SEDI ranking (see Figure 1.2 in Chapter 1) mirrored the HDI ranking. Marmara had the highest SEDI score, 1.702, compared to the country mean of zero. The next most developed regions, the Aegean and Central Anatolia, were very similar in terms of socioeconomic development as indicated by their close index scores, 0.483 and 0.481, respectively. The index score of the Mediterranean region reflected the country average (0.021) while the regions of the Black Sea, Southeastern Anatolia, and Eastern Anatolia were lagging behind with SEDI scores below the country average (-0.514, -1.011, and -1.162, respectively).

Dincer et al. (2003) also looked at the regional differences for the industry, health, and education components of the SEDI. The education component used the following six indicators of educational attainment: literacy rate, women's literacy rate, the proportion of higher education graduates, schooling rates in primary education, schooling rates in high school, and schooling rates in vocational and technical high school. The authors found that the ranking for the education component of the index from the most developed to the least developed regions corresponded very closely to the overall SEDI ranking. The SEDI education component was higher for Central Anatolia than the Aegean region, and for Eastern Anatolia compared to Southeastern Anatolia (see Figure 2.6).

Figure 2.6. SEDI Education Sector Rankings by Regions of Turkey



Note. Data are from Dincer, Ozaslan, & Kavasoglu (2003).

Many factors contribute to Marmara's robust development. Located in the northwest of the county bordering Europe, the region bridges two continents, Europe and Asia. It is the leading region in many industrial and commercial activities: thus, acting as a magnet for migration from less developed regions. Istanbul, having almost one-fifth of Turkey's population, is not only the most important city of the region, but also the economic, demographic, and cultural center of the entire country.

The Aegean, the second most developed region, lies along the coast of the Aegean Sea on the west of the country. Agricultural activities are important economically, given the rich soil and water resources of the region. The portal city, Izmir, is the economic and touristic center of the region. The Central Anatolia region is in the middle of Turkey and surrounded by the six other regions. It has the least mountainous topography compared with the other regions. The capital city, Ankara, is the trade center of the region housing many governmental activities. Average country development is best mirrored in Mediterranean region, which is located in the south of Turkey. The economic and touristic activities are concentrated along the coastline, similar to the Aegean region.

The Black Sea, Eastern Anatolia, and Southeastern Anatolia have the largest amount of emigration to more developed regions. Weak economic conditions are fostered by the harsh geography and climate. The Black Sea is located in the north of the country, where high mountains and forests provide poor conditions for agriculture and industry. Similarly, the high altitude of Eastern Anatolia does not offer the milder weather conditions of the coastal regions. Southeastern Anatolia also suffers from the lack of industrialization. Smits and Hosgor (2006) note that "Until recently, an important characteristic of some of the villages in this region [Southeastern Anatolia] was their tribal structure, and most people lived under the authority of their religious leaders (Sheiks)" (p.550). Aside from geographic similarities, these three undeveloped regions also share some socioeconomic characteristics, including a lack of investment and infrastructure, high unemployment, low income, high illiteracy rates, and low schooling rates (TESEV, 2006). This whole series of disadvantages creates a vicious circle with barriers to human development.

According to the UNDP's Country Evaluation Report (2004), the roots of these inequalities between the west and the east of the country are related to several economic, geographic, and political factors. The disparities are "due to differential natural and human resource endowments and due to the better access to world and regional markets of the coastal regions" as well as to "a relative neglect of the Eastern and Southeastern regions of the country by successive Governments" (chapter 2, p.16).

To better appreciate the political factors underpinning the large regional disparities, it is important to understand the ethnic differences in the country. Turkey has a predominantly Muslim population (more than 98%) with small minority groups such as Christians and Jewish people. Major ethnic minority groups are the Kurds and Arabs, both of which are concentrated in the eastern part of the country. Besides the Turkish-speaking majority, researchers estimate that somewhere between 10 and 15 percent of the population speaks Kurdish as their mother-tongue (Icduygu, Romano, & Sirkeci, 1999).

There is not much data on the percent of population whose native language is Arabic as their mother-tongue, but it is estimated to be much less than the percent of Kurdish speakers (Smits & Hosgor, 2003).

Educational Resources

In a recent report of the Turkish Economic and Social Studies Foundation, Keyder and Ustundag (2006) suggest that one commonly shared view in Turkey is that low education results in these impoverished regions are due to the cultural and ethnic background of the people living in those regions. However, the authors found that, in contrast to these prevalent conceptions, the primary educational obstacles in these deprived regions were poverty and a lack of educational investment. They recommended that investment in education should be expanded in these regions by means such as opening new schools, busing students to primary education and boarding them, distributing free-of-charge textbooks, and providing lunch for students in primary school.

These findings were supported by Cingi, Kadilar, and Kocberber's (2007) recent study that investigated district-level disparities in educational opportunities provided in primary schools in the academic year of 2006/07. The study found that inequalities existed in the distribution of resources across the regions in Turkey. To construct the *Educational Opportunities Index (EOI)*, Cingi et al. used 19 educational indicators including number of teachers, classrooms, and computers per student; number of libraries and science laboratories per school; and share of household expenditure. The authors then used the EOI figures for each of the 923 districts in Turkey to categorize each district as being in a good, medium, or poor EOI category. The results of the study confirmed that the educational opportunities in primary school were poor across the country and that these opportunities were unequally distributed. On average, only 8% of the districts provided good educational opportunities. The majority of the districts fell into the medium and poor categories (47% and 45 %, respectively). The proportion of districts with a good EOI level was highest in the Marmara region, particularly in Istanbul. Almost 40% of the districts in Istanbul provided good educational opportunities in primary education. The results for the districts in the Southeastern Anatolia were dismal. All of the districts in this socioeconomically least developed region fell into the poor category of the index.

Substantial differences in resources among primary schools were also documented in a report on Turkey's Education Sector Study prepared by the World Bank (2005). This study documented strong parental concerns about disparities in school equipment and facilities. In particular, parents with lower incomes or from rural settings were more concerned about educational conditions than the wealthier or urban parents. More than half of the rural parents reported problems related to educational facilities in schools while only one third of urban parents reported this concern. These findings provide additional evidence of inequities in the distribution of resources across schools as well as confirm that low-income families have less access to better school services in Turkey than high-income families.

Existing socioeconomic gaps among the regions have led to increasing internal migration, which has taken “the form of unskilled labor from low-income agricultural regions moving into wealthier urban areas” (Kirdar & Saracoglu, 2007, p.4). Rapid movement from villages or poorly developed cities to more developed regions still continues. Currently, 70% of the population lives in the urban settings (Turkish Statistics Institution, 2008) and that figure is expected to reach 90% in 2023, by the 100th birthday of the Republic (DPT, 2001).

Economically rooted rural to urban migration changed its characteristics in the 1990’s. The change began in the mid-eighties in the east and southeast of Turkey as a result of the conflict between the Turkish military and the PKK (Kurdistan Workers Party), which lasted fifteen years. As a result of rising security problems in the region “…over 3,000 villages have been evacuated; more than an estimated 3 million people have left the region…” (Icduygu et al., 1999, p.1003). More recent research by the Hacettepe University (in collaboration with Turkey’s State Planning Organization) has estimated the size of the internally displaced population originating from Eastern and Southeastern Anatolia due to security related reasons during the twenty years between 1986-2005, as “between 953,680 and 1,201,200” and “80 percent of the security related migration …is rural originated, and 20 percent is urban originated” (HUIPS, 2006, p.2). Most of the people who left Eastern and Southeastern Anatolia lacked employable skills and often spoke very little Turkish (Aydagul, 2007). As a result of this internal migration process, big cities that received many migrants were negatively affected, because the process gave rise to unemployment, urban poverty, and socioeconomic integration problems (TESEV, 2006).

The issue of substantial regional and rural-urban inequality in Turkey has been included in the national development objectives since the 1960s. The major regional development initiative, the Southeastern Anatolia Project [Guneydogu Anadolu Projesi —GAP] started in 1977, with an initial focus on infrastructure development and improvements in agriculture, and has lately evolved into a more comprehensive program targeting socioeconomic development in the region. To overcome the regional disparities, development projects for the Eastern Anatolia and Black Sea regions were also initiated in the 1990's. They were less ambitious than the GAP, but also were based on the premise of fighting poverty (UNDP, 2004).

Attention to these regional disparities increased with the start of Turkey's accession negotiations with the EU in 2005. A fundamental objective of the EU is "strengthening economic, social, and territorial cohesion by reducing developmental disparities between its regions" (EU, 2008, p.1). For the years 2007-2013, more than one-third of the EU budget is allocated to the EU cohesion policy. The government's commitment to diminish the regional disparities is reflected in the latest development plans. The State Planning Organization's Ninth Development Plan 2007-2013 (DPT, 2006) included "ensuring regional development" as one of the five axes of socioeconomic development. The government considers the EU accession process to be "a comprehensive renovation and reform process" and targets an ambitious goal of "convergence to the economic and social standards of the EU" by the end of 2013 (p.21).

Given the importance of regional cohesion policies in the EU, Turkey's existing regional disparities need to be addressed in the move from an EU candidate country to full membership status by 2013. Therefore, an exploration of factors related to the existing regional disparities in educational quality is useful and timely. Understanding and identifying constraints and differences in learning outcomes between the developed and undeveloped regions will assist in formulating more equitable educational policies, including how to better prioritize and allocate resources.

Research on Factors Associated with Science Achievement

The overview of research studying the relationships between home and school factors and science achievement begins with a description of student background characteristics including family background, educational aspirations, and attitudes toward science. The discussion of student background factors is followed by a discussion of school context factors and classroom processes, including educational resources, instructional approaches, school climate, and community type.

Student Background Factors

Home Background

A substantial body of research in the social sciences has shown that family background is a key factor affecting students' learning outcomes. The most influential of such studies, the *Equality of Educational Opportunity*, known as the *Coleman Report* (Coleman et al., 1966) was conducted in the mid-sixties. This landmark study described the relationship between student and school characteristics and student achievement in grades 1, 3, 6, 9, and 12 as measured by performances on standardized achievement tests in reading comprehension and mathematics in the United States. One important finding of the report was that the students with educated parents and with those greater home educational resources (e.g., books and dictionaries) performed better than those from disadvantaged socioeconomic background. Further, the report found that the variance in student achievement accounted for by family background exceeded the effects of school resources including student/teacher ratios, number of books in the library, science laboratory facilities, and teacher characteristics. The conclusion of the report which is "schools bring little influence to bear on a child's achievement that is independent of his background and general social context" (Coleman et al., 1966, p.325) has been heavily contested ever since.

Heyneman and Loxley (1983) found that effects of student home background variables are not uniform across countries. This study included the following home background variables: age, sex, mother's education, father's education, father's occupation, number of books at home, presence of dictionary at home, and a measure of consumption such as a record player or dishwasher. The authors also found that the importance of such variables as predictors of student achievement was related to a country's economic development. That is, student home background variables, or "preschool effects" as Heyneman and Loxley called them, were "significantly more powerful determinants of achievement in high-income countries" (p.1176).

Heyneman and Loxley's findings were revisited two decades later by Baker, Goesling, & Letendre (2002) who used the TIMSS 1995 eighth grade data from 36 high-, middle-, and low-income countries and employed HLM (hierarchical linear models) which accounts for the hierarchical nature of students nested within schools. The authors found no "Heyneman-Loxley effect" but found instead what they called a "spreading Coleman effect". Their findings showed that student background measured by parents' education level and number of books in the home had a powerful effect on science achievement, regardless of national income.

Findings of the Baker et al. (2002) study were consistent with results from TIMSS school effectiveness study (Martin, Mullis, Gregory, Hoyle, & Shen, 2000), which also used TIMSS 1995 eighth grade data and employed HLM. This TIMSS 1995 study revealed that, in almost all countries, students in high-achieving schools had favorable home background including higher levels of parental education, books in the home, and other educational aids such as a study desk and computer.

Effects of home background were also studied in IEA's First International Science Study (FISS) and Second International Science Study (SISS) conducted in 1970/71 and 1983/84, respectively, for students who were 10 years old, 14 years old, and in the final year of secondary school. One of the key findings of the report (Keeves, 1992) that compiled the results of the 10 countries that took part in both studies of science education was that there were highly consistent positive relationships across countries between the science achievement of 14-year-old students (mostly in the eighth grade) and the students' home background, which was measured by parents' education level, use of dictionary, books in the home, and family size.

An exhaustive review of research conducted in the 1980s about major factors influencing the outcomes of mathematics and science education was documented in *Indicators for Monitoring Mathematics and Science Education*. In her chapter in this book, "Creating Indicators that Address Policy Problems", Oakes (1989) identified students' socioeconomic background among key variables that are associated with achievement. She concluded that sources of any inequity in schooling were likely to be linked to student characteristics as well as school opportunities for teaching and learning. Oakes also documented that family income, parental education level, parents' aspirations for their children, and the encouragement they provide for academic success were closely connected and interacted with what students experience at school.

Buchmann (2002) reviewed twenty-one international studies conducted between 1970 and 1995 that investigated the associations between family background and student achievement. Of these studies, six used science achievement data from FISS and SISS —the First International Science Study and Second International Science Study— as the learning outcome. These six studies measuring the effect of family background on science achievement used indicators of family socioeconomic status which typically included parental education, parental occupation, and number of books in the home. Buchmann's review of this body of international studies revealed consistent positive relationships between these family background variables and student achievement in science.

IEA's TIMSS assessments conducted after FISS and SISS provided additional evidence that eighth grade student performance in science is related to home background. TIMSS 1995, 1999, and 2003 identified the following factors among the important indicators of a home environment that is likely to support academic achievement: parents' education level, number of books in the home, and availability of educational resources such as a study desk and computer. Results from TIMSS 1995 (Beaton et al., 1996), TIMSS 1999 (Martin, Mullis, Gonzalez, et al., 2000), and TIMSS 2003 (Martin, Mullis, Gonzalez, & Chrostowski, 2004) consistently showed that, in almost all countries, home background as measured by these variables was positively related to eighth grade students' science achievement. Higher levels of parents' education, availability of higher numbers of books at home, ownership of a study desk, and home possession of a computer were all associated with higher science achievement.

Studies from four EU countries —Slovenia, Finland, Romania, and Bulgaria (Brecko, 2004; Reinikainen, 2004; Istrate, Noveanu, & Smith, 2006; Bankov, Mikova, & Smith, 2006, respectively) as well as from Turkey (Aypay, Erdogan, & Sozer, 2007; Berberoglu, Celebi, Ozdemir, Uysal, & Yayan, 2003; Ozdemir, 2003) used data from one of the three TIMSS cycles conducted in 1995, 1999, or 2003 and agreed with the previous findings of positive associations between favorable family background resources and eighth grade students' science performance. These studies found that students whose parents had higher levels of education performed better than those whose parents had less education. The number of books at home was also shown to be an important predictor of student achievement, except in Finland where the variable was not a significant predictor of achievement. Reinikainen (2004) explained the contradictory finding in relation to reading habits in Finland: "Finnish students are the most active library book borrowers within OECD countries, thus there is no need for large home-libraries in Finland" (p.197).

These studies identified two additional predictors of science achievement: speaking the language of the test at home and home possession of educational items such as a computer and study desk. Brecko (2004) found that Slovenian eighth grade students who often spoke the language of the test (Slovene) at home had higher science achievement than those who spoke it less often. Analyses of TIMSS 2003 data in Romania (Istrate et al., 2006) and Bulgaria (Bankov et al., 2006) highlighted that the possession of educational items at home was associated with higher science achievement.

To assess the effects of socioeconomic background on student performance, PISA 2006 constructed a composite measure that included various home background variables, including parents' occupational status, parents' education level, access to educational resources at home (e.g., study desk and Internet connection), and proxies of family wealth (e.g., ownership of a computer, a dishwasher, or a DVD player). This composite measure or index was a standardized variable with an OECD mean of zero and a standard deviation of one. Higher index values corresponded to favorable home backgrounds and lower values to unfavorable backgrounds (OECD, 2007a). PISA 2006 results showed that "in all countries, students with more advantaged home backgrounds tend to have higher PISA scores" (p.182). Turkey's national report on PISA 2006 documented (EARGED, 2007) that the range of the home background index value for most of the Turkish students who participated in the study was -2 to -1, indicating that most of Turkish students had unfavorable home background compared to the students on across OECD countries.

Caliskan (2008) used Turkey's data from PISA 2006 to study the effects of home background on science literacy. In this study, indicators of a disadvantageous home background were low level of parental education, family income, and number of books, as well as absence of a study desk or a computer at home. The author found that Turkish 15-year-old students (mostly ninth grade students) who came from a disadvantageous home background were likely to perform lower in science literacy than those from a favorable home background, which was characterized by a high level of parental education, family income, number of books, and the presence of a study desk or a computer.

TIMSS 2007, IEA's most recent international study in science, also found relationships between student achievement and family background variables. In almost all of the 49 countries that took part in the study, TIMSS 2007 found higher science achievement among eighth grade students whose parents had higher educational levels, that had more books and a computer at home, and that frequently spoke the language of the test at home (Martin et al., 2008, chapter 4). In Turkey, the association between parental level of education and science achievement was striking. The average science achievement score of Turkish students whose parents had a university degree was 135 score points higher (i.e., more than one standard deviation) than students with parents who had less than lower secondary schooling. This compared to a difference of 85 score points, on average, across the countries that participated in TIMSS 2007. Also, Turkey, among all 49 countries, had the lowest percentage of students (7%) with at least one parent who had graduated from a university.

Other large score differences in achievement results for groups of students highlighted Turkey's vast achievement gaps and socioeconomic disparities compared to other TIMSS 2007 participants, many of them developing countries. For example, only 5% of the Turkish eighth grade students reported having more than 200 books at home. This group of students scored almost one standard deviation higher than the one fourth of students (26%) with no more than 10 books. The difference in science achievement was more than half a standard deviation higher for those Turkish students who spoke Turkish always or almost always at home (89%) than for their counterparts who spoke Turkish sometimes or never, those who had computer (43%), and who had an Internet connection

(20%) at home. Of the 12 EU countries in TIMSS 2007 at the eighth grade, all had higher proportions than did Turkey of students with access to more than 200 books, a computer at home, and an Internet connection at home.

Educational Aspirations and Attitudes

FISS and SISS identified students' attitudes toward science among the factors that influence academic achievement (Keeves, 1992). Positive attitudes toward science developed in the home, the class, and society were found to be positively correlated with higher science achievement at all three ages tested —10, 14, and 18— in these two international studies in science. Students who thought science was not a difficult subject, that the science learned was useful for solving everyday problems, and considered science lessons to be enjoyable achieved higher scores in science achievement compared to their peers who held less favorable attitudes toward science. Keeves (1992) argued that attitudes play an important role in influencing performance in science at two levels — student and class. At the first level, students with more favorable attitudes relative to other students in the same class "recognize their higher level of attitude and behave accordingly to enhance their performance in science" (p.7). At the second level, the attitudes of the class members "may serve to lift or depress the performance of the group" (p.7). Therefore, the influence of attitudes at both levels should be considered by teachers and school administrators.

In their chapter in *Indicators for Monitoring Mathematics and Science Education* entitled “Outcomes, Achievement, Participation, and Attitudes”, Carey and Shavelson (1989) argued that students’ attitudes toward science were important because they predicted student achievement, persistence in attaining goals in science classes, and students’ decisions about whether to continue taking science courses and to pursue scientific careers. In particular, they identified the following student attitudes that were related to achievement: students’ perceived usefulness of learning science, their views about the capacity of science to help resolving social problems, their self-confidence to achieve in science, and their interest in and enjoyment of science.

In the TIMSS 1995 school effectiveness study (Martin, Mullis, Gregory, et al., 2000), students’ aspirations for further education were found to be a strong predictor of science achievement across 11 countries. Results from both TIMSS 1999 (Martin, Mullis, Gonzalez, et al., 2000) and TIMSS 2003 (Martin et al., 2004) provided additional evidence about the positive association in almost every country between science achievement and students’ educational aspirations in terms of how much they expected to advance their education. Eighth grade students expecting to finish university had substantially greater average science achievement than those with less than university-degree expectations. Data from TIMSS 1999 showed that more than half of Turkish eighth grade students reported that they expected to finish university and those students had higher scores in science achievement than those who expected to complete their education with less than a university degree.

Specifically, a study by Tai, Liu, Maltese, and Fan (2006) investigated, using a nationally representative longitudinal data, whether science-related career expectations of eighth grade students in the United States predicted the concentrations of their future college degrees. The authors found that students "who reported that they expected to enter a science-related career by age 30 obtained baccalaureate degrees in science-related fields at higher rates than students who did not have this expectation" (p.1143). The results of the study suggested that educational policies that encourage students' interest in science early on in their education may be effective in attracting more students into the science-related careers.

Eighth grade student achievement in science was also shown to be related to students' attitudes in the International Science reports from TIMSS 1995, 1999, and 2003 (Beaton et al., 1996; Martin, Mullis, Gonzalez, et al., 2000; Martin et al., 2004, respectively). In each assessment, there was an association between science achievement and students' positive attitudes toward science. That is, the more the students liked science, valued science in their life, and felt confident in learning science, the higher achievement scores they had.

Results from secondary analyses of data from TIMSS 1995, 1999, and 2003 are consistent with the TIMSS reports' findings about the relationship between science achievement and students' attitudes toward science. Based on TIMSS 1995 data for Ireland and Hong Kong (House, 2000, 2003) and TIMSS 1999 data for Cyprus (Mettas, Karmiotis, & Christoforou, 2003), eighth grade performance in science was higher if students reported that they liked science or enjoyed learning it than those who reported that science is boring. Results of the studies that examined Turkey's TIMSS 1999 science achievement were inconclusive. Based on an analysis using Structural Equation Modeling, Ozdemir (2003) concluded that there was "no or a very low relationship between students' science achievement and their perception of enjoyment of science" (p.56). However, Aypay et al. (2007) found, employing Discriminant Function analysis, that students in high performing schools in Turkey reported that they liked science or enjoyed learning it.

For the United States and Korea, House (2006) showed, using data from TIMSS 2003, that eighth grade students performed better in science if they reported that they learned things quickly in science and usually did well in science compared to their peers who indicated that science was not one of their strengths. Similarly, Berberoglu et al. (2003) and Ozdemir (2003) found, using TIMSS 1999 data, that science achievement of Turkish eighth grade students was lower for those who reported that science was not one of their strengths or science was more difficult for them than for many of their classmates.

Also, PISA 2006 examined students' attitudes and engagement with science in several areas including students' appreciation and support for scientific inquiry, students' value of science in society and in their personal life, students' confidence as science learners, and students' enjoyment in learning science (OECD, 2007a). Results from PISA 2006 found that, in the majority of countries, a strong appreciation of scientific inquiry, a strong value of science, high opinions of abilities in science, and enjoyment of learning science were associated with better performance in science. In Turkey, Caliskan's study (2008) examining the effects of students' attitudes on science literacy scores from PISA 2006 found attitude-achievement relationship patterns similar to the ones revealed by the TIMSS assessments. Ninth-grade Turkish students who reported that they learned school sciences topics quickly and easily performed better than their peers who reported less self-confidence in learning science.

Most recently, TIMSS 2007 explored eighth grade students' attitudes toward science and found that the student's enjoyment in science, student's value of science, and student's confidence in learning science were all positively associated with science achievement. Specifically, the more they enjoyed learning science, the more value they placed on its role in providing advantages to their future, and the more they had self-confidence in learning it, the higher achievement scores they attained (Martin et al., 2008, chapter 4).

School Factors

The long debate about factors contributing to the differential success of schools was fueled four decades ago with the controversial conclusion of the Coleman Report that “schools bring little influence to bear on a child’s achievement that is independent of his background and general social context” (Coleman et al., 1966, p.325). However, later studies involving a range of countries with varying levels of economic development have noted that schools do make a difference in academic achievement, over and above family background.

A study by Scheerens and Creemers (1989) presented a basic framework of a model for school effectiveness. The model “includes variables at the levels of the school, the context of the school, and the classroom, while background variables of pupils are also taken into account” (p.691). The authors emphasized that the critical element of the framework is the relationship between levels of the education system, —from higher to lower, school, classroom, and student levels— and asserted that “higher levels should provide facilitative conditions for the central processes at lower levels” for school effectiveness (p.702). That is, supportive conditions of the school should prepare the medium for effective instruction at the classroom level and the quality of classroom processes, coupled with the student background characteristics, influence the student achievement. Scheerens and Creemers concluded that, to enhance understanding of school effectiveness, research should be based on these cross-level relationships identified in the framework.

Resources

Two decades after the Coleman Report, Heyneman and Loxley's (1983) study addressed the power of schools in poor economic conditions. The study found evidence that schools in developing countries can compensate for the unfavorable effects of disadvantaged home backgrounds on learning outcomes. The authors explored the effects of various school variables on the science achievement of eighth grade students across 29 high- and low-income countries from Africa, Asia, Latin America, and the Middle East. The analysis included "close to 30 school variables at a time in each country's regression" (p.1171). Heyneman and Loxley considered the school variables as indicators of "school and teacher quality" such as number of students in laboratory classes, time spent on laboratory work, budget for science equipment, science teacher's age, and in-service training in science. The authors also found that "the poorer the country, the greater the impact of school and teacher quality on science achievement" (p.1180) as evidenced by the greater proportion of variance explained by the school and teacher quality variables in comparison to the proportion of explained variance by student background variables.

A review of research about the effects of school resources conducted in the 1980s (Oakes, 1989) identified two main school factors that are linked to science achievement: 1) the extent to which schools provide students with opportunities to learn science, including more teaching time and a rigorous curriculum, and 2) the extent to which school conditions provide a positive climate for teaching and learning, including parent involvement as well as professional development of teachers and school administrators.

The TIMSS 1995 school effectiveness study (Martin, Mullis, Gregory, et al., 2000) showed that, in some countries, school/classroom-related variables such as school size and location, school social climate, instructional activities, and amount of daily homework discriminated between the high- and low-achieving schools and were related to average school science achievement, even though these school variables were not consistent predictors of achievement across all countries.

Results from TIMSS 1999, 2003, and 2007 (Martin, Mullis, Gonzalez, et al., 2000; Martin et al., 2004; Martin et al., 2008, respectively) provided additional evidence that the availability of school resources for science instruction were related to student performance in science. The International Science reports of these TIMSS assessments presented results for an "Index of Availability of School Resources for Science Instruction" with three levels (high, medium, and low). The index was computed based on principals' responses to questions about shortages affecting schools' capacity to provide instruction in general (e.g., instructional materials and spaces and budget for supplies) and science instruction in particular (e.g., science laboratory equipment and supplies and audio-visual resources). The TIMSS results showed that on average, across countries, eighth grade students in schools with no or few resource shortages affecting instructional capacity (i.e., the high level of the index) had higher science achievement than students in schools with some or a lot resource shortages affecting teaching (i.e., the low level of the index). In Turkey, only 2% of the students were assigned to the high level of the index in TIMSS 1999 and 7% in TIMSS 2007. In 2007, this was the lowest proportion of students at this level of the index among the 12 EU countries.

Instructional Approaches

In addition to resources available for science instruction, the ways students are engaged in science appear to be important in enhancing student learning. Eighth grade science teaching practices were studied in the TIMSS 1999 Video Study (Roth et al., 2006). The study was a supplement to the TIMSS 1999 assessment and aimed to investigate and describe kinds of opportunities provided for students to learn science in eighth grade classrooms in five countries —Australia, the Czech Republic, Japan, Netherlands, and the United States.

Based on the analysis of videotaped lessons from the five countries, the study found that countries implemented different science teaching practices though they also shared some similarities in the teaching of science. The countries had different content features and ways in which students were involved in doing science activities in science lessons. The characteristics of science teaching that were commonly shared and accounted for at least 70 percent of lessons in all five countries included: whole-class presentations and/or discussions during the science lessons, development of new science content, explicit statements of lesson goals, and engaging students in actively doing science work.

Of these five countries, Australia, the Czech Republic, Japan, and the Netherlands had relatively higher achievement in the TIMSS 1995 and 1999 assessments at the eighth grade than the other participating countries. Science teaching shared two common features in these four relatively higher achieving countries:

- high content standards and expectations for student learning, though the definitions of "high content standards" varied across the four countries.
- a consistent, commonly shared instructional approach (as opposed to a variety of instructional approaches) across teachers within a country, though there was no single science teaching approach shared by the four countries.

Constructivist views of teaching and learning have gained popularity since the 1980's and, despite some debates and criticism, constructivism is "undoubtedly a major theoretical influence in contemporary science and mathematics education" (Mathews, 2000, as cited in Guo, 2007, p.232). Wynne (1999) reviewed the literature on effective science teaching and pointed out that there is a sound base of evidence that students construct their own ideas and understanding about scientific phenomena even before they were exposed to teaching about the phenomena. Reynolds (2007) pointed out that the new perspectives on the process of learning resulted in reconceptualization of teaching as an active process in which the student plays the active part in construction of knowledge in contrast to the passive role of being instructed. The author asserted that ideas about active learning change the role of the teacher: "The teacher is seen as a manager, an orchestrator of that learning process and is no longer seen as a person who delivers the content and the instruction, but as a supervisor and a counselor" (p.479). Wynne (1999) concluded that, according to constructivist views of teaching and learning, instruction should begin with some activities that are designed to allow students to express their ideas to the teacher, but that there is "less consensus [in the literature] about how to introduce the scientific view" and "no firm evidence as to the effectiveness of different approaches to developing pupils' ideas within a constructivist framework" (p. 40).

As mentioned previously, recent science curriculum reforms in Turkey are expected to promote constructivist ways of teaching and transform science teaching from teacher-centered practices to constructivist and student-centered practices (MoNE, 2005). Studies that used Turkey's data from TIMSS 1999, however, consistently found that science achievement had a negative relationship with so called student-centered classroom activities such as working in small groups, project work, and classroom discussions (Berberoglu et al., 2003; Ozdemir, 2003). Also, Aypay et al. (2007) found that some teacher-centered classroom activities were characteristics of the high-performing schools including demonstrations given by teachers and having students copy the notes from the board.

These findings might be explained with ineffective implementation of student-centered classroom activities in eighth grade science classes in Turkey as well as they might be related to the culture-sensitive nature of teaching and learning. Cobern (1996) argued that adopting constructivist views of teaching and learning could serve curriculum development efforts in non-western countries. However, the author cautioned developers of curriculum and other instructional materials that direct adoption of science textbooks written in western countries or adoption with only minor revisions may not work for countries in different cultures.

In addition to providing the guidelines on instructional approaches, Turkey's science curriculum in primary education also specified the amount of instructional time that should be devoted to science teaching. *TIMSS 2007 International Science Report* (Martin et al., 2008) presented data about the time spent in teaching science. In Turkey, science is taught as a single, general subject through the eighth grade whereas some other countries teach the sciences as separate subjects (e.g., biology, chemistry, physics). Among general science countries, teachers in Turkey reported that 8% of the total instructional time was devoted to science, which translated to 72 hours of science instruction per year, compared to the average figures across general science countries, 11% and 110 hours, respectively. These results meant that Turkish eighth grade students were provided with less time or opportunity to learn science compared to their peers in other countries.

School Environment

Key school characteristics associated with successful schools were summarized in the *International Handbook of School Effectiveness Research*. Among such characteristics, Reynolds and Teddlie's chapter (2000) included the following "processes of effective schools": teachers' expectations of high academic performance from all students (together with the communication of such expectations), increasing students' sense of motivation, and promoting strong parental involvement in schools. The authors concluded that "high expectations of students have been one of the most consistent of findings in the literature" (p.148) and "research generally supports the belief that parental involvement is productive of effective schools" (p.150).

Teachers' expectations of high student achievement were also identified among significant determinants of student performance in McKinley (2007). The author argued that teachers' low expectations result from "deficit thinking" which manifests itself in seeing non-mainstream or minority cultures as inferior, believing that student's background prevents learning, stereotyping students as not trying hard enough, and not taking on the responsibility to teach all students.

The *TIMSS 2003 International Science Report* (Martin et al., 2004) examined the impacts of "school processes". To measure the extent to which schools established a positive climate for learning, TIMSS 2003 created an index measuring principals' perceptions of school climate. School principals characterized the climate of their school in relation to the following characteristics of the learning environment: teachers' job satisfaction, teachers' understanding of the school's curricular goals, teachers' degree of success in implementing the school's curriculum, teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, student's regard for school property, and students' desire to do well in school. The index was based on principals' ratings of these aspects of school climate on a scale from "very high" to "very low". Eighth grade students were assigned to the high level of the index if they attended schools where the principal, on average, viewed these characteristics of school climate "high" or "very high". Students whose principals rated the school climate characteristics as "low" or "very low" were placed in the low category of the index. The results showed that there was strong positive relationship between principals' view of school climate and average science achievement at eighth grade.

Results from the *TIMSS 2007 International Science Report* (Martin et al., 2008) revealed a similar relationship between perceived school climate and science achievement. Students at the high level of the "Index of Principals' Perception of School Climate" had higher average science achievement, across all countries at eighth grade, compared to the students at the low level. In Turkey, on average, 8% of students were at the high level of the school climate index and 36% at the low level. Average science achievement was higher among students at the high index level and lower among students at the low level (499 points and 427 points, respectively).

Community Type

A recent review of literature on the "context of effective schools" identified the type of community, in which the school is located, such as urban or rural, among school features related to learning outcomes (Teddlie, Stringfield, & Reynolds, 2000). Even though there was no common definition of rural or urban areas across countries, rural settings were characterized by their relatively small population size or density as well as lack or absence of services and activities (Markandey, 2006). Geographical isolation and restricted access to services was reported to result in rural schools receiving less favorable resource allocations than urban schools, thus leading to lower student achievements (Webster & Fisher, 2000). However, it has also been suggested that schools located in smaller communities may generate more community support, thus may overcome educational obstacles and achieve better than urban schools (Young, 1998).

Results of some educational research have found rural-urban differences in achievement change from one country to another. For example, in Romania, eighth grade students in urban settings had higher science scores than their peers attending schools in rural areas (Istrate et al., 2006). Similarly, the Western Australian School Effectiveness Study (Young, 1998) revealed that Australian students attending rural schools performed lower in science than of students from urban schools. Contrary to the findings from Romania and Australia, Bulgarian students in rural places performed better compared to those who attended urban schools (Bankov et al., 2006).

Also, Trong (2009) used Progress in International Reading Literacy Study (PIRLS 2006) data from 40 countries to study the relative risk of low reading achievement for fourth grade students attending rural schools. The author found that there was a significant risk of low achievement associated with attending a rural school in 14 countries while in 6 countries attending a rural school had a decreased risk of low achievement. This study concluded that the level of reading achievement in relation to an urban, suburban, or rural school location is country specific. The results from this study were consistent with the results from PIRLS 2001 that found "In most countries, reading achievement is highest for those students in urban schools, lower in suburban schools, and even lower in rural schools" (Mullis, Martin, Gonzalez, & Kennedy, 2003, p.224). PIRLS 2001 also found that, in Turkey, average achievement of fourth grade students in urban schools (36%) was 41 points higher than those attending rural schools (25%).

This section reviewed the literature on factors related to science achievement and identified several home background and school context variables that are associated with science achievement. These variables consisted of student background characteristics such as socioeconomic home background, educational aspirations, and attitudes toward science as well as school factors including educational resources for science teaching, school climate for academic achievement, and community type. Investigation of Turkey's regional differences in achievement will be performed in light of this review.

Chapter 3

Methodology

The aim of this dissertation was to examine the extent of Turkey's regional differences in student achievement in science and to investigate factors associated with these differences. To reach this goal, this study used Turkey's TIMSS 2007 eighth grade science achievement data as well as background information from the questionnaires administered by TIMSS to students, science teachers, and school administrators.

This chapter documents the methodological aspects of the study in two main sections. First, it provides a description of the TIMSS 2007 database, including the sample design and implementation for Turkey as well as the science test and contextual background questionnaires, which were the instruments used in this dissertation. The TIMSS scaling methodology and the TIMSS 2007 international benchmarks in science are also discussed. The second section describes the methods that were followed in this study in analyzing the TIMSS 2007 data for Turkey. This section describes the two main phases of data analysis: first, the investigation of Turkey's regional differences, and second, the exploration of home and school factors contributing to the regional differences. The section on exploration of home and school factors includes procedures for exploratory analyses, ideas for the construction of composite variables, and plans for multilevel modeling.

Description of TIMSS 2007 Database

In order to work effectively with the TIMSS 2007 data it was important to have an understanding of the characteristics of this ambitious international assessment, involving complex procedures for sampling students, measuring students' achievement, and analyzing the data. These features of the TIMSS 2007 assessment are described in detail in the *TIMSS 2007 Technical Report* (Olson, Martin, & Mullis, 2008). The achievement data as well as student, teacher, school, and curricular background data for participant countries comprised the TIMSS 2007 international database, which is available for public use together with the *TIMSS 2007 User Guide* (Foy & Olson, 2009).

The User Guide describes the organization, content, and format of the data collected in TIMSS 2007 and presents methods and examples on how to analyze the data using various statistical software programs. The guide also provides the following four supplementary volumes:

- international version of TIMSS 2007 background questionnaires,
- description of the national adaptations made by specific countries to particular questions in each questionnaire (e.g., level of parents' education),
- explanation of how TIMSS constructed the derived variables in the database, and
- sampling stratification variables for each country.

Target Population and Sampling Implementation

At eighth grade, the TIMSS 2007 target population included all students enrolled in the eighth year of formal schooling, counting from the first year of primary school as defined by UNESCO's International Standard Classification of Education (ISCED) (Joncas, 2008a). For most countries, including Turkey, the target grade was the eighth grade.

To draw nationally representative samples of students, TIMSS 2007 used a two-stage cluster sampling technique (Joncas, 2008a). In this sampling method, the first stage was to sample schools with probability proportional-to-size (PPS). That is, the larger the size of a school, the greater the chance of being selected in the sample. Following the sampling of schools, the second stage was sampling one or more intact classes from the eighth grade in the sampled schools. Classrooms were selected with equal probabilities (i.e., random sampling). Typically, approximately 150 schools were sampled in each participating country, which yielded a representative sample of approximately 4,500 students in each participant country.

In TIMSS 2007, schools in Turkey with students in the eighth grade were first stratified by geographic region prior to sampling. The population of schools was split into seven strata—the Marmara, Aegean, Central Anatolia, Mediterranean, Black Sea, Southeastern Anatolia, and Eastern Anatolia regions. Following stratification, at the first stage of sampling 150 schools were selected using a systematic (random start, fixed interval) PPS sampling method from across the seven school sampling frames. This was intended to provide a school sample distributed across the regions in proportion to the number of students in each region. Of the 150 sampled schools in Turkey, four of them were found to contain no eighth grade students and were ineligible for participation in the test. All of the remaining 146 schools participated in TIMSS 2007 (Olson, Martin, & Mullis, 2008, Appendix B). At the second sampling stage, all eighth grade classes were listed within each sampled school and one class was randomly selected from the school. The students within the sampled classes comprised the TIMSS 2007 student sample for Turkey. A nationally representative sample of 4,498 Turkish eighth grade students participated in TIMSS 2007 (Joncas, 2008b).[10] Table 3.1 presents details of the regional sampling implementation in Turkey in TIMSS 2007.

Table 3.1. *Turkey's Sample Allocation in TIMSS 2007 at the Eighth Grade*

Region	Number of Schools Participated	Number of Students Participated	Average Age (SE)
Marmara	39	1362	13.96 (0.0)
Aegean	18	505	14.04 (0.0)
Central Anatolia	26	739	13.96 (0.1)
Mediterranean	18	527	14.06 (0.1)
Black Sea	16	442	14.02 (0.1)
Southeastern Anatolia	17	592	14.30 (0.1)
Eastern Anatolia	12	331	14.07 (0.2)
TURKEY	146	4498	14.03 (0.0)

Note. "Number of Schools" from Appendix B of the *TIMSS 2007 Technical Report* (Olson, Martin, & Mullis, 2008). For computing average age, IEA's International Database Analyzer (IEA, 2008) was used.

[10] Based on this sample, Turkey's eighth grade student population is estimated to be 1,091,654 (Joncas, 2008b).

This study capitalized on two characteristics of Turkey's student sample from TIMSS 2007:

- the sample was nationally representative, which allowed for generalizations of the results of this study to the national level, and
- region-level stratification, which enabled investigation of the extent of regional differences in student achievement.

Science Test

As explained in detail in the science framework published in the *TIMSS 2007 Assessment Frameworks* (Mullis et al., 2005), the science test questions (i.e., items) in the TIMSS 2007 assessment were developed to measure both content and cognitive dimensions. The content dimension or domains specified the subject matter that was assessed in the TIMSS 2007 science test. The cognitive dimension or domains specified the thinking processes that students were likely to utilize as they responded to the items. At the eighth grade, all science items were categorized according to one of four content domains —biology, chemistry, physics, and earth science— and one of three cognitive domains —knowing, applying, and reasoning. Some of the science items also tested students' scientific inquiry skills, which were treated in the TIMSS science framework as an overarching field of science that encompassed both content and cognitive dimensions.

The TIMSS 2007 science test items were developed through a collaborative process. Item writing and review, field-testing, and revision involved representatives of the participating countries as well as an international panel of experts in science. This extensive process ensured content accuracy, grade appropriateness, framework fit, and sound psychometric characteristics of the items (Ruddock, O'Sullivan, Arora, & Erberber, 2008). The TIMSS 2007 eighth grade science test included a total of 214 science items. Half of the items were in multiple-choice format and worth one score point each. The other half consisted of constructed-response items that required students to write their responses. The constructed-response items were worth either one score point if a short response was required or two points for items requiring longer explanations. The total number of score points on the science test was 240.

To ensure reliable scoring of student responses to constructed-response items, scoring teams in each country went through extensive scoring training using carefully developed scoring guides and training materials that included sample student responses and practice papers. Moreover, the scorers' actual scoring performance was continuously monitored during the scoring activity. Details of the TIMSS scoring methods and guidelines, the development of the scoring guides, and the procedures for conducting the scoring training are explained in Ruddock et al. (2008).

TIMSS 2007 documented the extent to which constructed-response science items were scored consistently by the scorers in each country. The percentage of exact agreement between scorers, on average internationally, was 96 percent, and 97 percent for the scorers in Turkey (Olson, Martin, Mullis, Foy, et al., 2008). This high degree of scoring consistency indicated that the TIMSS 2007 scoring procedures were accurate and reliable. TIMSS 2007 also documented the reliability of the science test for each country. Reliability was estimated using the Kuder-Richardson Formula 20 (KR-20). The coefficient was the median KR-20 reliability across all the 14 booklets in the test. Reliabilities were generally high. The median of the reliability coefficients across all countries was 0.84 and the coefficient for Turkey was 0.85 (Martin et al., 2008).

The TIMSS 2007 assessment had very ambitious goals for subject coverage, resulting in many more items than any one student could be expected to take. In fact, the TIMSS 2007 eighth grade test, including both science and mathematics items would require nearly 11 hours of testing time if a single student were to take all of the items (Mullis et al., 2005). In order not to exceed the individual student testing time of 90 minutes, while keeping the broad framework coverage, TIMSS used a matrix-sampling approach. Matrix-sampling involves grouping the test items into “test blocks” and distributing the blocks across a number of test booklets, with each student answering the science and mathematics items in only one booklet. In TIMSS 2007, the entire set of mathematics and science items was grouped into 28 blocks, 14 for mathematics and 14 for science. The blocks were distributed according to a rigorous design across 14 booklets, each containing two science blocks and two mathematics blocks.

This complex assessment design provided an efficient method of data collection. That is, data were collected across a broad expanse of science content without overburdening the students. However, because each student responded only to a single booklet containing a subset of items and not to the entire set of items in the test, TIMSS data are not intended for making decisions or statements about individual students. Rather, the information each sampled student provides is used to make inferences about the distribution of achievement in the student population (Foy, Galia, & Li, 2008).

Scaling Method

To make inferences about the science achievement of the Turkish eighth grade student population, this dissertation used TIMSS 2007 science proficiency scores that were imputed using a sophisticated scaling method. As explained in detail in Foy et al. (2008), TIMSS used Item Response Theory (IRT) scaling in combination with conditioning and multiple imputation ("plausible values" methodology) to provide estimates of student achievement for analysis and reporting purposes.

The IRT scaling produces a score by averaging the responses of each student to the items, taking into account the difficulty and discriminating power of each item. A student's score is an estimate of proficiency on the entire test even though the student was administered just part of the test. Because the IRT estimate of a student's score is based on the student's responses to the items that the student takes in just one booklet, the estimated score has relatively larger uncertainty than would an estimate based on the entire test.

To improve reliability of the performance measurement, TIMSS uses an approach known as "conditioning" which draws on information about students' background characteristics, in addition to students' responses to the items they were administered. In this procedure, student responses to the items on the test are combined with all available background information to estimate the distribution of student achievement in the population, conditional on this background information. Using this achievement distribution of the student population, for each student in the population a score on the entire test is imputed based on the student's item responses as well as his or her background characteristics. This imputed score is also known as a *plausible value*.

A plausible value is not a personal test score in the usual sense, but rather an *imputed* score conditional on the item responses and background characteristics. Therefore, there is uncertainty or error inherent in this imputation process. To quantify the error, TIMSS repeats the imputation process and generates five plausible values for each student. The variation between the five plausible values allows estimating the imputation error in the measurement model. Analyses with the TIMSS plausible values, therefore, should be conducted five times, using a different plausible value each time. The average of the five sets of results provides the best estimate of the statistic in question. The difference between the results of the five replicated analyses reflects the imputation error. In this dissertation, all five plausible values in science were used in the analyses of Turkey's data from the *TIMSS 2007 International Database* (Foy & Olson, 2009).

International Benchmarks of Science Achievement

As summarized in the previous section, considerable effort was devoted to constructing the TIMSS 2007 science achievement scale. To facilitate users of TIMSS scale scores in interpreting the meaning of the scores, TIMSS 2007 used a scale anchoring procedure to summarize and describe student achievement at four points on the scale, selected to represent important benchmarks internationally. Detailed information about the process of selecting the benchmarks in TIMSS science scale as well as on the procedure of scaling anchoring is provided in Mullis, Erberber, and Preuschoff (2008).

The TIMSS 2007 International Benchmarks correspond to four points on the TIMSS achievement scale as follows: Advanced International Benchmark (625), High International Benchmark (550), Intermediate International Benchmark (475), and Low International Benchmark (400). The scale anchoring procedure first identified students who scored at each international benchmark (i.e., within plus or minus 5 scale points of the benchmark). The next step was determining the science items that anchored at each of the benchmark points. To do this, criteria were applied to determine the sets of items that students reaching each international benchmark were likely to answer correctly and that those at the adjacent lower benchmark point were unlikely to answer correctly. For example, a multiple-choice item anchored at the Advanced International Benchmark if at least 65 percent of students scoring at the Advanced International Benchmark answered the item correctly and less than 50 percent of students scoring at the High International Benchmark answered it correctly.

After determining the items that anchored at each of the benchmarks, an international panel of experts in science education scrutinized those anchor items and their scoring guides. The purpose of this process was to describe the knowledge and skills demonstrated by students correctly answering each item that anchored at each international benchmark. The experts then synthesized these item descriptions to provide a general description of student competency at each benchmark. At the eighth grade, competency in science ranged from demonstrating a grasp of some complex and abstract concepts in science at the advanced benchmark to simply recognizing some facts from the life and physical sciences at the low benchmark (Martin, et al., 2008, chapter 2).

Background Questionnaires

In addition to assessing students' performance in mathematics and science, TIMSS 2007 collected a wealth of information about the home and school contexts in which learning takes place. This contextual information is crucial to understanding the achievement results, because it sheds light on the factors likely to shape students' outcomes. TIMSS 2007 gathered this contextual information via background questionnaires. A description of the contextual framework underlying the questionnaires, the process used to develop them, and the content of the questionnaires is provided in detail in Erberber, Arora, and Preuschoff (2008).

In TIMSS 2007, four different background questionnaires were administered to gather information from the participating students, the students' mathematics and science teachers, their school principals, and curriculum experts in the participating countries. The *Student Questionnaire*, completed by the students, collected information about students' family background characteristics and resources, their attitudes toward learning mathematics and science, and their school experiences and instruction. Science teachers of the students completed the *Science Teacher Questionnaire* which focused on the classroom activities for science instruction, the teacher's background and training, and instructional approaches and resources for science teaching. The *School Questionnaire* gathered information from the school principals about school demographics, facilities available to support teaching and learning, and the school climate for learning and teaching. Finally, the *Curriculum Questionnaire*, completed by curriculum experts in each country, collected information on the science curriculum and policies of the participant countries.

Methods

The aim of this dissertation study was two fold: first, to examine the extent of Turkey's regional differences in science achievement, and second, to investigate factors associated with the differences. Consequently, data analysis in this study consisted of two phases. In the first phase, regional differences in student achievement were investigated. In the second phase, home and school background factors contributing to the regional differences were explored using a multilevel statistical model of student achievement.

Taken together, the results from the TIMSS contextual questionnaires provided approximately 400 potential explanatory variables at the eighth grade. This extensive database provided a solid basis for analyzing factors associated with regional differences in science achievement in Turkey.

To make inferences about the science achievement of the eighth grade Turkish student population, this study used data from Turkey's TIMSS 2007 student sample. In analyzing the sample data, it was necessary to take the TIMSS sampling design into account so that sample statistics would accurately reflect population attributes. Therefore, in all analyses of this study, the student sampling weight (TOTWGT) was used. This sampling weight was provided for each student in the *TIMSS 2007 International Database* (Foy & Olson, 2009) and properly accounts for the sample design, takes the stratification into account, and includes adjustments for non-response (Joncas, 2008b). The use of TOTWGT in this dissertation ensured that all subgroups of the sample were properly represented in the estimation of population parameters.

Phase 1: Investigation of Turkey's Regional Differences in Achievement

As presented in Chapter 1 of this dissertation, three research questions were investigated in this study. The first phase of the data analysis produced statistics to address the first research question, the investigation of Turkey's regional differences in science achievement. The remaining two research questions concerning home and school factors influencing the regional differences were addressed in the second analytic phase using multilevel modeling as described in a subsequent section of this chapter.

The first phase of the data analysis began with computing average science achievement for each region as well as for Turkey as a whole. For this computation, the IEA's International Database (IDB) Analyzer (IEA, 2008) was used. The IDB Analyzer was developed by IEA to analyze data from IEA surveys such as TIMSS 2007 that used a complex sample design and made use of the plausible value methodology. The program computes achievement means for groups of students using all five plausible values for each student. That is, it computes a mean using the first plausible value for each student, a mean using the second plausible value, and so forth through all five plausible values and averages the results.

The IDB Analyzer computes standard errors for statistics of interest using the jackknife repeated replication method. The jackknife method provides unbiased estimates of the standard errors by taking into account the sampling design used in the TIMSS 2007 as well as the variation among the five plausible values generated for each student (Foy et al., 2008). That is, the jackknife standard errors produced by the IDB Analyzer incorporate two components: sampling variance (uncertainty due to generalizing from student samples to entire student population) and imputation variance (uncertainty due to estimating students' performance on the entire test based on their performance on the subset of items they took in the test).

Once the estimate of average science achievement (and its standard error) was computed for Turkey and for each region, the next step in the first phase of the data analysis was to describe regional achievement differences at the TIMSS International Benchmarks using the IDB Analyzer. It was important to provide descriptive information about regional differences in the types of science knowledge, concepts, and methods represented by the gaps in average achievement between higher and lower performing regions. For example, students reaching the Advanced International Benchmark demonstrated a grasp of complex and abstract science concepts, while those reaching the Low International Benchmark only demonstrated recognition of basic science facts. The TIMSS 2007 database included five benchmark variables for each student, indicating the international benchmark each student reached based on his or her five plausible values on the science scale. The percentages of students meeting the four TIMSS International Benchmarks for science achievement were computed for Turkey, and separately by region, using the IDB Analyzer.

Phase 2: Investigation of Factors Contributing to Regional Differences

The second phase of the data analysis addressed the second and third research questions of this dissertation, the exploration of home and school background factors contributing to Turkey's regional differences in science achievement. To investigate such factors, the TIMSS 2007 background variables associated with achievement differences across regions were identified via an exploratory analysis and then examined for their contribution to reducing the regional differences in achievement using a multilevel modeling technique.

Exploratory Analyses

The wide range of background information collected by TIMSS 2007 from various levels of the education system —students, teachers, principals— facilitated the exploration of factors helpful in understanding regional science achievement differences in Turkey. After exploratory analyses of Turkey's extensive background questionnaire data, a number of student background factors and school context factors emerged to be included in developing a model of regional differences in science achievement in Turkey.

Keeping the review of literature in mind, exploratory analyses of Turkey's background questionnaire data began with a review of the data almanacs provided in the *TIMSS 2007 International Database* (Foy & Olson, 2009). Background data almanacs consisted of descriptive statistics for each country and averaged internationally. A variety of statistics were provided for categorical background variables (e.g., gender), including the percentage of students in each category and mean science achievement, and for continuous variables (e.g., total instructional hours in school in a day), including the minimum, mean, mode, and percentile scores. These statistical summaries of the data for the hundreds of background variables collected via the student, teacher, and school questionnaires were reviewed for Turkey and a preliminary set of variables that showed an association with science achievement were selected for inclusion in developing the science achievement model. In addition, exploratory analyses were performed to investigate whether the associations identified at the country level were also found at the region level.

Before proceeding with the inclusion of any selected variables in further analyses, some of them were recoded to have a better response distribution compared to the original variables and have the benefit that higher category codes characterize higher levels of the variables. In addition, original variables were reviewed for national adaptations that were implemented by Turkey. Supplement 2 of the TIMSS 2007 database provides information on the variables that countries adapted, did not administer, or modified to suit their national context.

Constructing Composite Variables

The TIMSS 2007 questionnaires often included several questions related to a single underlying construct. In these cases, responses to the individual questions were combined to create a derived variable to be used in the eventual multilevel modeling analysis for Turkey. Derived variables are comprised of various facets of the construct of interest, and thus provide a more comprehensive picture of the construct than the individual variables. An individual variable "may not capture the complexity of the phenomenon of interest" whereas a derived variable consisting of several components "may capture the essence of such a variable with a degree of precision that a single item could not attain" (Devellis, 2003, p. 9-10). Therefore, derived variables have an advantage of providing a more reliable measure of the construct. For example, the student questionnaire collected data on home resources including the number of books, availability of a computer, an Internet connection, and a study desk for student's use, as well as a number of home possessions that was used as a proxy measure of family income specific to each country. Turkey's TIMSS 2007 student questionnaire asked about the availability of a dishwasher, a washing machine, a heating system, and a DVD player. These individual variables targeting the students' home resources were used in constructing a derived variable that became an "Index of Home Resources".

The procedure for developing the indices involved several steps. First, some variables needed to be reverse coded so that the scale direction would make more sense conceptually. For example, the students who responded "Yes" to home possession variables were expected to have higher science achievement than those with "No" responses. Originally, home possession variables were coded as "Yes=1" and "No=2" in the TIMSS 2007 database. For the purposed if this dissertation, these variables were recoded as "Yes=1" and "No=0" so that the higher values of the variables indicated presence of the resources at home and the variables had a positive relationship with the achievement.

Second, principal components analyses were performed to examine the underlying dimensionality of the indices using different combinations of variables. Composite variables "capture much of the information originally contained in a larger set of items" (Devellis, 2003, p.128). The unidimensionality of an index was examined to see whether there was evidence of one common factor (composite variable) that was sufficient to account for the pattern of responses to the individual (component) questions.

When the emergent factor explained most of the variance among the individual variables, it was considered that there was evidence that the component questions were measuring the same construct of interest. The degree of reliability of an index was also assessed. The variables that lowered the reliability of an index (i.e., the variables that were not highly correlated with the other individual variables) were dropped from the set of items that contributed to the construction of the index. After component variables of a construct were identified, the index scores were computed by averaging the numerical values associated with each response option.

To provide interpretability of results from this study, as an additional step, students were assigned to two index levels with substantive meanings. Responses that were expected to characterize the most supportive learning environment were assigned to the high category of an index. By contrast, the low category of the index included the responses that were expected to characterize the least supportive learning environment. For example, the scores on the "Index of Home Resources" were computed by averaging the students' responses to seven source variables (i.e., computer, study desk, Internet connection, number of book, dishwasher, heating system, and DVD player). Next, students with access to at least four of the seven home resources (i.e., average index score above 0.5) were placed in the high category of the index while students with access to three or less home resources (i.e., average index score below 0.5) were assigned to the low level of the index.

Modeling Science Achievement in Turkey

Following the identification of background variables and development of composite variables that were associated with regional differences, the next analysis phase was to use a multilevel modeling technique to investigate the relationship of student background and school context variables with science achievement in Turkey. This investigation was designed to increase understanding of the underlying reasons for the regional achievement differences revealed by the first phase of the data analysis.

In the TIMSS 2007 sampling design, sampled students were clustered within schools/classes. Due to this nesting, students share the same context (e.g., they might come from the same neighborhood, they might share the same teachers and classroom resources), and hence tend to be more like each other in terms of an outcome of interest than would be students *randomly* sampled from the entire student population (Snijders & Bosker, 1999). Hierarchical Linear Modeling (HLM) explicitly accounts for the multilevel structure of the nested data, thus standard errors of regression coefficients can be estimated without bias (Raudenbush & Bryk, 2002). Considering the nested structure of the TIMSS data, in this dissertation study the HLM6 software program (Raudenbush, Bryk, & Congdon, 2004) was used. This program is designed to carry out the computations with five plausible values in the TIMSS 2007 dataset and can utilize the sampling weight variables of the dataset. Moreover, similar to the IDB Analyzer, HLM6 produces unbiased estimates of the standard errors by including two components of variation: the sampling variance as well as an imputation variance.

In TIMSS 2007, because students were nested within classes and classes within schools, there were three possible sources of variation in student achievement: the differences between schools, between classrooms within schools, and within classrooms. However, variance was not separated at the class level, because in TIMSS 2007 in Turkey only one class was selected from each sampled school. As a result, each school in the country was represented by one class and the differences between classes were indistinguishable from the ones between schools. Therefore, “schools” stands for “schools/classes” in this dissertation.

Unconditional Model

This two-level hierarchical nature of Turkey’s data lent itself to multilevel modeling at two levels —the school/class level (level-2) and the student-within-school/class level, also known as the student level (level-1). In modeling science achievement in Turkey, the preliminary step was estimation of the *unconditional model*. It is called unconditional because it examines the achievement variance without considering any explanatory variables. Two levels of the *unconditional model* are shown in Equation 3.1 (level-1 or student-level) and Equation 3.2 (level-2 or school/class level). The combined or mixed model that analyzed the data simultaneously at two levels of the educational hierarchy is presented in Equation 3.3

Level-1: $$y_{ij} = \beta_{0j} + r_{ij} \tag{3.1}$$

Level-2: $$\beta_{0j} = \gamma_{00} + u_{0j} \tag{3.2}$$

Mixed model for the *unconditional model*: $$y_{ij} = \gamma_{00} + u_{0j} + r_{ij} \tag{3.3}$$

Where:

y_{ij} = Science score of student *i* in school/class *j*

β_{0j} = Mean science score for *j* school/class

γ_{00} = Grand mean science score

r_{ij} = Random error associated with student *i* in school/class *j*

u_{0j} = Random error associated with school/class *j*

The *unconditional model* provides decomposition of the total achievement variance into two components: between-school/class and within-school/class. Between-school/class variance is the variation in the achievement of students that lies between schools/classes and within-school/class variance is due to the individual students' characteristics and home environment. Variables measured at the school/class level, such as region or rural/urban setting of a school, cannot be used to explain variance at the student level because such variables are constant for all students within a school/class (i.e., all students have the same value on school/class level variables).

Further, the *unconditional model* allows for the calculation of the intraclass correlation coefficient (ICC) —the ratio of the between school/class variance to the total achievement variance. The ICC is an indicator of the degree to which schools/classes within Turkey differ in their mean science achievement and sets the maximum amount of between-school/class variance that is available to be explained. The ICC was computed as follows (Equation 3.4):

$$ICC = \rho = \frac{\hat{\tau}_{00}}{\hat{\tau}_{00} + \hat{\sigma}^2} \tag{3.4}$$

Where:

$\hat{\tau}_{00}$ = Between-school/class variance

$\hat{\sigma}^2$ = Within-school/class variance

Base Model

Following the *unconditional model*, several conditional models were tested. Because investigation of the independent effects of geographical regions was a primary interest of this dissertation study, the basic conditional model was the one that included only the region factor and no other exploratory variable. All other conditional models included the region factor but also other predictors of student achievement. The aim of the analysis was to identify factors that when added to the basic model reduced the regional effect. Therefore, the model that included only the region variable was considered as the *base model* in this dissertation.

As mentioned in the literature review, Turkey has a highly centralized education system, including a standardized curriculum in primary education (grades 1 to 8), which prescribed the content to be taught and the guidelines to be followed while teaching and assessing the content. All Turkish students across the country are intended to be provided with similar learning opportunities in terms of teaching time and content by the end of primary education. As documented in the *TIMSS 2007 International Science Report* (Martin et al., 2008), in Turkey, there was indeed no TIMSS 2007 science topic that was intended to be taught only to top track students and Turkish science teachers reported that most of the eighth grade students had been taught the science topics in TIMSS 2007.

In such a centralized system, one would expect that all schools in Turkey would look similar in terms of their average student achievement, regardless of the geographical location of the schools. Yet, this dissertation study hypothesized that schools in Turkey's different regions vary with respect to the achievement of their students and, specifically, the schools in socioeconomically less developed regions would attain lower science scores than schools in developed regions. Thus, the *base model* explored whether the Turkish educational system performs differently in different regions. The model tested the effect of attending school in each of the six regions compared to attending school in the Marmara, the most socioeconomically developed region. Because the *base model* did not consist of any predictors at the student level, it had the same level-1 equation of the *unconditional model*. At level-2, however, the *base model* elaborated the intercept parameter (β_{0j}) of the *unconditional model* via including six region variables (see

Equation 3.5). Thus, the *base model*, could be represented in a combined or mixed model as shown in Equation 3.6.

Level-1: $$y_{ij} = \beta_{0j} + r_{ij} \tag{3.1}$$

Level-2: $$\beta_{0j} = \gamma_{00} + \gamma_{01}(Central_j) + \gamma_{02}(Aegean_j) + \gamma_{03}(Mediterranean_j)$$

$$+ \gamma_{04}(BlackSea_j) + \gamma_{05}(East_j) + \gamma_{06}(Southeast_j) + u_{0j} \tag{3.5}$$

Mixed model for the *base model*:

$$y_{ij} = \gamma_{00} + \gamma_{01}(Central_j)...\gamma_{06}(Southeast_j) + u_{0j} + r_{ij} \tag{3.6}$$

Where:

$\gamma_{01} \ldots \gamma_{06}$ = Main effects for the six region variables

As mentioned previously, all of the other conditional models were built on the *base model*. That is, these models always included the region factor but also other variables measured at student-level or school/class-level. The goal was to identify variables that, if altered, would serve to reduce the magnitude of the region effect. To explore the individual contribution of each student background variable and school context variable to the regional achievement differences, each variable was added to the *base model* individually. This allowed exploring the extent to which controlling each variable could be expected to diminish the effect of region. The following sections present the *student background models* and then the *school context models* that were built on the *base model*.

Student Background Models

As discussed in detail in Chapter 2, the regions in the western part of Turkey lag far behind the regions in eastern Turkey in terms of all socioeconomic indicators, including educational and wealth factors. As a result, disadvantaged students tend to be concentrated in the eastern part of the country and enter schools with vast socioeconomic background differences in terms of their parental education level and home resources. Turkish students may also vary widely in their attitudes toward science and in terms of their educational aspirations because these student characteristics are mainly developed and shaped in the home, school, and society in which they live. As summarized in the literature review, socioeconomic home background characteristics and students' individual characteristics were identified as powerful indicators of achievement. Moreover, a major ethnic group (Kurds) in the country populated the eastern part of Turkey, speaking mostly their mother-tongue at home. Less fluency in Turkish, the formal language of instruction in Turkey, may limit the grasp of instruction in class and influence student achievement.

To explore the contribution of these student background characteristics to the regional achievement differences, several *student background models* attempted to discover the effect of student characteristics and socioeconomic background on science achievement. Each model was built upon the *base model* (i.e., the region model) and included only one student-level variable. For example, the *parental education model* included only the parental education predictor at level-1 (Equation 3.7). As shown in

Equation 3.8, formulation of level-1 model with a predictor required level-2 model to be characterized by a regression coefficient, β_{1j}, in addition to the intercept, β_{0j}, of the *base model*. Therefore, the mixed model was represented as in Equation 3.9.

Level-1: $y_{ij} = \beta_{0j} + \beta_{1j} Parentaleducation_{ij} + r_{ij}$ (3.7)

Level-2: $\beta_{0j} = \gamma_{00} + \gamma_{01}(Central_j) + \gamma_{02}(Aegean_j) + \gamma_{03}(Mediterranean_j)$

$$+ \gamma_{04}(BlackSea_j) + \gamma_{05}(East_j) + \gamma_{06}(Southeast_j) + u_{0j} \quad (3.5)$$

$$\beta_{1j} = \gamma_{10} \quad (3.8)$$

Mixed model for the *parental education model*:

$$y_{ij} = \gamma_{00} + \gamma_{01}(Central_j)...\gamma_{06}(Southeast_j) + \gamma_{10}(Parentedu_{ij}) + u_{0j} + r_{ij} \quad (3.9)$$

Where:

γ_{10} = Regression coefficient associated with predictor “parent education”

Similar to the *parental education model*, other *student background models* were build on the *base model*, thus the mixed model of these models had an equation similar to Equation 3.9 but with a level-1 predictor other than the parental education variable. These mixed models included the following student background variables: frequency of speaking Turkish at home, home resources, and parental education level.

The final student background model examined the joint effects of all student background factors on the regional achievement differences. Therefore, the model included all student-level variables added to the *base model*. This analysis revealed the extent to which regional differences in science achievement were related to student background factors, before taking school factors into account. The mixed model for this final student background model — *overall student background model* (Equation 3.10) had an equation similar to Equation 3.9 of the *parental education model* but also included all other student-level variables.

Mixed model for the *overall student background model*:

$$y_{ij} = \gamma_{00} + \gamma_{01}(Central_j)...\gamma_{06}(Southeast_j) + \gamma_{10}(Stdlevel1_{ij})...\gamma_{Y0}(StdlevelY_{ij}) + u_{0j} + r_{ij} \tag{3.10}$$

Where:

$\gamma_{10} \cdots \gamma_{Y0}$ = Regression coefficients associated with student-level variables

School Context Models

The literature review suggested that several school factors, such as availability of school resources and positive school climate for academic achievement, can be changed or improved to create conditions conducive to teaching and learning. Thus, such school environment variables were considered as potential mechanisms to help alleviate socioeconomic disadvantage. As documented in Chapter 2, in Turkey, school resources were distributed unevenly, with inadequacies of resources in some regions, including lack of space, limited budget for supplies, little or no science laboratory equipment, and few audio-visual resources, all with the potential to negatively affect the quality of science instruction. Moreover, characteristics of the learning environment in Turkey's schools, including the level of teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, and students' desire to do well in school, also differed across regions and varying levels of school climate for learning were related to the differences in science achievement.

To explore the contribution of school factors to the regional achievement differences, several *school context models* attempted to discover the effect of school factors on science achievement. Each model built upon the *base model* (i.e., the region model) and included only one school/class level variable. This allowed investigating the influence of each school/class factor on regional achievement differences. For example, the *school resources model* tested the effects of shortages of school resources available for science instruction. Because the *school resources model* did not consist of any predictor at the student-level, it had the same level-1 equation of the *base model*. However, at level-2 (Equation 3.11), the school resources variable was included in the model in addition to the six region variables of the *base model*. The combined model for the *school resources model*, that analyzed the data simultaneously at two levels, is represented in Equation 3.12.

Level-1: $y_{ij} = \beta_{0j} + r_{ij}$ (3.1)

Level-2:

$$\beta_{0j} = \gamma_{00} + \gamma_{01}(Central_j) + \gamma_{02}(Aegean_j) + \gamma_{03}(Mediterranean_j) + \gamma_{04}(BlackSea_j)$$

$$+ \gamma_{05}(East_j) + \gamma_{06}(Southeast_j) + \gamma_{07}(Schoolresources_j) + u_{0j} \quad (3.11)$$

Mixed model for the *school resources model*:

$$y_{ij} = \gamma_{00} + \gamma_{01}(Central_j)...\gamma_{06}(Southeast_j) + \gamma_{07}(Schoolresources_j) + u_{0j} + r_{ij} \quad (3.12)$$

Effects of a school atmosphere that is more conducive to learning may be investigated in a *school climate model* which was also build on the *base model* following the approach used in the *school resources model*. The mixed model of the *school climate model* would, therefore, have an equation similar to Equation 3.12 but including a school climate variable instead of a school resources variable.

Turkey's less developed regions have higher proportions of rural schools compared to developed regions. Also, isolated or less populated rural schools in Turkey characterized by scarcer resources compared with urban schools, thus it was anticipated that they would underachieve compared with urban schools. The literature review suggested that school community type (i.e., rural or urban) may affect students' academic achievement in Turkey. Because of the relationship of the two school/class-level variables —region and community type of the school— with each other as well as with achievement, there is an interest in attempting to disentangle the independent effects of region and community type on achievement even though they are highly correlated. The next school model explored the effects of school community type on the regional achievement differences. As in the case for the mixed model of the *school climate model*, combined equation of the *school community model* was similar to Equation 3.12 but included school community as the level-2 predictor rather than the school resources variable.

The final school context model examined the aggregate effects of all school context factors on the regional differences in science achievement. Therefore, the model included all school/class-level variables added to the *base model*. This analysis revealed the extent to which regional differences in science achievement were related to school context factors, before taking student background factors into account.

As shown in Equation 3.13, the mixed model for this final school context model — *overall school context model* — had an equation similar to Equation 3.12 of the *school resources model* but also included all other school/class-level variables.

Mixed model for the *overall school context model*:

$$y_{ij} = \gamma_{00} + \gamma_{01}(Schlevel1_j)...\gamma_{0X}(SchlevelX_j) + u_{0j} + r_{ij} \tag{3.13}$$

Where: $\gamma_{01} \ldots \gamma_{0X}$ = Main effects for school-level variables

Final Model

The *final model* builds on the student background and school context models presented in the previous sections. As discussed earlier, these student background and school context models aimed to identify the independent or isolated effects of student background and school context factors on the regional differences in science achievement. Admittedly, however, the schooling process is a complex dynamic system in which all student background and school context factors act interdependently in influencing student outcome. That is, these factors do not operate in isolation but rather they simultaneously act in an education system. Therefore, Turkey's regional differences in student achievement cannot be seen as solely a result of student background characteristics or of school context factors. To acknowledge the integrated nature of the education system, where multiple factors at different levels of the system (i.e., student-level and school/class-level) operate simultaneously, the effects of these factors on the regional achievement differences were studied by taking one another into account.

To determine the effects of school context factors after taking student background into account, a *final model* was developed via combining the *overall student background model* (Equation 3.10) and *overall school context model* (Equation 3.13). The *final model* was the most inclusive one consisting of all student-level and school/class-level variables and building on the *base model*. The mixed model for the *final model* is presented in Equation 3.14.

Mixed model for the *final model*:

$$y_{ij} = \gamma_{00} + \gamma_{01}(Schlevel1_{j})...\gamma_{0X}(SchlevelX_{j}) + \gamma_{10}(Stdlevel1_{ij})...\gamma_{Y0}(StdlevelY_{ij}) + u_{0j} + r_{ij}$$

(3.14)

Where:

$\gamma_{01} \ldots \gamma_{0X}$ = Main effects for school-level variables

$\gamma_{10} \ldots \gamma_{Y0}$ = Mean regression coefficients associated with student-level variables

Chapter 4

Regional Differences in Science Achievement in Turkey and the Influences of Student and School Factors

Using Turkey's TIMSS 2007 science achievement data, the first phase of the data analysis investigated regional differences in student outcomes at the eighth grade which also is the end of compulsory education in Turkey. The second analytic phase using multilevel statistical models capitalized on the student and school background data from TIMSS 2007 to examine the relative impact of home and school factors associated with regional differences in achievement. Hierarchical Linear Modeling (HLM) was used to detect potential sources or reasons for the disparities in achievement between higher- and lower-achieving geographic regions.

This chapter presents the results of each data analysis phase, beginning with a section that presents the scope of Turkey's regional disparities in science achievement at the eighth grade. Possible explanations of the regional differences are presented in a subsequent section. In all figures and tables, results are shown for the seven geographic regions (see Figure 1.1 in chapter 1 for the map of Turkey) in descending order of their Socioeconomic Development Index (SEDI) ranking (see Figure 1.2 in chapter 1).

Describing Turkey's Regional Differences in Science Achievement at the Eighth Grade

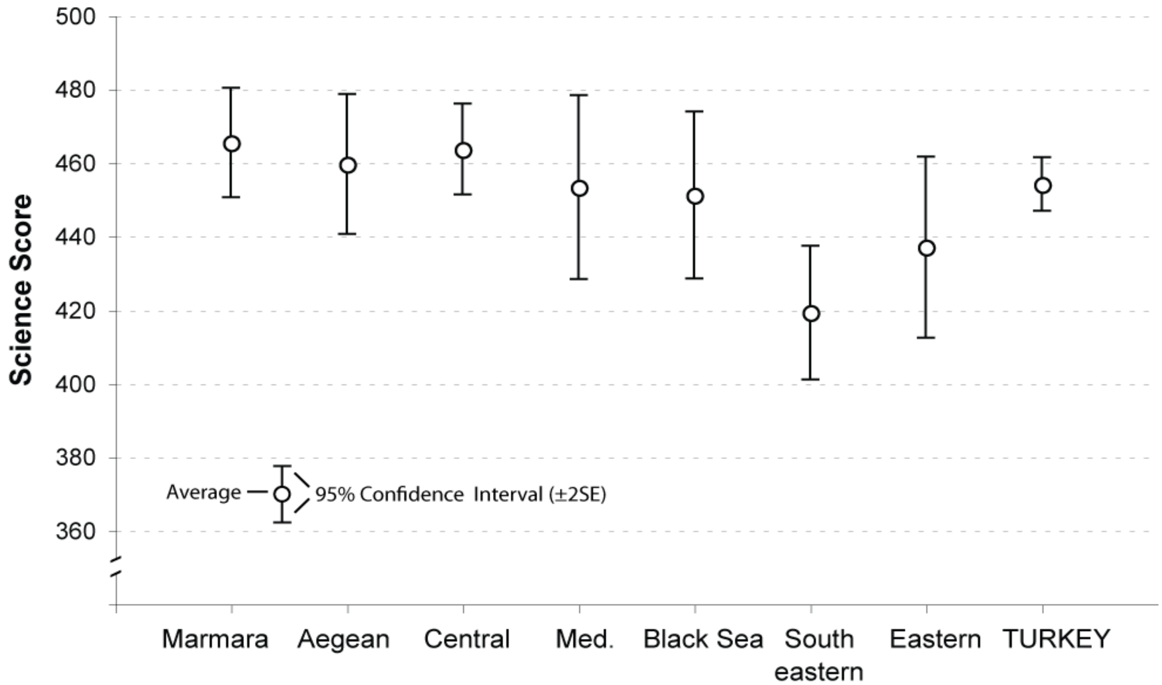
The hypothesis for this dissertation study was that Turkey's different geographic regions varied with respect to their student outcomes at the end of primary education (grades 1 to 8), and specifically, that the socioeconomically less developed eastern part of Turkey would attain lower science scores than the developed western part of the country. This is despite the fact that Turkey has a firmly centralized education system and *all* students are intended to be provided with similar learning opportunities in terms of teaching time and content by the end of eighth grade. To examine Turkey's regional differences in student outcomes, average science achievement in each region and for the country as a whole was computed.[11]

Differences in Average Achievement

Figure 4.1 displays, for each region and for Turkey, the TIMSS 2007 average (mean) science scale scores (denoted by circles) with their 95 percent confidence intervals (indicated by the bars extended above and below the circles). To aid in the interpretation of the results, the percentages of students in the regions, the standard deviations of the science scores, the SEDI (Socioeconomic Development Index) scores, and the average age for the students tested are also shown in the table beneath the figure.

[11] For this computation, IEA's International Database Analyzer (IEA, 2008) was used.

Figure 4.1. TIMSS 2007 Average Science Achievement in Turkey and its Regions



	Number of Cases	Percent of Students (SE)	Average Science Score (SE)	Standard Deviation (SE)	Average Age (SE)	SEDI Score
Marmara	1,362	25 (0.8)	465 (7.6)	92 (2.9)	13.96 (0.0)	1.702
Aegean	505	14 (1.2)	460 (9.7)	97 (4.5)	14.04 (0.0)	0.483
Central	739	19 (0.8)	464 (6.3)	90 (4.2)	13.96 (0.1)	0.481
Mediterranean	527	12 (0.8)	453 (12.8)	92 (3.6)	14.06 (0.1)	0.021
Black Sea	442	12 (0.6)	451 (11.6)	86 (4.6)	14.02 (0.1)	-0.514
Southeastern	592	10 (0.6)	419 (9.3)	86 (4.6)	14.30 (0.1)	-1.011
Eastern	331	8 (0.6)	437 (12.6)	91 (4.5)	14.07 (0.2)	-1.162
TURKEY	4,498	100 (0.0)	454 (3.7)	92 (1.7)	14.03 (0.0)	0.000

Note. Standard errors are computed using jackknife procedure.
SEDI scores are from Dincer, Ozaslan, & Kavasoglu (2003).

The TIMSS 2007 science scores indicated, in general, that the differences in student outcomes corresponded to the socioeconomic disparities between the western and eastern parts of Turkey. As expected, the pattern was that Marmara (the most developed region with the highest SEDI score) together with the Aegean and Central Anatolia regions had the highest average achievement. Eastern and, in particular, Southeastern Anatolia (the two least developed regions with the lowest SEDI scores) were the lowest achieving regions. Specifically, Marmara's average score was 46 points above the average score for Southeastern Anatolia.

The confidence intervals presented in Figure 4.1 may be used as a rough indication of whether a region's mean score is different from the mean of another region or Turkey.[12] However, a more sensitive test of statistical significance was performed in this study as part of the HLM (Hierarchical Linear Modeling) analyses conducted to examine potential sources of the regional differences. As explained later in the chapter, the more sophisticated test of significance revealed that achievement differences between Marmara and the two least developed regions were statistically significant, while the differences between Marmara and the other four regions —Aegean, Central Anatolia, Mediterranean, and Black Sea— were not. That is, these four regions and Marmara performed similarly on the TIMSS 2007 science test. Overall, although a pattern exists, there was more similarity in educational outcomes than in socioeconomic development levels. This might be partially explained by Turkey's common curriculum in primary

[12] Confidence intervals allow for an "eyeball" test of significance on whether the differences in the estimates (i.e., means in this case) are statistically significant. If the confidence intervals of two estimates do not overlap, then the two estimates are considered to be statistically different. If the confidence intervals do overlap, then the estimates may or may not be statistically different.

schools. The fact *all* students are intended to be provided with similar learning opportunities by the end of primary schooling may be helping Turkey's large socioeconomic disparities not to mirror precisely in educational achievement.

Differences at the TIMSS 2007 International Benchmarks

How can one interpret Turkey's regional differences in science achievement in terms of how much science students know and what they are able to do? What does, for example, a 46 score point gap between Marmara and Southeastern Anatolia translate into in terms of the size of student groups with different competency levels? In this study, to better interpret the meaning of science achievement scores in Turkey and its regions, student performance is described at the Advanced, High, Intermediate, and Low International Benchmarks of the TIMSS 2007 science test (see Chapter 3 for a detailed discussion of the TIMSS 2007 international benchmarks). To aid in interpretation, a short definition of student competency at each benchmark is presented in Table 4.1.[13]

Table 4.1. *Summary Definitions of the TIMSS 2007 International Benchmarks for Science Achievement*

TIMSS 2007 International Benchmarks of Science Achievement	Summary Definitions
Advanced International Benchmark	Apply complex and abstract concepts
High International Benchmark	Understand cycles, systems, and principles
Intermediate International Benchmark	Communicate basic knowledge
Low International Benchmark	Recognize some science facts

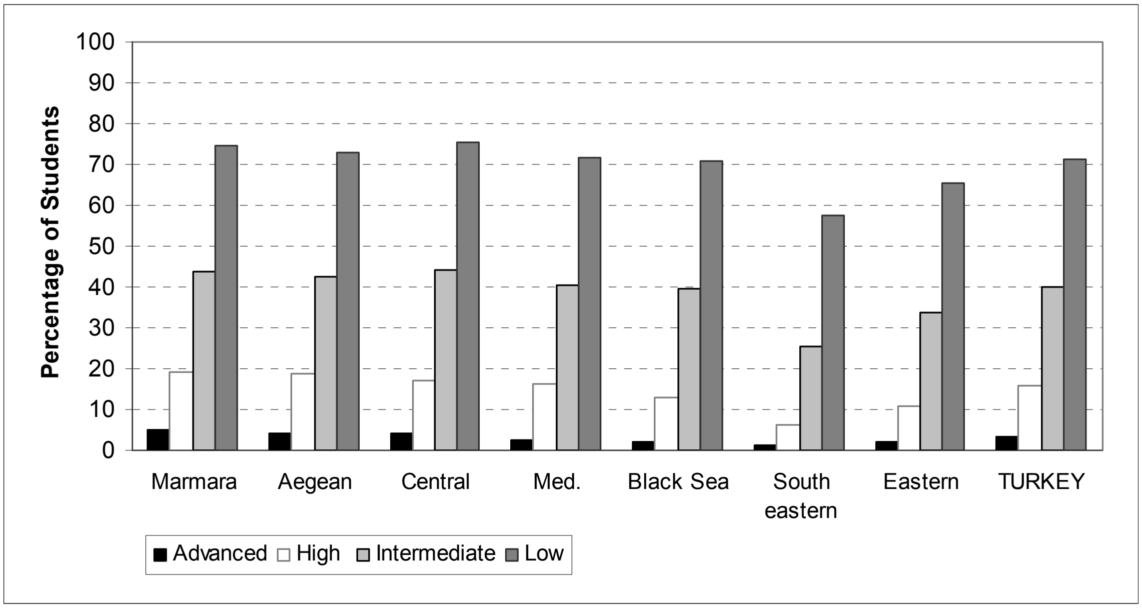
[13] A general description of student competency at each benchmark is provided in Chapter 2 of the *TIMSS 2007 International Science Report* (Martin et al., 2008).

For Turkey and the regions, the percentages of students that reached each of the four international benchmarks were computed[14] and the results are displayed in Figure 4.2. In general, the higher performing more socioeconomically developed regions had greater percentages of students reaching each benchmark and the lower performing undeveloped regions had smaller percentages, though the variation in achievement at the *Advanced International Benchmark* was not large. Unfortunately, in all regions, only a very small percentage of Turkish eighth grade students reached the *Advanced International Benchmark.* The hallmark of the Advanced Benchmark was demonstrating competence on the TIMSS 2007 items concerning complex science concepts and involving reasoning skills. The finding that only such small percentages of students reached this level suggests that high quality education is provided for only a small fraction of students in Turkey.

The distribution of low performers varied across the regions and was in line with the results in Figure 4.1. That is, Southeastern and Eastern Anatolia had the lowest percentages of students reaching the *Low International Benchmark* (57% and 66%, respectively). This meant that, for example in Southeastern Anatolia, nearly half (43%) of the students did not reach the lowest benchmark, indicating they did not demonstrate a grasp of even the most basic facts in science. In contrast, the percentage of those students who performed below the lowest benchmark was 25% in Marmara and Central Anatolia, the two best performing regions.

[14] For this computation, IEA's International Database Analyzer (IEA, 2008) was used.

Figure 4.2. Percentages of Students Reaching the TIMSS 2007 International Benchmarks of Science Achievement in Turkey and its Regions



		At Advanced or Above	At High or Above	At Intermediate or Above	At Low or Above
Marmara	N	68	265	589	1,004
Percent of Students (SE)		5 (1.1)	19 (2.6)	44 (3.5)	75 (2.9)
Aegean	N	39	122	238	382
Percent of Students (SE)		4 (1.0)	19 (1.9)	43 (4.5)	73 (4.3)
Central	N	45	157	363	581
Percent of Students (SE)		4 (1.5)	17 (3.2)	44 (3.0)	75 (1.8)
Mediterranean	N	18	102	236	394
Percent of Students (SE)		3 (0.8)	16 (3.7)	40 (5.1)	72 (6.0)
Black Sea	N	10	61	184	325
Percent of Students (SE)		2 (0.9)	13 (3.0)	40 (5.7)	71 (5.9)
Southeastern	N	11	46	152	328
Percent of Students (SE)		1 (0.7)	6 (2.4)	25 (5.5)	57 (4.2)
Eastern	N	9	42	124	228
Percent of Students (SE)		2 (1.0)	11 (3.9)	34 (5.8)	66 (4.8)
TURKEY	N	199	795	1,885	3,242
Percent of Students (SE)		3 (0.5)	16 (1.2)	40 (1.8)	71 (1.5)

Note. Standard errors are computed using jackknife procedure.

Comparison of Student and School Variance in Turkey

To further examine the regional differences in achievement, a series of statistical analyses were carried out using HLM (Hierarchical Linear Modeling). HLM is a regression technique for examining data with a hierarchical or nested structure (e.g., data from schools, where students are nested within classes, and classes are nested within schools) as in the case of Turkey's sample in TIMSS 2007, and "at present, the use of HLM is strongly recommended for nested data" (Braun, Jenkins, & Grigg, 2006a, p.7). For this dissertation, the HLM analyses were performed using the HLM6 program (Raudenbush, Bryk, & Congdon, 2004). Results from the HLM analyses of this study are presented in the following paragraphs.

An analysis based on HLM typically begins with an *unconditional model* (also known as the *null model*), which does not include any explanatory variables (see Equation 3.3 in Chapter 3). This model decomposes the total achievement variance into two components: variance between-upper level units ("schools/classes" in this study) and variance between-lower level units ("students" in this study). As stated by Braun, Jenkins, and Grigg (2006b), "the results of the variance decomposition enhance the understanding of the likely sources of heterogeneity in student achievement and, consequently, of the context in which the HLM analyses take place" (p.13).

The *unconditional model* analysis showed that one-third (34%) of the total variation in science achievement in Turkey was due to differences among schools and the remaining two-thirds (66%) of the total variance was attributable to heterogeneity among students. These results suggest that the variation in Turkish students' performance might be related to school characteristics (i.e., factors that are constant for all students within a school, such as the rural/urban setting of a school) as well as student characteristics (i.e., factors that varied for each student within a school, such as parental education).

It can be noted that the *unconditional model* estimated Turkey's TIMSS 2007 average science achievement as 452. This estimate by HLM6 (the intercept term in the *unconditional model*) was slightly different than the IDB Analyzer's estimate (454) even though the analyses with both programs included the same number of students, incorporated five plausible value estimates of students' science performance, and took sampling (design) weights into account when estimating the population parameters (intercepts and regression coefficients) and their standard errors. The estimates obtained from the two programs were similar but not identical because the HLM's multilevel conceptual approach to parameter estimation differs from the IDB Analyzer's single-level approach.[15] Therefore, "the model parameter estimated in a student-level analysis is not generally the same as the model parameter estimated in a multilevel analysis" (Braun, Jenkins, & Grigg, 2006b, p.37) and the two estimates would only be the same "in simple situations with equal numbers of students per school and random sampling at both levels"

[15] As discussed in detail in Raudenbush and Bryk (2002), a single-level analysis obtains an ordinary least square estimate, while HLM's multilevel estimate is a precision (reliability) adjusted least square estimate. In HLM, schools with larger numbers of students count more in the estimation process because they are considered to provide more precise estimates compared to schools with small numbers of students.

(p.38). The estimate of Turkey's mean science score obtained by HLM6's two-level analysis (school- and student-level) represents the weighted average of *school mean scores* using a procedure that weights large schools somewhat more heavily, while the estimate from the IDB Analyzer's student-level analysis represents the average of individual *student scores*. Because the number of students in Turkey's sampled schools/classes varied substantially (from 5 to 67), it was expected that the two estimates would not be identical.

Regional Differences in School Achievement

Following the *unconditional model*, the first conditional model of this study tested the effects of the region factor in order to establish a *base model* for subsequent multilevel analyses. Further conditional models investigated student and school background factors that, if controlled statistically, could be expected to diminish the magnitude of the region effect. The steps involved in these analyses are summarized in Table 4.2. The *base model* included no exploratory variable at the student-level (level-1) and only region at the school-level (level-2). Subsequently, *student models* and *school models* were built on the *base model* to show how the inclusion of various student-level and school-level predictors changes the estimate of the region effects. Lastly, the predictors that were statistically significant were included together in a *final model* that tested the joint effects of those predictors on regional differences in achievement. The results from the *base model* are presented in this section. The next section —explaining regional differences— presents the results from the subsequent statistical models.

Table 4.2. *Steps Involved in Modeling Regional Differences*

Multilevel Model	Variables in Student-Level	Variables in School-Level
Base	None	Region
Student	Important student characteristics	Region
School	None	Region + Important school characteristics
Final	Significant student characteristics	Region + Significant school characteristics

Table 4.3 displays the results from the *base model*, which compared average science achievement (based on the weighted average of school means as described earlier) in Marmara (the most developed region) to average science achievement in each of the other six regions.[16] The table shows the estimates (regression coefficients) of regional contrasts that represent the average achievement difference between Marmara and each region. That is, the *base model* tested the effect of attending school in each of the six regions compared to attending school in Marmara. The results revealed that students in the two least developed regions, Eastern and Southeastern Anatolia, performed significantly lower, on average, than students in Marmara (p_{Eastern}=.020 and $p_{\text{Southeastern}}$=.001, respectively). Specifically, the mean TIMSS 2007 science score in Southeastern Anatolia was estimated to be 47 points lower than the mean score in Marmara.[17]

[16] Each region was represented with a dummy variable where Marmara was the reference category as presented in Table A.2 of the Appendix A. Base model was represented in Equation 3.6 in Chapter 3.
[17] The intercept and regression coefficients of the *base model* were not identical but very close to the ones presented in Figure 4.1 As explained previously, the differences in the parameter estimates are due to the conceptual differences in parameter estimation techniques between a multilevel and a single-level analysis.

Table 4.3. *Base Model of TIMSS 2007 Science Achievement in Turkey (N=4,498)*

Intercept reliability	0.935	
Intercept (Marmara)		
Predicted mean science score (SE)	468	(8.3)
Aegean	-10	(16.4)
Central	-11	(12.2)
Mediterranean	-17	(16.3)
Black Sea	-21	(16.5)
Southeastern	-47**	(13.9)
Eastern	-40*	(16.7)

Note. Hierarchical linear models with random intercepts weighted by TOTWGT.
**p < .01., *p < .05.

Explaining Turkey's Regional Differences in Science Achievement at the Eighth Grade

Why are eighth grade students in Southeastern and Eastern Anatolia lagging behind those in Marmara despite the fact that *all* students in Turkey are intended to be provided with similar educational opportunities by the end of primary education? What are those student background and school context factors that contribute to the regional achievement differences in compulsory education in Turkey? These questions were examined during the second analytic phase and the results are presented in this section.

There are many possible reasons why science achievement in Southeastern and Eastern Anatolia was significantly lower than in Marmara. Students' varying home background characteristics and attitudes toward science, the differential aspects of the schools they attend, or various combinations of student and school factors might all be playing significant roles in Turkey's regional differences in student outcomes. This section presents the results from a series of multilevel analyses that were conducted to explore factors that contributed to Turkey's regional disparities in achievement. Statistical modeling was carried out in two steps. First, a lengthy process was used to screen and identify background variables for inclusion in the multilevel modeling. Next, those variables that were selected in the screening process were included in the statistical models to identify factors that, if altered, could serve to reduce the magnitude of the region effect.

Identification of Factors Related to Regional Differences in Science Achievement

This study used two criteria to identify background factors to be included in the multilevel models of regional achievement. Background variables that satisfied these criteria were included in the student and school models in order to test whether the variables accounted for regional differences in science achievement:

1. The variable was positively associated with achievement both at the country and the regional level. That is, achievement was higher for students in some categories of the variable than others (e.g., for the parental education variable, students whose parents had university or higher education had higher achievement than students whose parents had lower levels of education).

2. The percentages of students in various categories of the variable differed among regions, particularly between the developed and undeveloped regions. For example, Marmara (and/or other developed regions) had higher percentages of students in the favorable categories of the variable (e.g., parents with university degree) or, Southeastern and Eastern Anatolia had higher percentages of students in the unfavorable categories of the variable (e.g., parents with less than primary education).

As noted earlier, the aim of this study was to develop an explanatory model of Turkey's *regional achievement differences* and not simply a model of *student achievement differences* in Turkey. In the case of the latter model, it would have been sufficient to identify those variables that would explain the most variation in student achievement. Even though the first criterion is important and a prerequisite for explaining regional differences in achievement, it does not mean that those factors that are associated with higher student achievement overall necessarily contribute to regional disparities. In addition to satisfying the first criterion, for a variable to help explain the relatively higher performance of the developed regions, it needed to vary between developed and undeveloped regions in such a way that it had favorable values for developed regions. Similarly, to help explain the low performance of undeveloped regions, a variable needed to vary in such a way that it had unfavorable values for undeveloped regions.

The literature review (Chapter 2) established the theoretical base for exploration of those background variables that satisfied the above two criteria and the background data almanacs in the *TIMSS 2007 International Database* (Foy & Olson, 2009) provided the empirical basis. For each country, these data almanacs provided statistical summaries of the data collected from students, teachers, and schools. First, based on the literature review, the almanacs for Turkey were reviewed to identify those factors that showed an association with science achievement. In addition, the IDB Analyzer was used to perform a similar review at the region level. As a result of this exploratory analysis, more than 30 variables were identified that satisfied the first criterion of being associated with science achievement in Turkey and its seven regions.

Because some of these initial variables were related to a single underlying construct, responses to the individual variables were combined to create an index that would summarize the information from the component variables in a concise manner (see Chapter 3 for a discussion of constructing the indices). Thus, a total of 10 background measures —based on four single variables and six indices— were examined at the initial exploratory data analysis stage. As shown in Table 4.4, these included a range of seven student background measures and three school background measures.

Table 4.4. *Background Factors Explored for Association with Regional Differences in Science Achievement*

Student Background Measure	School Background Measure
1. Frequency of speaking Turkish at home	1. School community type (based on principals' reports)
2. Parents' highest education level	2. Index of principals' reports on positive school climate for academic achievement
3. Index of home resources	3. Index of teachers' reports on adequacy of school resources in teaching science
4. Index of self-confidence in learning science	
5. Index of valuing science	
6. Index of positive affect toward science	
7. Students' educational aspirations	

Detailed information about these student and school background measures are provided in the Appendix, in Tables A.1 and A.2, respectively. This information includes the source of the data (i.e., whether the data were collected from students, teachers, or schools), the text of the questions together with their response categories, and how missing data were handled.[18] The appendix tables also include information about recoded or collapsed response categories. For example, the question about school community type originally had six response options and was recoded for the purposes of this study into two categories —rural and urban. Finally, the appendix also provides an explanation of how each index was computed along with the reliability of the underlying scale and the total scale variance accounted for by the component variables of the index.

[18] Response rates for the variables under exploration were high (98% or above). Therefore, missing data did not pose any problem in general. However, HLM6 requires complete data at level-2 of the analysis, hence missing data were replaced prior to the multilevel analysis using the conditional mean imputation method.

The 10 variables meeting the first criteria of being related to science achievement were then further examined to determine whether or not they satisfied the second criterion of differing among regions. For each of the 10 background measures, the weighted percentages of students (together with the average science achievement) in different categories of the variables were computed[19] for Turkey and the regions. Results for the seven student indicators are shown in Figures 4.3 to 4.7 and for the three school indicators in Figures 4.8 to 4.10. These results essentially formed the basis for judging whether any of the 10 variables also satisfied the second criteria for inclusion in the multilevel models —that higher performing regions would have higher percentages of students in the more favorable categories and lower percentages in less favorable categories.

Regional Differences in Student Background Measures Related to Science Achievement

Figures 4.3 to 4.7 present the extent to which the students across the regions differed from each other regarding the seven student background measures. In summary, among the seven background measures, three met both criteria of inclusion in the multilevel models. These measures consisted of frequency of speaking Turkish (the language of the test) at home, parents' highest education level, and index of home resources. The remaining four factors related to students' attitudes, including the index of self-confidence in learning science, index of valuing science, index of positive affect

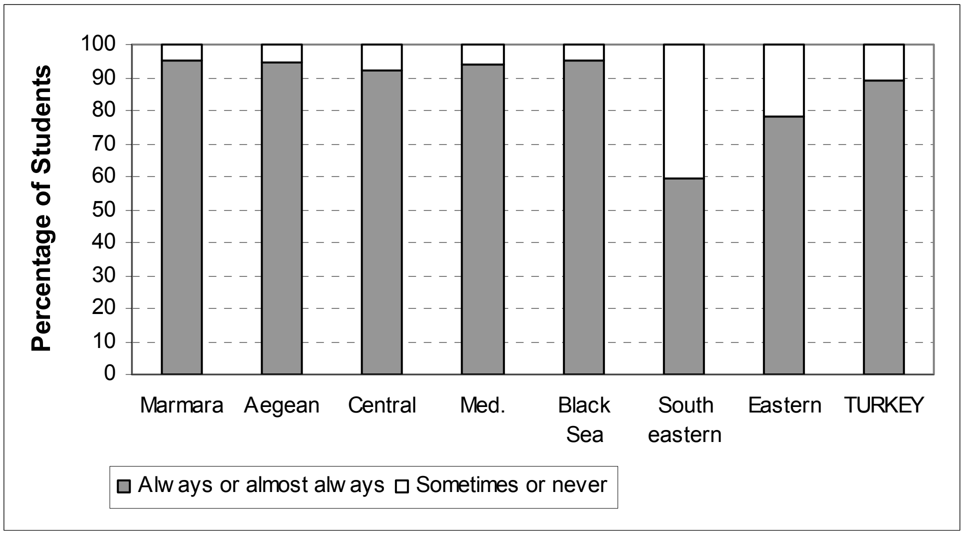
[19] For this computation, IEA's International Database Analyzer (IEA, 2008) was used.

toward science, and students' educational aspirations did not show that regional differences in higher or lower levels of science achievement were systematically related to more or less positive attitudes in the regions.

Figure 4.3 summarizes students' reports of how frequently they spoke Turkish at home, together with average science achievement. On average in the country, a large majority of students (89%) reported always or almost always speaking Turkish at home and these students had higher average science achievement than those who reported speaking Turkish less frequently (sometimes or never) —461 points and 396 points, respectively. That is, student achievement increased as the fluency in Turkish, the language of instruction, increased. This finding is consistent with the language situation in Turkey. As mentioned in the literature review (Chapter 2), Turkish is the formal language of instruction in Turkey, but a major ethnic group (Kurds) with a mother-tongue other than Turkish populates the eastern part of the country.

The overall national result between language spoken at home and science achievement was also evident at the regional level. In all regions, there was a positive relationship between the frequency of speaking Turkish at home and science achievement. The two lowest performing regions, Southeastern and Eastern Anatolia, had the highest percentages of students from homes where Turkish is not often spoken (41% and 22%, respectively), while in the higher performing regions, the percentages of students in this category were less than 10 percent. Clearly, students in Southeastern and Eastern Anatolia may be disadvantaged in terms of their fluency speaking Turkish

Figure 4.3. Frequency of Speaking Turkish at Home in Turkey and Its Regions



		Always or almost always	Sometimes or never
Marmara	N	1,287	75
% of Students (SE)		95 (0.7)	5 (0.7)
Mean Score (SE)		468 (7.6)	424 (13.9)
Aegean	N	477	27
% of Students (SE)		94 (2.4)	6 (2.4)
Mean Score (SE)		464 (8.9)	382 (11.7)
Central	N	702	36
% of Students (SE)		92 (4.8)	8 (4.8)
Mean Score (SE)		470 (7.5)	393 (14.3)
Mediterranean	N	495	31
% of Students (SE)		94 (1.8)	6 (1.8)
Mean Score (SE)		458 (12.4)	383 (21.2)
Black Sea	N	418	22
% of Students (SE)		95 (0.8)	5 (0.8)
Mean Score (SE)		454 (12.2)	396 (19.1)
Southeastern	N	364	226
% of Students (SE)		59 (6.7)	41 (6.7)
Mean Score (SE)		436 (10.6)	396 (7.9)
Eastern	N	260	67
% of Students (SE)		78 (3.9)	22 (3.9)
Mean Score (SE)		451 (11.6)	387 (14.9)
TURKEY	N	4,003	484
% of Students (SE)		89 (1.2)	11 (1.2)
Mean Score (SE)		461 (3.8)	396 (5.1)

Note. Standard errors are computed using jackknife procedure.

(the medium of instruction) and their understanding of what is spoken in class. These unfavorable conditions may in turn hinder students' capacity to grasp content of the instruction and develop cognitive skills.

Also discussed in Chapter 2, socioeconomically disadvantaged students tend to be concentrated in the eastern part of Turkey and attend schools with large differences on all socioeconomic indicators, including parental education level and home resources. The scope of the regional differences in parental education and home resources are depicted in Figures 4.4 and 4.5, respectively. Figure 4.4 presents students' reports of the highest level of education attained by their parents. For each region and for Turkey as a whole, the percentage of students in each of the six categories of parents' educational level is shown, together with average science achievement. The education level of the parent with more education was used in assigning students to categories.[20] The sixth category —"I do not know" — was also included even though, in Turkey, only one percent of students reported not being certain about their parents' level of educational attainment.

Perhaps most striking, Figure 4.4 reveals a grim picture of the level of parental education in Turkey. For two-thirds of the Turkish eighth grade students (68%), the highest level of education for either (or both) parents was very minimal (i.e., either with a primary school education or did not finish primary school or go to school at all). Twenty percent had at least one parent with high school education, and only 10 percent had at least one parent who completed a degree beyond high school. Consistent with the

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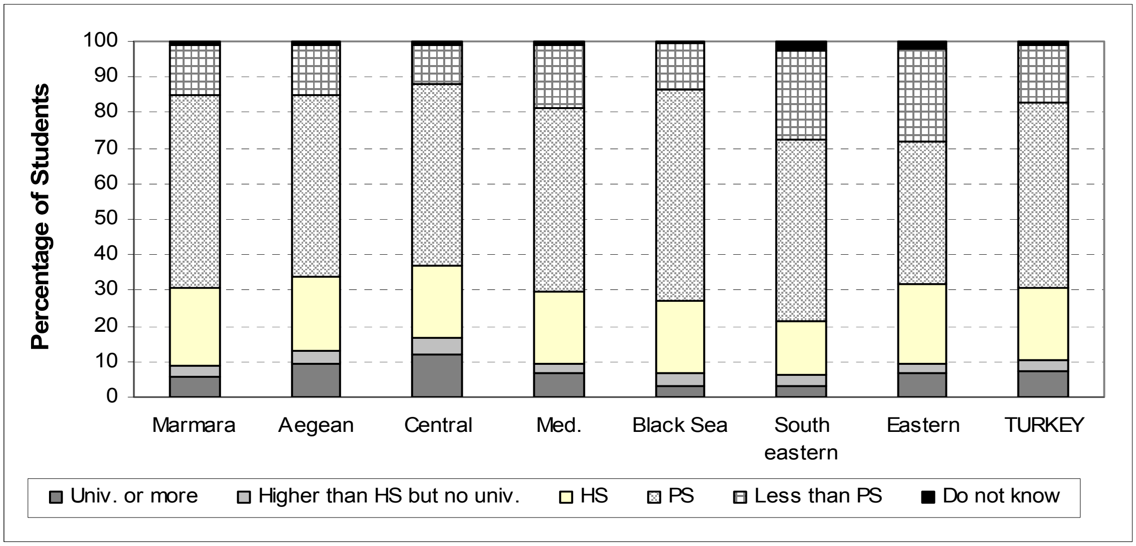
[20] This essentially meant in Turkey that fathers' education level was used when assigning students to categories because only 6% of the students had a mother with more education than the father.

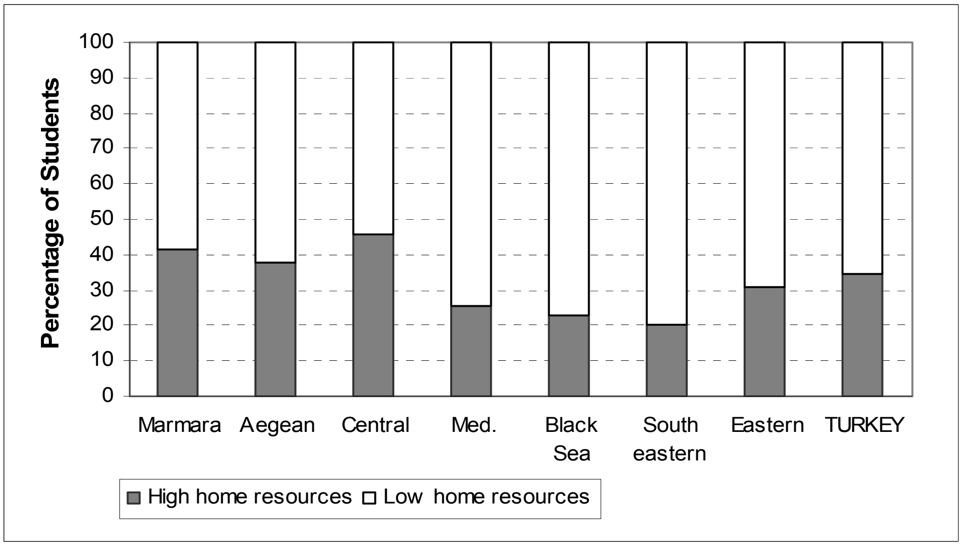
Figure 4.4. Parents' Highest Education Level in Turkey and Its Regions



		University or higher	Higher than high school but not univ.	High school	Primary school	Less than primary school	Do not know
Marmara	N	97	42	286	726	191	13
% of Students (SE)		6 (1.1)	3 (0.7)	22 (2.1)	55 (2.0)	14 (1.8)	1 (0.3)
Mean Score (SE)		570 (13.2)	511 (18.2)	490 (7.3)	453 (7.3)	427 (9.4)	387 (32.2)
Aegean	N	65	22	106	240	63	5
% of Students (SE)		9 (2.7)	4 (0.8)	21 (4.1)	51 (3.7)	14 (3.8)	1 (0.5)
Mean Score (SE)		567 (13.9)	550 (14.4)	485 (8.9)	441 (11.7)	409 (10.9)	384 (46.0)
Central	N	120	41	164	334	67	8
% of Students (SE)		12 (3.3)	5 (0.7)	20 (2.1)	51 (3.2)	11 (2.1)	1 (0.7)
Mean Score (SE)		560 (13.8)	520 (15.8)	490 (8.1)	435 (3.8)	428 (8.4)	411 (37.8)
Mediterranean	N	44	16	119	255	87	6
% of Students (SE)		7 (1.4)	3 (0.9)	20 (2.8)	52 (2.8)	18 (2.1)	1 (0.6)
Mean Score (SE)		550 (16.1)	528 (14.5)	493 (7.2)	436 (14.1)	417 (11.6)	390 (39.2)
Black Sea	N	15	15	94	248	54	2
% of Students (SE)		3 (1.5)	3 (1.1)	20 (5.1)	60 (6.0)	13 (2.3)	0 (0.3)
Mean Score (SE)		525 (17.6)	491 (15.5)	486 (18.7)	438 (14.2)	434 (14.3)	408 (49.1)
Southeastern	N	20	19	95	288	145	17
% of Students (SE)		3 (0.8)	3 (1.1)	15 (3.1)	51 (3.9)	25 (2.3)	3 (1.3)
Mean Score (SE)		486 (32.4)	490 (20.2)	452 (17.4)	416 (8.0)	404 (8.2)	326 (22.6)
Eastern	N	25	10	81	122	78	7
% of Students (SE)		7 (2.8)	2 (1.0)	23 (5.0)	40 (3.6)	26 (4.1)	2 (1.0)
Mean Score (SE)		516 (28.1)	461 (25.4)	472 (12.9)	427 (15.9)	418 (9.0)	347 (45.4)
TURKEY	N	386	165	945	2,213	685	58
% of Students (SE)		7 (0.8)	3 (0.3)	20 (1.2)	52 (1.3)	16 (1.0)	1 (0.2)
Mean Score (SE)		554 (7.0)	513 (8.0)	485 (4.0)	439 (4.0)	420 (4.8)	373 (15.9)

Note. Standard errors are computed using jackknife procedure.

Figure 4.5. Index of Home Resources in Turkey and Its Regions



		High home resources	Low home resources
Marmara	N	602	760
% of Students (SE)		41 (4.1)	59 (4.1)
Mean Score (SE)		497 (7.6)	443 (6.7)
Aegean	N	221	284
% of Students (SE)		38 (5.7)	62 (5.7)
Mean Score (SE)		515 (8.9)	426 (10.4)
Central	N	395	344
% of Students (SE)		46 (4.3)	54 (4.3)
Mean Score (SE)		501 (12.1)	433 (3.7)
Mediterranean	N	161	366
% of Students (SE)		26 (5.1)	74 (5.1)
Mean Score (SE)		508 (9.9)	435 (12.6)
Black Sea	N	111	331
% of Students (SE)		23 (5.4)	77 (5.4)
Mean Score (SE)		490 (14.1)	440 (13.1)
Southeastern	N	138	454
% of Students (SE)		20 (3.4)	80 (3.4)
Mean Score (SE)		460 (21.8)	409 (6.4)
Eastern	N	116	215
% of Students (SE)		31 (6.9)	69 (6.9)
Mean Score (SE)		491 (16.3)	413 (9.9)
TURKEY	N	1,744	2,754
% of Students (SE)		34 (1.9)	66 (1.9)
Mean Score (SE)		498 (4.5)	430 (3.6)

Note. Standard errors are computed using jackknife procedure.

disparities in socioeconomic development, parents' education level differed across the regions. Central Anatolia (it includes the capital city, Ankara), one of the most developed and high performing regions, had the highest percentage of students (17%) with parents who finished a degree beyond high school. Regarding the least educated parents, the students in Southeastern and Eastern Anatolia were in the most disadvantaged home environments with a quarter of the students having neither parent finish even primary schooling.

As shown in Figure 4.4, higher levels of parents' education are associated with higher average achievement in all regions and in Turkey as a whole. The pattern of association between parental education and student outcomes was most evident in the Aegean region where average science achievement of eighth grade students with university (or advanced degrees) educated parents was 158 points greater than the average of students whose parents had less than primary schooling.

Figure 4.5 presents, for Turkey and the regions, the percentages of students at the high compared to the low level of the index of home resources, together with the students' average science achievement. The "Home Resources Index" was developed based on students' reports of the following variables: number of books in the home; presence in the home of three educational aids, including a computer, study desk for student's own use, and Internet connection in the home; [21] and having three home possessions (a dishwasher, a heating system with radiator, and a DVD/CD player). This index was used as a proxy measure of family income specific to Turkey. [22] Students assigned to the high level of this index came from homes with four or more of these seven resources.[23] Students assigned to the low level had three or fewer home resources.

On average in Turkey, one-third of students were at the high level of the "Home Resources Index", although the distribution varied from region to region. Central Anatolia had the highest proportion of students from well-resourced homes (almost half of them were at the high index level). In comparison, Southeastern Anatolia had the lowest proportion of students (20%) at the high level. In all regions, students at the high level of the index had higher average achievement compared with those at the low level.

Figures 4.3 to 4.5 show clearly that disadvantaged students in Turkey tended to be concentrated in the eastern part of the country and had vast home background disadvantages compared to the high performing regions in terms of frequency of speaking the language of instruction, parental education level, and home resources. These three home background measures satisfied both criteria for inclusion in the multilevel modeling.

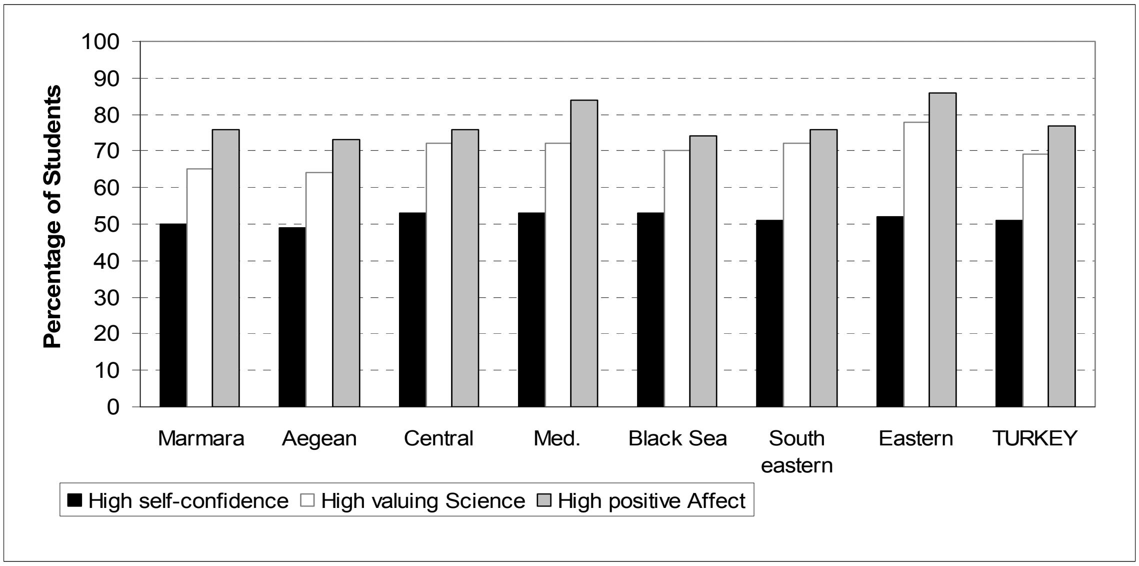
[21] Having a dictionary at home was not included in the index because almost all Turkish eighth grade students (94%) had a dictionary at home. As to the calculator variable, despite some observed variability (84% of the students had a calculator at home) it was omitted from the index because it did not help increasing the index reliability.
[22] Almost all students (94%) came from homes with a washer, thus the variable was not among the selected proxy measures of family income in Turkey.
[23] Presence of books at home corresponded to having more than 25 books and absence of books was defined as having 25 or fewer books at home.

As discussed in the literature review, students with positive attitudes toward science may be more motivated to learn, which in turn is likely to increase achievement in science. In addition to home background factors, this study also examined students across the regions in terms of the following four attitudinal dimensions: how they perceived their abilities in learning science (i.e., whether they were self-confident in learning science), the value they placed on science (i.e., whether they thought that it was advantageous in life to learn science well), how much they liked science (i.e., whether they liked science and enjoyed learning it), and their expectations for further education.

Figure 4.6 shows the extent to which Turkish students across the regions differed from each other in relation to the following three measures of students' attitudes: index of self-confidence in learning science, index of valuing science, and index of positive affect toward science.[24] In Turkey and in all the regions, there was a positive association between science achievement and self-confidence in learning science —the first attitudinal dimension shown in Figure 4.6. Students at the high level of the index (i.e., students who are confident about their science ability, including those who reported that they learn things quickly in science and perform well in science) had higher average science achievement than those at the low level (484 points and 424 points, respectively). However, the percentages of students at the levels of the index did not vary across the regions. In all regions, while half of the students expressed high confidence levels about

[24] Table A.1 provides detailed information about component variables that were combined to construct these three student attitude indices. Bars on the figure represent the percentage of students in the high category of the three indices. The percentage of students in the low category may simply be calculated by subtracting the percentage of students in the high category from 100. The table beneath the figure presents, for Turkey and the regions, the percentage of students at both levels of the indices, together with the average science achievement for the students.

Figure 4.6. High Categories of Self-confidence in Learning Science Index, Valuing Science Index, and Positive Affect Toward Science Index in Turkey and Its Regions



		High self-confidence	Low self-confidence	High valuing science	Low valuing science	High positive affect	Low positive affect
Marmara	N	668	684	874	478	1,023	327
% of Students (SE)		50 (2.6)	50 (2.6)	65 (1.7)	35 (1.7)	76 (2.0)	24 (2.0)
Mean Score (SE)		501 (8.5)	431 (7.1)	469 (7.9)	459 (7.9)	472 (7.7)	447 (8.6)
Aegean	N	252	248	320	181	133	370
% of Students (SE)		49 (3.8)	51 (3.8)	64 (3.9)	36 (3.9)	73 (5.0)	27 (5.0)
Mean Score (SE)		497 (9.0)	425 (10.2)	467 (9.4)	449 (13.6)	473 (8.2)	426 (16.8)
Central	N	381	350	509	221	186	547
% of Students (SE)		53 (3.1)	47 (3.1)	72 (2.4)	28 (2.4)	76 (2.7)	24 (2.7)
Mean Score (SE)		491 (9.5)	435 (6.4)	468 (7.3)	456 (8.0)	474 (7.2)	434 (11.4)
Mediterranean	N	279	234	370	145	427	87
% of Students (SE)		53 (5.0)	47 (5.0)	72 (2.2)	28 (2.2)	84 (1.8)	16 (1.8)
Mean Score (SE)		478 (12.5)	431 (13.9)	455 (13.9)	457 (10.3)	457 (11.8)	444 (20.3)
Black Sea	N	243	192	310	128	335	104
% of Students (SE)		53 (2.8)	47 (2.8)	70 (1.7)	30 (1.7)	74 (2.7)	26 (2.7)
Mean Score (SE)		477 (11.8)	422 (13.7)	458 (12.5)	437 (14.2)	459 (12.0)	429 (13.4)
Southeastern	N	299	283	416	163	448	135
% of Students (SE)		51 (2.9)	49 (2.9)	72 (2.8)	28 (2.8)	76 (2.9)	24 (2.9)
Mean Score (SE)		441 (9.3)	400 (9.4)	423 (8.8)	415 (10.6)	424 (8.8)	409 (12.7)
Eastern	N	174	149	256	72	278	48
% of Students (SE)		52 (3.9)	48 (3.9)	78 (2.8)	22 (2.8)	86 (1.4)	14 (1.4)
Mean Score (SE)		473 (11.5)	403 (14.0)	441 (12.6)	429 (16.9)	441 (12.9)	423 (16.4)
TURKEY	N	2,296	2,140	3,055	1,388	3,428	1,020
% of Students (SE)		51 (1.3)	49 (1.3)	69 (1.0)	31 (1.0)	77 (1.1)	23 (1.1)
Mean Score (SE)		484 (4.0)	424 (3.9)	458 (3.9)	448 (4.4)	462 (3.7)	433 (5.2)

Note. Standard errors are computed using jackknife procedure.

their science ability, the other half did not. Stated differently, no region was in a comparatively favorable or unfavorable situation in terms of students' self-confidence in science. That Turkish students' perceived level of difficulty in science was similar from one region to another may partially be explained by Turkey's common science curriculum in primary education across the country.

The second attitudinal dimension shown in Figure 4.6 is the index of valuing science. This index measured the value students placed on science in their lives. Students in the high level of the index showed that they placed a high value on science by agreeing with statements that learning science would help them in their daily life, learn other school subjects, get a university education, and the job they desired. Students who disagreed with these statements were assigned to the low level. Even though Turkish eighth grade students generally placed a high value on learning science (69% of students on average) there was no or little association between valuing science learning and average science achievement across the regions.

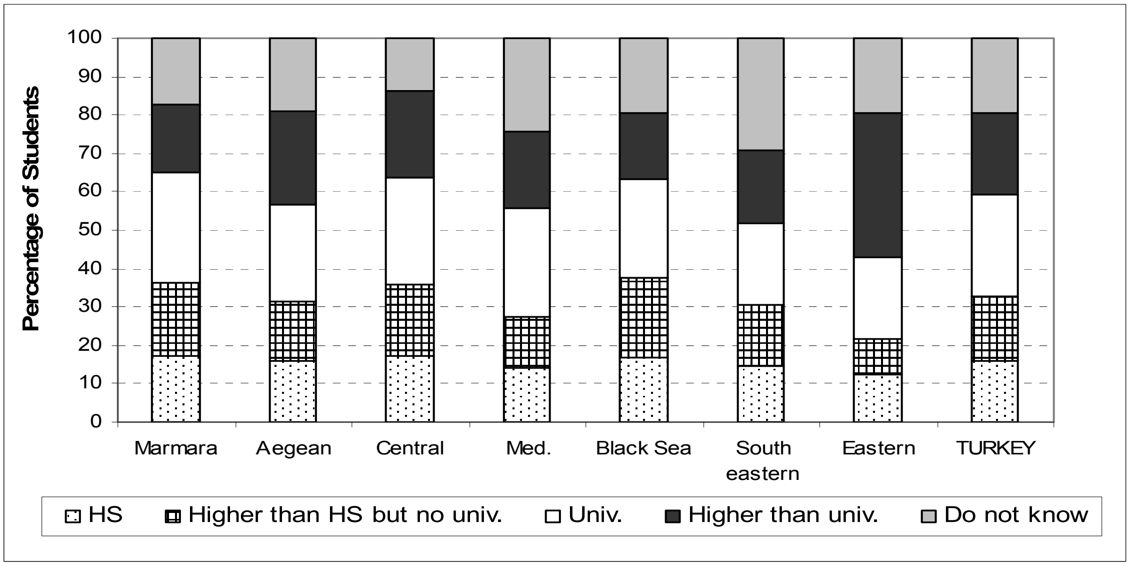
As indicated by the results for the third dimension presented in Figure 4.6, Turkish eighth grade students also had very positive attitudes toward science, generally. In Turkey, 77 percent of students were in the high category of the "Positive Affect Toward Science Index", agreeing to statements indicating that they liked science and enjoyed learning it. Students in the high category of the index performed moderately higher in science compared with students who were placed in the low index level (462 and 433 points, respectively). However, three-fourths or more of the students were at the high level in all regions.

In addition to the limited variability across regions in the three attitudinal dimensions, was the unexpected finding that more students in Eastern Anatolia than other regions reported positive attitude toward science. Eastern Anatolia, the least socioeconomically developed region and one of the two lowest performing regions, had the highest percentage of students at the high levels of the index of valuing science and the index of positive affect toward science (78% and 86%, respectively). Because it is widely believed that positive attitudes motivate students to learn and this in turn enhances achievement, the findings in Eastern Anatolia might seem counterintuitive. Nevertheless, low-achieving students reporting very positive attitudes has occurred before. For example, most recently in TIMSS 2007 (Martin et al., 2008), the highest percentage (92%) of eighth grade students who placed a high value on science (i.e., agreed to statements that learning science would help them in their daily life, learn other school subjects, and get the university education and the job they want) was reported by students in Ghana, the least performing and the least developed nation among 49 participating countries. Also in Ghana, 80 percent of eighth grade students highly endorsed statements such as “I like science” and “I enjoy learning science”.

Consistent findings have emerged from another international study —ROSE (Relevance of Science Education), which investigated 15-year-old students’ attitudes toward science and technology. Sjoberg and Schreiner (2006) found that most students (aged 14 to 16) in 25 participating countries agreed to statements valuing science (e.g., science is important for society) but students in developing countries, such as Uganda and Bangladesh responded more positively than students in developed countries including England, Japan, and Norway. The authors also found that "In general, students in developing countries like school science very much, whereas students in richer parts of the world are more negative" (p.68). It is unclear why students in less developed areas provide socially desirable responses to attitudinal statements. Various psychological, social, and economic factors may play a role in responding in a socially desirable manner.

Because an expectation to pursue further education may motivate students to put more effort into learning and this could result in higher levels of performance, regional differences in students' educational aspirations are presented in Figure 4.7. There was a positive association between Turkish eighth grade students' educational expectations and science achievement. That is, the more schooling they expected to pursue, the higher their science achievement on TIMSS 2007. However, as shown in the figure, Turkish students across the regions had similar educational expectations. In general, approximately 20% of eighth grade students did not know how far they might advance in their education, about 30% reported plans to complete high school and perhaps some further vocational training, and almost half of the students said that they expected to finish university or receive advanced degrees including master's and doctoral degrees. Considering that only seven percent of the students had parents who completed a university or higher degree (see Figure 4.4), at the very least the results suggest that Turkish students expect to receive more education than their parents.

Figure 4.7. Students' Educational Expectations in Turkey and Its Regions



		High school	Higher than high school but not univ.	University	Higher than univ.	Do not know
Marmara	N	233	247	382	247	243
% of Students (SE)		17 (1.7)	19 (1.3)	29 (1.4)	18 (1.7)	17 (2.0)
Mean Score (SE)		404 (7.8)	444 (7.9)	497 (6.4)	546 (7.2)	417 (9.1)
Aegean	N	69	76	127	139	87
% of Students (SE)		16 (2.2)	15 (2.6)	26 (3.4)	24 (2.6)	19 (4.1)
Mean Score (SE)		394 (7.5)	443 (11.2)	492 (9.7)	539 (9.2)	393 (11.0)
Central	N	105	133	211	195	91
% of Students (SE)		17 (1.6)	19 (2.2)	28 (2.0)	23 (2.4)	14 (1.4)
Mean Score (SE)		393 (7.9)	450 (5.0)	489 (8.6)	536 (13.5)	404 (7.5)
Mediterranean	N	65	73	149	117	121
% of Students (SE)		14 (3.0)	13 (3.3)	29 (2.9)	20 (3.3)	24 (2.5)
Mean Score (SE)		395 (15.6)	438 (15.2)	483 (8.0)	523 (14.4)	405 (13.2)
Black Sea	N	71	90	117	79	72
% of Students (SE)		17 (2.7)	21 (2.4)	26 (4.2)	17 (3.9)	19 (4.4)
Mean Score (SE)		396 (11.7)	443 (7.3)	495 (9.3)	512 (13.4)	409 (22.1)
Southeastern	N	88	87	127	121	161
% of Students (SE)		15 (2.1)	16 (1.9)	21 (2.7)	19 (2.8)	29 (3.7)
Mean Score (SE)		379 (8.7)	416 (11.2)	459 (8.5)	476 (19.3)	379 (4.0)
Eastern	N	37	33	70	124	62
% of Students (SE)		12 (3.1)	9 (2.1)	21 (3.8)	38 (4.9)	20 (3.6)
Mean Score (SE)		369 (15.4)	425 (19.3)	460 (15.4)	476 (14.8)	391 (13.3)
TURKEY	N	668	739	1,183	1,022	837
% of Students (SE)		16 (0.9)	17 (0.9)	27 (1.0)	21 (1.1)	19 (1.1)
Mean Score (SE)		394 (4.1)	441 (3.7)	487 (3.7)	521 (4.8)	401 (4.2)

Note. Standard errors are computed using jackknife procedure.

Consistent with the high percentages of students valuing science and having a positive affect toward science, Eastern Anatolia had the highest percentage of students with the most ambitious educational aspirations. That is, 38 percent of the students in the region reported that they expected to get a master's or doctoral degree. The other two regions with relatively high percentages of students within the most favorable category were the relatively higher performing Aegean and Central Anatolia regions (24% and 23%, respectively). As shown in Figure 4.4, students in these three regions also had the highest percentages of students in the most favorable parental education category (i.e., finished university or master's or doctoral degree), suggesting that a high level of parental education may be a motivating factor in students' aspirations for further education.

Regional Differences in Effective School Contexts for Learning Science

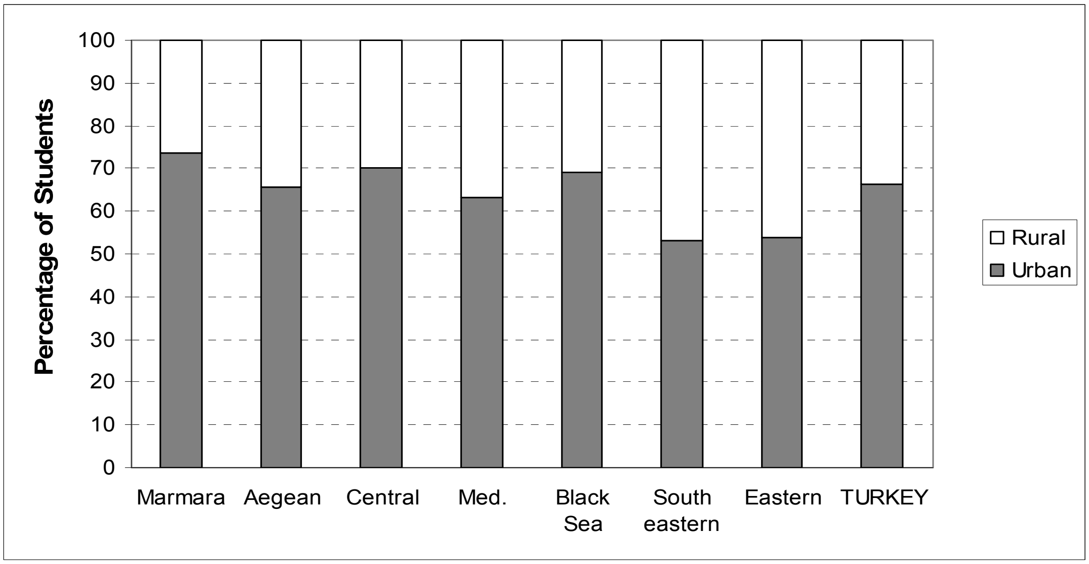
In addition to students' characteristics, the learning environments that schools provide are critical in enhancing student achievement. Figures 4.8 to 4.10 show the extent to which schools across the regions differed from each other in regard to three school background measures including school community type (i.e., whether schools are located in rural or urban settings), the index of principals' reports on positive school climate for academic achievement, and the index of teachers' reports on adequacy of school resources in teaching science. In summary, all three school context factors identified in the exploratory analysis as being positively associated with higher science achievement in Turkey overall and regionally also met the criteria for inclusion in the multilevel models. That is, higher performing regions also had higher percentages of students in effective school contexts.

The community contexts in which the Turkish schools operate may vary from region to region. Considerable research has shown that for Turkey, schools in urban settings are more likely to have access to school resources while schools in rural areas may lack such resources. Figure 4.8 presents, for Turkey and its regions, the percentages of eighth grade students in schools located either in an urban or rural setting. [25] In Turkey, two-thirds of eighth grade students (66%) were enrolled in schools in urban areas and one-third in rural areas. Three-fourths of students (74%) in Marmara (the most developed region) attended urban schools. From the opposite perspective, in Marmara, one-fourth of the students attended rural schools, whereas almost half of the students attended rural schools in Southeastern and Eastern Anatolia (45% and 46%, respectively).

In Turkey, average science achievement in rural schools was lower than in urban schools (430 points and 468 points, respectively). Although this pattern of achievement was apparent in all regions in the country, it was more evident in Eastern Anatolia (the least urbanized region) with a 73 point difference in favor of those attending urban schools. The pattern was less evident in Marmara (the most urbanized region) where the average achievement difference was 8 points between students attending rural schools and those attending urban schools.

[25] Urban areas are defined in this study as areas where population is greater than 50,000.

Figure 4.8. School Community Type in Turkey and Its Regions



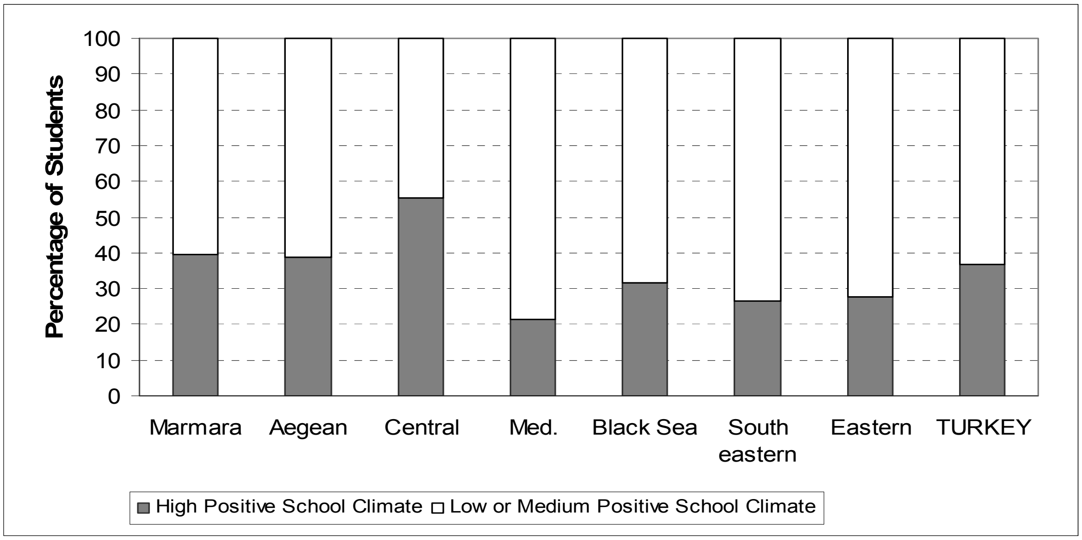
		Urban	Rural
Marmara	N	1,076	286
% of Students (SE)		74 (5.5)	26 (5.5)
Mean Score (SE)		467 (10.0)	461 (10.2)
Aegean	N	348	130
% of Students (SE)		66 (5.0)	34 (5.0)
Mean Score (SE)		483 (13.5)	413 (12.8)
Central	N	545	169
% of Students (SE)		70 (9.2)	30 (9.2)
Mean Score (SE)		482 (8.9)	434 (8.1)
Mediterranean	N	357	140
% of Students (SE)		63 (4.8)	37 (4.8)
Mean Score (SE)		472 (11.7)	430 (23.6)
Black Sea	N	302	140
% of Students (SE)		69 (11.3)	31 (11.3)
Mean Score (SE)		452 (13.5)	450 (20.3)
Southeastern	N	345	247
% of Students (SE)		55 (12.1)	45 (12.1)
Mean Score (SE)		433 (13.0)	404 (9.2)
Eastern	N	195	136
% of Students (SE)		54 (14.0)	46 (14.0)
Mean Score (SE)		471 (16.3)	398 (9.3)
TURKEY	N	3,168	1,248
% of Students (SE)		66 (3.2)	34 (3.2)
Mean Score (SE)		468 (4.6)	430 (5.6)

Note. Standard errors are computed using jackknife procedure.

Figure 4.9 presents, for Turkey and each region, the percentage of students at two levels of the index of principals' reports on positive school climate for academic achievement, together with average science achievement. Students were placed in the high category of the index if they attended schools where the principals responded, on average, that the following aspects of school climate were high or very high: teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, and students' desire to do well in school. Students in the other category of the index were those who attended schools for which principals characterized the elements of school climate, on average, as less than positive (i.e., medium, low, or very low).

In Turkey, only 37 percent of the students attended schools where the principal rated the school climate favorably. In terms of attending a school environment supportive of learning, the principal's ratings were the most positive in Central Anatolia (one of the most developed and higher performing regions), where about half of the students (55%) attended schools with positive climates. In contrast, only a quarter of students (27%) in Southeastern and Eastern Anatolia attended such schools. Across all regions, but particularly in Eastern Anatolia, students who attended schools with a positive school climate performed higher than those in schools where the environment for enhancing learning was rated poorly by principals (512 points and 409 points, respectively).

Figure 4.9. Index of Principals' Reports on Positive School Climate for Academic Achievement in Turkey and Its Regions



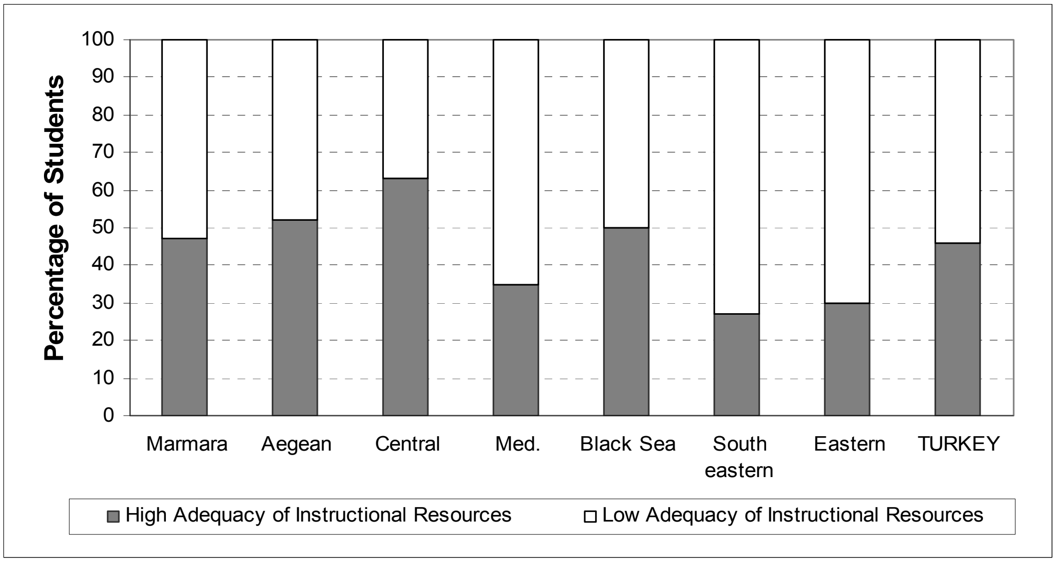
		High Positive School Climate	Low or Medium Positive School Climate
Marmara	N	530	832
% of Students (SE)		40 (8.1)	60 (8.1)
Mean Score (SE)		496 (10.7)	446 (8.3)
Aegean	N	243	262
% of Students (SE)		39 (10.7)	61 (10.7)
Mean Score (SE)		508 (13.0)	430 (14.9)
Central	N	482	257
% of Students (SE)		55 (7.3)	45 (7.3)
Mean Score (SE)		479 (14.7)	445 (9.0)
Mediterranean	N	128	399
% of Students (SE)		21 (10.9)	79 (10.9)
Mean Score (SE)		485 (49.3)	445 (14.5)
Black Sea	N	145	297
% of Students (SE)		32 (12.2)	68 (12.2)
Mean Score (SE)		462 (16.4)	446 (17.4)
Southeastern	N	159	433
% of Students (SE)		27 (12.8)	73 (12.8)
Mean Score (SE)		441 (17.1)	411 (10.3)
Eastern	N	111	220
% of Students (SE)		27 (8.8)	73 (8.8)
Mean Score (SE)		512 (10.0)	409 (10.4)
TURKEY	N	1,798	2,700
% of Students (SE)		37 (3.8)	63 (3.8)
Mean Score (SE)		485 (6.7)	436 (4.8)

Note. Standard errors are computed using jackknife procedure.

Shortages in school resources for teaching science may affect the quality of science teaching, which in turn may influence student's science achievement. It may be that students in the eastern part of Turkey attended schools where science instruction was affected by resource inadequacies. To explore the extent to which regions differed in terms of availability of school resources for science instruction, an index of teachers' reports on adequacy of school resources in teaching science was constructed. The index was based on science teachers' perceptions of the extent to which inadequacies of the following resources limited science instruction: physical facilities, equipment for teacher use in demonstrations, computer hardware, computer software, support for using computers, and other instructional equipment for student's use. Students were assigned to the high level of the index if their science teachers' average rating for school resources available for science instruction was positive (i.e., the shortage of those resources had, on average, little or no impact on science instruction). If their science teachers' rating was poor (i.e., the shortage of resources resulted in, on average, some or a lot of limitations to science instruction), then students were assigned to the low level of the index. Figure 4.10 displays, for Turkey and each region, the percentage of students at the high and low levels of the index, together with average science achievement.

On average in Turkey, students were split almost evenly into the two categories of the index and those at the high level performed higher than those at the low level (470 points and 440 points, respectively). Although almost half of the students (46%) in Turkey were at the high category of the index, there was considerable variation among

Figure 4.10. Index of Teachers' Reports on Adequacy of School Resources in Teaching Science in Turkey and Its Regions



		High Adequacy of Instructional Resources	Low Adequacy of Instructional Resources
Marmara	N	637	725
% of Students (SE)		47 (9.0)	53 (9.0)
Mean Score (SE)		484 (12.5)	450 (9.1)
Aegean	N	272	233
% of Students (SE)		52 (14.1)	48 (14.1)
Mean Score (SE)		491 (13.0)	425 (19.1)
Central	N	468	271
% of Students (SE)		63 (10.5)	37 (10.5)
Mean Score (SE)		467 (12.4)	459 (13.7)
Mediterranean	N	162	365
% of Students (SE)		35 (14.5)	65 (14.5)
Mean Score (SE)		458 (23.9)	451 (14.0)
Black Sea	N	225	217
% of Students (SE)		50 (13.9)	50 (13.9)
Mean Score (SE)		466 (17.4)	437 (19.7)
Southeastern	N	173	419
% of Students (SE)		27 (13.1)	73 (13.1)
Mean Score (SE)		420 (22.1)	419 (11.6)
Eastern	N	120	211
% of Students (SE)		30 (15.4)	70 (15.4)
Mean Score (SE)		454 (25.6)	430 (18.5)
TURKEY	N	2,057	2,441
% of Students (SE)		46 (4.7)	54 (4.7)
Mean Score (SE)		470 (6.2)	440 (5.4)

Note. Standard errors are computed using jackknife procedure.

regions. On the basis of science teachers' reports, in Central Anatolia (a higher performing region), the majority of students (63%) attended schools where shortages of school resources for science instruction were, on average, not a problem. In contrast, a considerably lower percentage of students had the advantage of attending such schools in Southeastern and Eastern Anatolia (27% and 30%, respectively).

Investigation of Factors Contributing to Regional Differences in Achievement

The exploratory analysis of Turkey's extensive array of TIMSS 2007 background data revealed six key indicators that were related to higher science achievement in Turkey, overall and regionally. The analysis also showed that there are regional gaps in these key indicators. More specifically, students in Southeastern and Eastern Anatolia —the two lowest performing regions— had less favorable conditions in these key variables compared with students in the higher performing regions. The six indicators meeting the criteria for inclusion in a series of multilevel models, which include three student background measures and three school context measures, are listed in Table 4.5.

The six selected variables were examined in a series of multilevel models to explore their possible contribution to reducing the Turkish region effect (i.e., the negative effect of attending schools in Southeastern or Eastern Anatolia on student outcomes).

Table 4.5. *Background Factors Related to Regional Differences in Science Achievement*

Student Background Measure	School Background Measure
1. Frequency of speaking Turkish at home	1. School community type
2. Parents' highest education level	2. Index of principals' reports on positive school climate for academic achievement
3. Index of home resources	3. Index of teachers' reports on adequacy of school resources in teaching science

This section presents results from the statistical models, which were built to explore whether altering these variables would serve to reduce the magnitude of the region effect.

As summarized previously in Table 4.2, several steps were involved in the multilevel statistical analyses. First, several *student models* and *school models* were built from the *base model* (see Equation 3.6). Each student or school variable was first added separately to the *base model* to examine independent effects of the variables on the regional achievement differences. Next, to investigate the overall effect of student background, student variables that were significantly related to achievement were added as a group to the *base model* in an *overall student model* (see Equation 3.10). This model provided an estimate of what the average achievement difference between Marmara and Southeastern Anatolia, as well as between Marmara and Eastern Anatolia could be expected to be, if all regions had the similar distributions on selected home background variables. That is, if differential student characteristics between the regions were controlled statistically, would regional achievement differences be expected to disappear? The impact of home environment was investigated via the *overall student model*.

Similarly, an *overall school model* (see Equation 3.13) was built by adding all significant school context variables to the *base model*. The *overall school model* allowed for exploration of what the average achievement difference between Marmara and Southeastern Anatolia and also between Marmara and Eastern Anatolia would be, if all regions had the similar distributions in terms of the selected school context variables. In other words, school models explored whether regional differences may be expected to disappear or continue once differential school characteristics were controlled. These questions were addressed via the *overall school model*. Lastly, all of the significant variables were added to the *base model* in a *final model* (see Equation 3.14) to test the joint effect of selected predictors on regional differences.

In this dissertation study, to aid the interpretation of results, variables included in the multilevel models were dummy coded with values of 0 and 1. The favorable category of the explanatory variables (e.g., the high level of an index) was coded 0 while the unfavorable category (e.g., the low level of an index) was set to 1. This way of coding allowed the regression coefficient values from each model to have substantial meaning to increase understanding, and thus facilitate the interpretation of results from the statistical analyses. Following this coding scheme, the regression coefficients of the explanatory variables were interpreted as the estimated change in science score associated with moving from the favorable category of the variable to the unfavorable level (e.g., moving from the high level of the index to the low level).

Student models analyzed the extent to which Turkey's regional differences in science achievement were related to the following three student home background variables: frequency of speaking Turkish at home, parents' education level, and index of home resources. As shown in Table 4.6, results from the individual models for each student variable revealed that all three variables had a highly significant relationship with science achievement ($p_{\text{homeresources}} < .0005$, $p_{\text{language}} < .0005$, $p_{\text{parentedu}} < .0005$) when added to the *base model* —the model of regional achievement differences only. For example, the individual model for parental education variable estimated Marmara's average science score as 491 points when the predictor was favorable; that is, students had parents with more than a primary school education. Average achievement was predicted to be 33 score points lower for the unfavorable condition, which is when students had parents who at best completed primary school.

When the three student variables were taken into account together with region in the *overall student model* (see Table 4.6), the effect of each one on science achievement was reduced due to intercorrelations among these three variables (e.g., it is likely that as parental education level increases, level of resources available at home also increases). For example, the 33 score point effect of the individual parental education variable was reduced to a 28 point effect in the *overall student model*. Nevertheless, the three student home background variables were all shown to be significant predictors of science achievement when they were included with region in the *overall student model* ($p_{\text{homeresources}} < .0005$, $p_{\text{language}} < .0005$, $p_{\text{parentedu}} < .0005$).

Table 4.6. *Student Models of TIMSS 2007 Science Achievement in Turkey (N=4,498)*

	Base Model	Index of Home Resources	Speaking Turkish at Home	Parental Education	Overall Student Model
Intercept reliability	0.934	0.921	0.932	0.919	0.906
Intercept (Marmara)					
Predicted mean science score (SE)	468 (8.3)	484 (7.7)	470 (8.2)	491 (7.9)	500 (7.5)
School-level variables					
Aegean	-10 (16.4)	-9 (14.6)	-10 (16.0)	-10 (14.5)	-9 (13.3)
Central	-11 (12.2)	-11 (10.6)	-9 (11.8)	-11 (10.5)	-10 (9.4)
Mediterranean	-17 (16.3)	-12 (14.8)	-17 (16.1)	-16 (14.6)	-12 (13.8)
Black Sea	-21 (16.5)	-16 (15.3)	-21 (16.3)	-19 (15.0)	-16 (14.4)
Southeastern	-47** (13.9)	-42** (12.8)	-34* (13.2)	-44** (12.5)	-29* (11.8)
Eastern	-40* (16.7)	-36* (15.0)	-33* (15.7)	-38* (15.2)	-30* (13.5)
Student-level variables					
Index of Home Resources (High=0, Low=1)		-27** (3.2)			-18** (3.3)
Speaking Turkish at Home (Always or almost always=0, Sometimes or never=1)			-35** (5.8)		-32** (5.7)
Parental Education (Higher than primary school=0, Primary school or less=1)				-33** (3.4)	-28** (3.6)

Note. Hierarchical linear models with random intercepts weighted by TOTWGT.
**p < .01., *p < .05.

Results from the individual student models also showed that controlling for each student factor might be expected to reduce the Turkish region effect (i.e., the negative effect of attending schools in Southeastern or Eastern Anatolia on student outcomes) though the region effect remains statistically significant (see Table 4.6). For example, the individual model for the parental education variable estimated that, if all regions had the same distributions on this factor, the initial 47 score point gap in average science achievement between Marmara and Southeastern Anatolia (estimated by the *base model*) would reduce to 44 points, but this reduced achievement difference was still significant ($p_{southeastern} = .001$). As estimated by the *overall student model*, the initial 47 score point gap would be decreased to 29 points if all regions had similar distributions on all three student variables. However, achievement differences between Marmara and Southeastern Anatolia and also between Marmara and Eastern Anatolia were still significant ($p_{southeastern} = .015$, $p_{eastern} = .030$).

The school models examined the extent to which Turkey's regional differences in science achievement were related to three school background measures including the community type of school (i.e., rural/urban), the index of positive school climate for academic achievement, and the index of adequacy of school resources in teaching science. As shown in Table 4.7, results from the individual models for each school variable revealed that all three school variables had a highly significant relationship with science achievement ($p_{communitytype} < .0005$, $p_{schoolclimate} < .0005$, $p_{instructionalresources} = .002$) when added to the *base model*. For example, the individual model for the index of positive school climate for academic achievement estimated Marmara's average science

Table 4.7. *School Models of TIMSS 2007 Science Achievement in Turkey (N=4,498)*

	Base Model	Community Type	Index of Positive School Climate	Index of Adequacy of Instructional Resources	Overall School Model
Intercept reliability	0.935	0.929	0.921	0.931	0.913
Intercept (Marmara)					
Predicted mean science score (SE)	468 (8.3)	479 (9.1)	497 (9.6)	484 (9.6)	511 (10.0)
School-level variables					
Aegean	-10 (16.4)	-10 (15.2)	-7 (14.1)	-11 (15.0)	-9 (12.8)
Central	-11 (12.2)	-9 (11.8)	-13 (11.4)	-15 (12.4)	-15 (10.9)
Mediterranean	-17 (16.3)	-14 (15.6)	-7 (15.5)	-14 (15.7)	-5 (15.0)
Black Sea	-21 (16.5)	-20 (17.4)	-15 (15.7)	-22 (15.3)	-15 (15.2)
Southeastern	-47** (13.9)	-40** (13.2)	-39** (13.3)	-40** (13.9)	-30* (13.8)
Eastern	-40* (16.7)	-32* (14.6)	-29* (13.1)	-33* (16.2)	-21 (11.4)
Community Type (Urban=0, Rural=1)		-35** (8.1)			-24** (7.6)
Index of Positive School Climate (High=0, Low or medium=1)			-49** (9.0)		-41** (8.9)
Index of Adequacy of Instructional Resources (High=0, Low=1)				-30** (9.0)	-23** (8.3)

Note. Hierarchical linear models with random intercepts weighted by TOTWGT.
**p < .01., *p < .05.

score as 497 score points when the variable was favorable; that is, students attended schools where principals perceived high positive school climate for student achievement (e.g., high level of teachers' expectations and parental support for student achievement). Average achievement was predicted to be 49 score points lower for the unfavorable condition, where principals perceived low positive school climate for academic achievement.

When the three school variables were taken into account together with region in the *overall school model* (see Table 4.7), the effect of the variables on science achievement was reduced because it is likely that these three school variables are intercorrelated (e.g., the level of school resources available for teaching are likely to be lower in rural schools compared with schools that are located in urban settings in Turkey). For example, the 49 score point effect of the index of positive school climate for academic achievement was reduced to a 41 point effect in the *overall school model*. However, based on the results from the *overall school model* which included region, all three school context variables were still significantly related to science achievement ($p_{\text{communitytype}} = .003$, $p_{\text{schoolclimate}} < .0005$, $p_{\text{instructionalresources}} = .008$).

Results from the individual school models also showed that controlling for each school factor might be expected to reduce the negative effect on achievement of attending schools in Southeastern or Eastern Anatolia even though the region effect remains significant (see Table 4.7). For example, the individual model for the index of positive school climate for academic achievement estimated that, if all regions had the same distributions on this variable, the initial 47 score point difference in average science achievement between Marmara and Southeastern Anatolia would reduce to 39 points, but this reduced achievement gap remains statistically significant ($p_{\text{southeastern}}$= .004). Controlling for the three school context factors (i.e., if all regions had the same distributions on these three school factors) resulted in insignificant achievement differences between Marmara and Eastern Anatolia. Specifically, the initial 40 score point gap between Marmara and Eastern Anatolia was reduced to 21. However, the negative effect of Southeastern Anatolia on science achievement was still statistically significant ($p_{\text{southeastern}}$= .029).

As previously mentioned, the individual student background and school context models aimed to identify the independent effects of the three factors at student level and three factors at school level on the regional differences in science achievement. The *overall student model* and *overall school model* examined the aggregate effects of the student level factors and school level factors, respectively. However, these factors do not operate in isolation in the schooling process. That is, they are interconnected—both within and among the different levels— in influencing student outcomes. For example, it is likely that as parental education level (a student level factor) increases, both home resources level (a student level factor) and parental support for student achievement (a factor contributing to positive school climate —a school level factor) increases.

Considering the complex nature of the education system, the *final model* built on the student background and school context models and included six significant student and school variables in addition to region. As shown in Table 4.8, when added together with region, these six variables are significant predictors of science achievement

($p_{homeresources} < .0005$, $p_{language} < .0005$, $p_{parentedu} < .0005$, $p_{communitytype} < .023$, $p_{schoolclimate} < .0005$, $p_{instructionalresources} = .006$). Among the student background variables examined, speaking Turkish —medium of instruction in Turkey— was the strongest predictor of science achievement, followed by parental education level, and home resources ($b_{language} = -31$, $b_{parentedu} = -27$, $b_{homeresources} = -17$, respectively).[26] As to the school background variables, positive school climate for achievement was the strongest predictor of achievement ($b_{schoolclimate} = -29$), followed by adequacy of school resources in teaching science ($b_{instructionalresources} = -20$) and school community type ($b_{communitytype} = -15$).

Due to intercorrelations among the six variables of the *final model*, the independent effects of each variable on science achievement were reduced as the variables were clustered either in the *overall student model* or *overall school model* and eventually added together in the *final model*. For example, the 49 score point effect of the index of positive school climate for achievement was reduced to 41 in the *overall school model* and eventually 29 in the *final model* (see Table 4.8). However, as mentioned previously, the index of positive school climate for achievement and the other five variables included in the *final model* are significant predictors of science achievement.

Results of the *final model* suggest that controlling statistically for the differences in the six student and school factors examined would be expected to greatly reduce the magnitude of the region effect. Specifically, the *final model* estimated Marmara's average

[26] The regression coefficients of the *final model* were interpreted as the estimated change in achievement associated with moving from the favorable category of the predictors to the unfavorable level, thus the regression coefficients had negative values.

Table 4.8. *Final Model of TIMSS 2007 Science Achievement in Turkey (N=4,498)*

	Base Model		Final Model	
Intercept reliability	0.935		0.930	
Intercept (Marmara)				
Predicted mean science score (SE)	468 (8.3)		530 (8.7)	
School-level variables				
Aegean	-10	(16.4)	-9	(10.8)
Central	-11	(12.2)	-14	(8.6)
Mediterranean	-17	(16.3)	-4	(13.0)
Black Sea	-21	(16.5)	-12	(13.4)
Southeastern	-47**	(13.9)	-17	(12.7)
Eastern	-40*	(16.7)	-16	(9.9)
Community Type (Urban=0, Rural=1)			-15*	(6.6)
Index of Positive School Climate (High=0, Low or medium=1)			-29**	(7.5)
Index of Adequacy of Instructional Resources (High=0, Low=1)			-20**	(7.1)
Student-level variables				
Index of Home Resources (High=0, Low=1)			-17**	(3.3)
Speaking Turkish at Home (Always or almost always=0, Sometimes or never=1)			-31**	(5.8)
Parental Education (Higher than primary school=0, Primary school or less=1)			-27**	(3.6)

Note. Hierarchical linear models with random intercepts weighted by TOTWGT.
**p < .01., *p < .05.

science score as 530 points when the six predictors were optimal; that is, the students attended schools where principals perceived high positive school climate for student achievement (e.g., high level of teachers' expectations and parental support for student achievement), the science teachers rated the level of school resources available for teaching science as high, and the schools were located in urban areas as well as the students came from home environments where they had high levels of home resources (e.g., access to computer, Internet connection, and study desk), often spoke Turkish at home, and had parents with more than a primary school education.

Under the same optimal conditions, the model estimated the average science achievement only 17 points lower for Southeastern Anatolia (i.e. 513 score points) and 16 points lower for Eastern Anatolia (i.e. 514 score points), and these achievement differences were not statistically significant (see Table 4.8). That is, initial significant difference estimates —47 points lower for Southeastern Anatolia and 40 points lower for Eastern Anatolia— were reduced to the extent that the initial achievement differences were no longer statistically significant. These findings suggest that, if all regions had the same distributions in terms of the six student and school variables, the average achievement difference between Marmara and Southeastern Anatolia and also between Marmara and Eastern Anatolia could be greatly reduced.

Under the least favorable conditions, the *final model* estimated Marmara's average science score 139 points lower (i.e. 391 score points). The least favorable conditions were when students attended schools where principals perceived low positive school climate for academic achievement, where science teachers rated the level of school resources available for teaching science as low, and schools were located in rural areas as well as where students had low levels of home resources, infrequently (i.e., sometimes or never) spoke Turkish at home, and had parents who at best had only completed primary school.

As presented previously, the results of the *unconditional model* (that included no explanatory variables) showed that 34 percent of the total variation in science achievement in Turkey was due to differences among schools/classes and 66 percent of the total variance was attributable to differences among students. When selected student and school variables were included in the *final model*, a small fraction of the between-student variance was accounted for (4% of the 66%) compared to the between-school component (51% of the 34%). This meant that 20 percent of the total variance in achievement was accounted for by the student and school variables included in the *final model*. This relatively low percentage of total variation accounted for stems from the fact that the primary interest of this study was to develop an explanatory model of Turkey's *regional* achievement differences and not a model of *student* achievement differences in Turkey. That is, the purpose was to explain the variation among regions as opposed to variation in student achievement. The purpose of this study drove the selection of variables included in the *final model*. Therefore, even though several student attitude variables associated with student achievement were identified at the exploratory stage (e.g., self-confidence in learning science), they were not included in the *final model* because they did not vary across the regions, suggesting that they would not have necessarily contributed to the regional disparities.

In regard to the findings of this study, previous studies have also found that eighth grade students in Turkey whose parents had higher levels of education performed better in science than those whose parents had lower levels of education (Aypay, et al., 2007; Berberoglu, et al., 2003; Ozdemir, 2003). These studies also have shown that the number of books at home as well as home possession of other educational items such as a computer and study desk are among the important predictors of student achievement. This dissertation study identified an additional predictor of science achievement in Turkey: speaking the language of the test at home. This finding, however, is not consistent with the results reported by Caliskan (2008), who found, using Turkey's science literacy data from PISA 2006, that speaking Turkish most of the time at home "was not significant for Turkish [15-year-old] students" (p.157).

The inconsistency between the findings from this dissertation study and Caliskan's study (2008) may stem from the differences in the student sample used in each study. This study used Turkey's TIMSS 2007 data, which was collected from eighth grade students who were, on average, 14 years old at the time of testing. In comparison, the latter study used Turkey's data from PISA 2006, which tested 15-year-old students who were mostly ninth grade students in Turkey. In Turkey, eighth grade is the final grade of compulsory primary education and has a high enrollment ratio, while ninth grade is the beginning of noncompulsory secondary education and has a substantially lower enrollment ratio.

In Turkey, at the time of the TIMSS 2007 testing, the net enrollment ratio for primary school was 97 percent, whereas at the time of PISA 2006 testing, the ratio was 57 percent for secondary education (MoNE, 2008). Therefore, when evaluating data from Turkish ninth grade students, it should be noted that almost half of the secondary school age children were excluded from the picture, simply because they were no longer enrolled in school. Unfortunately, the high percent of dropouts in Turkey (i.e., students who do not continue their schooling after compulsory education) are usually low performing students who come from disadvantaged home backgrounds. Therefore, it is reasonable to assume that students who continue their education after compulsory schooling are, to a large extent, relatively high performing students who probably come from affluent homes.

This means that PISA's Turkish ninth grade student sample may underestimate the distribution of disadvantaged background characteristics, while overestimating the achievement of 15 year olds in Turkey. In fact, based on PISA 2006 data, essentially all students (98%) spoke Turkish most of the time at home (Caliskan, 2008). Consequently, the language variable did not vary among the PISA ninth grade students and thus could not be related with achievement. Based on TIMSS 2007, however, a somewhat smaller percentage of students (89%) reported speaking Turkish always or almost always at home, and this factor was shown in this study to be a significant predictor of achievement.

In summary, the results of the *final model* suggest that low performing students in the Southeastern and Eastern Anatolia regions would have performed much more like the students in Marmara (i.e., there would not be any statistically significant differences in achievement) if students across the regions were provided with similar resources and opportunities in terms of the characteristics of the schools they attended and their home backgrounds. The school context characteristics that contributed to the regional disparities in achievement included the level of positive school climate for academic achievement, availability of school resources for teaching science, and school community type. Characteristics of student home background that contributed to the regional achievement differences included the level of fluency in Turkish, availability of home resources, and parental education.

The findings of this study suggest that improving the conditions for school factors would serve to reduce the magnitude of the Turkish region effect on student outcomes. However, it would be very difficult to this in isolation, since the school factors are intercorrelated with the student factors and, therefore, partly a reflection of the student factors. For this reason, in order to overcome low student achievement in the Southeastern and Eastern Anatolia regions, all factors contributing to the region effect need to be eventually addressed. That is, for *all* students to succeed in Turkey, efforts to improve each factor should not be isolated from each other, instead a strategic comprehensive approach that connect and integrate all efforts should be in place.

However, the relative effects of the particular home background and school context factors estimated in this study should be interpreted with caution. This is despite the fact that the findings of this study are based on sophisticated statistical analyses and similar to other findings in the literature reporting associations between achievement and home and school background factors. Even though TIMSS collected hundreds of background variables from students, teachers, and school principals, it is virtually impossible, due to cost and practicality reasons, to collect all information that might be related to student achievement. Also, due to the crossectional and nonexperimental nature of the data, it is not possible to make definitive statements about cause and effect.

Despite the inherent limitations of using data from a cross-sectional study, the results of this dissertation study provide preliminary supportive evidence for policy makers to establish targeted educational policies in order to combat low levels of educational outcomes in Turkey in general and achievement disparities between its regions in particular. For example, the findings of this study may serve as a basis for some small-scale studies or programs in Turkey. A possible intervention for students in eastern Turkey may be a Turkish language program to compensate students who do not frequently speak Turkish at home. If new programs provide empirical evidence about the effects of the intervention on student achievement, a broad-scale implementation of the intervention could then be launched.

Also, it is recognized that these results primarily serve to underscore the enormous challenge facing Turkey in improving educational outcomes nationally and equitably across all regions. Addressing inequities in both home and school learning contexts is a monumental undertaking. The challenge of mitigating the effects of disadvantageous home backgrounds while enhancing the desirable characteristics of school context may be overwhelming in practice and would require dramatic changes in educational policies and practices.

Nevertheless, these enormous challenges are among other monumental socioeconomic challenges that Turkey faces as it seeks to be a part of the European Union by 2013. The challenges of substantially raising educational achievement in Turkey overall and especially in the lower performing regions would require political determination. The government’s strong will, the Ministry of National Education’s leadership, and ongoing commitment from various stakeholders is crucial for crafting specific educational policies aimed at mediating deeply-rooted interregional disparities in achievement, and thereby improving overall levels of student proficiency in Turkey.

Chapter 5

Conclusions

This final chapter begins with an overview of the research conducted in this study to investigate regional differences in science achievement in Turkey, and identify factors related to higher relative performance. The TIMSS 2007 data were analyzed using Hierarchical Linear Modeling (HLM), and differences in key educational resources were found between the highest and lowest performing regions. The main findings are summarized, and the policy implications of these findings are discussed. Finally, the limitations of the study and suggestions for future research are presented.

Overview of the Study

Despite being among the 20 largest economies of the world, Turkey has yet to provide its citizens with high quality living standards. According to the United Nations Development Programme's *Human Development Report 2007/2008*, Turkey is among the "medium level" countries in terms of the Human Development Index (HDI). By contrast, the 27 member states of the European Union (EU), of which Turkey seeks membership, are all considered "high level" HDI countries. When education, health, and economic components of the index are examined separately, it is evident that Turkey's medium HDI level mainly results from its low level on the education index (ranking 104th) compared with its life expectancy index and GDP index (ranking 84th and 67th, respectively). For example, consistent with Turkey's place in the human development rankings for education, TIMSS 2007 results showed that, of the 49 countries that participated in the study, Turkey had the lowest percentage of eighth grade students (7%) with at least one parent who had graduated from a university.

Issues of access, quality, and equity in education have been a challenge for Turkey since its founding less than a century ago in 1923. Because it is in the process of working towards incorporation into the EU by 2013, Turkey's existing educational issues have gained even greater significance and urgency. Turkey has worked steadily to improve access to education and in 1997 extended compulsory primary education from 5 to 8 years. With 11 million students in primary education (grades 1 to 8), remarkable progress has been made in terms of increasing access to primary schooling. The net enrollment ratio had increased to 97% in 2007 (MoNE, 2008). However, Turkey still faces enrollment deficits before and after the years of compulsory schooling. For example, the gross schooling rate for preschool was only 20 percent in 2005 (DPT, 2006) and the net enrollment ratio for secondary school was only 57 percent in 2007 (MoNE, 2008).

Despite the substantial progress in increasing access to primary schooling, improving the quality of primary education is still a source of considerable concern in Turkey. Low student achievement results in both international and national assessments show that improving student outcomes remains a challenge for Turkey. Most recently, Turkish eighth grade students had significantly lower average achievement in mathematics than students in all of the 12 EU countries that participated in TIMSS 2007, and although Turkey's average science achievement was similar to three EU countries (Romania, Malta, and Cyprus), it was lower than all the other EU countries. The eighth grade is an important educational milestone in Turkey because it is the end of primary education and the last grade of compulsory education.

The TIMSS 2007 results showed that, even at the eighth grade with nearly all students still enrolled in school, high quality education remains a privilege provided only for a small fraction of Turkish students. Only 5% of eighth grade students reached the TIMSS 2007 *Advanced International Benchmark* in mathematics and 3% in science, demonstrating competency in complex concepts and reasoning tasks. By contrast, an alarming 41% of Turkish students performed below the *Low International Benchmark* in mathematics, signifying they did not demonstrate a grasp of even basic computational skills. In science, 29% performed below the *Low International Benchmark*, indicating little knowledge of even basic facts from the life and physical sciences. These results suggest that, in addition to the challenge of maintaining high enrollment in grades 1-8, Turkey also faces the enormous challenge of providing quality education to all children in the nation.

Beyond the overarching concerns of access and quality, another aspect of Turkey's educational challenge relates to the persistent disparities in human development among its seven geographic regions. The urbanized west of Turkey is socioeconomically more developed than the rural east and apparently better educated. An in-depth understanding of regional inequalities in relation to educational outcomes is central to establishing strategies for reducing regional gaps. In particular, identifying the factors influencing regional inequalities in student learning is crucial for developing policies that will help raise the educational performance at the national level as well as close regional gaps in student achievement.

The overarching aim of this dissertation was to provide empirical information about the current picture of regional achievement disparities and the factors that are pertinent to reducing them. The unification process with the EU involves the immense tasks of supporting a globally competitive and sustainable economy as well as sharing an equitable social structure. As Turkey pursues full membership in the EU, the process presents a unique opportunity for socioeconomic reforms that are necessary to help improve conditions in the regions that are lagging behind the national average in human development.

Findings of the Study

To contribute to the discussion in Turkey about the best strategies for improving the overall level of student outcomes in primary education and eliminating the achievement inequalities among its regions, this dissertation analyzed eighth grade science achievement data from TIMSS 2007. The study began with an examination of the extent of Turkey's regional differences in science achievement at eighth grade.

Considering Turkey's persistent regional disparities in human development, the results of the initial analysis of achievement differences across regions were not overly surprising, but nevertheless disappointing. The study revealed that in general, the socioeconomic differences between the western and eastern parts of Turkey corresponded to the differences in student achievement at the end of compulsory primary education. Marmara, Aegean, and Central Anatolia —the most socioeconomically developed regions— were the highest performing regions. Eastern Anatolia and, in particular, Southeastern Anatolia —the two least developed regions— had the lowest science achievement in TIMSS 2007 at the eighth grade.

These inequalities in science achievement at the eighth grade occurred despite the fact that *all* students in Turkey are intended to be provided with similar teaching time and content by the end of primary school. In addition to the overall low performance at the national level, these findings highlighted yet another challenge for the Turkish educational system. That is, the already low educational quality is not distributed evenly across the country.

To identify factors associated with regional differences in educational achievement, this study involved extensive exploratory data analysis of the hundreds of background variables collected by TIMSS 2007 via student, teacher, and school questionnaires. The analyses revealed that, compared with students in high performing regions, the students in the two lowest performing regions had disadvantageous background on several key home background and school context variables associated with student achievement. In comparison to the students in the highest performing regions, the students in Southeastern and Eastern Anatolia came from homes with fewer educational resources (e.g., books, computer, Internet connection, and study desk), had parents with less education, and spoke Turkish less frequently at home. These students also attended schools with characteristics associated with low achievement, including being located in rural areas, not adequately equipped with instructional resources (e.g., physical facilities, equipment for teacher use in demonstrations, computer hardware and software, and other instructional equipment for student's use), and having a school climate not supportive of learning in terms of teachers' expectations for student achievement, parental support for student achievement, parental involvement in school activities, and students' desire to do well in school.

Using Hierarchical Linear Modeling (HLM) analyses, this study also found that controlling home background factors might result in reduced achievement differences across regions. Similarly, if school context factors were controlled, regional differences in achievement might be reduced. Moreover, a statistical model that controlled for both home background and school context factors reduced the region effect to the extent that the regional achievement gaps were no longer statistically significant. The statistical models applied in this study imply that if students across the regions were provided with similar opportunities in terms of the characteristics of the schools they attended and their home backgrounds, the significant achievement gaps across the regions could be greatly reduced.

Policy Implications of the Study

Over the past decade, the priority for Turkey's educational policies was providing universal access to primary schooling for the children in the nation, including girls and children in rural areas. In addition to the fundamental reform of increasing compulsory education from 5 to 8 years, important initiatives targeting school access were successfully implemented and as a result, the net enrollment ratio in primary school has reached 97 percent as of the 2007/08 academic year (MoNE, 2008). These educational projects included a girls' education campaign, busing students to schools in rural areas, and providing access to free boarding schools in primary education (Aydagul, 2007).

The results of this study suggest that, even though Turkey has nearly achieved equity in access to primary schooling, equity in educational outcomes at the end of primary education has yet to be achieved. There are significant regional disparities in student achievement at the end of compulsory education. This means that Turkey's challenge of improving overall education quality is coupled with the challenge of achieving equity in student achievement across the regions. Therefore, Turkey's remarkable success in expanding access to primary schooling needs to be repeated through complementary efforts to improve quality and equity in student achievement.

Educational policies aimed at improving the quality of teaching and learning in Turkey have already been launched. In 2003, Turkey initiated its most comprehensive curriculum reform to develop and implement new curricula in all core subjects in primary education. The new curricula for grades 1 to 5 were implemented in schools beginning in the 2005/06 academic year, followed by implementation for grades 6, 7, and 8 in the 2006/07, 2007/08, and 2008/09 academic years, respectively. Along with these curriculum reform efforts, the percentage of total instructional time allocated to science was increased from 10 to 13 percent (Demirer, et al., 2008).

Recent curriculum efforts are significant steps toward improving overall education quality in Turkey. However, to ensure the success of the main goal of progress in quality education overall, progress in student achievement in the eastern part of the country is necessary. Therefore, efforts aimed at increasing quality education needs to integrate measures for eliminating regional gaps in education quality. Such efforts should target barriers to progress in equity of student achievement across regions. Among hundreds of policy related background variables examined in this study, several factors emerged as key contributors to the low performance of students in Southeastern and Eastern Anatolia. These contributing factors were the disadvantages in home background, such as infrequently speaking Turkish (i.e., language of instruction) at home, low levels of parental education and educational resources at home, and unfavorable characteristics in school contexts including being located in rural areas, not adequately equipped with instructional resources, and having a school climate not supportive of learning.

In recent years, initial steps have been taken to combat the disadvantages in home background in the east of Turkey. These efforts included cash transfers made to the poorest six percent of families with children (World Bank, 2008) and implementing adult education programs. In Turkey, adult education initiatives are offered as part of nonformal education activities and mostly in collaboration with NGOs. Major recent programs that are being conducted by the Mother and Child Education Foundation (ACEV), a prominent NGO in Turkey, include literacy programs, such as *The Functional Adult Literacy and Women's Support Program* and parenting skills programs, such as the *Mother Support Program* and the *Father Support Program*. The findings of this study suggest that adult education programs are greatly needed in Southeastern and Eastern Anatolia and thus, should be supported and extended to all illiterate mothers and fathers across the country.

The results of this dissertation study also suggest that existing parent education programs should be enhanced so that they encompass strategies that equip parents to support student achievement and involvement in school activities. Such comprehensive education programs may be conducted jointly with schools and include teachers in order to create school climates generally supportive of student learning. Strategies may involve helping parents understand the main elements of the curriculum and keeping them informed about how well their children are progressing in school. Sustained training for parents and collaboration with teachers may help build trusting relationships among parents, teachers, and students. In such a supportive and collaborative system, teachers are more likely to have high expectations from students and in turn students are more likely to desire to perform well in school (Muijs, Harris, Chapman, Stoll, & Russ, 2005; Reynolds & Teddlie, 2000).

The results of this study suggest that one way to improve education levels in Turkey would be to develop educational policies in the low performing regions that aimed specifically to alleviate the disadvantages that stem from students receiving school instruction in Turkish but infrequently speaking Turkish at home. Currently, such policies for second language learners are essentially absent in Turkey. If Turkish remains the only formal language of instruction, initiatives should be put in place to compensate for the negative influences of not being fluent in Turkish. Students who do not speak Turkish frequently at home may benefit from studying Turkish as a second language or from special training programs in the Turkish language. These extra Turkish language programs may be embedded in after-school programs offering extended learning time in the language of instruction. For schools with double-shift education where two sets of students are taught in a full day due to shortage of classrooms and teachers, school facilities might not be available for such language programs. In these cases, special training programs in the Turkish language may be part of summer school programs. Most recently, the United States' *the National Literacy Panel on Language-Minority Children and Youth* examined the research on acquiring literacy in a second language and concluded that the most promising literacy programs for language-minority students provide an early, ongoing, and intensive instructional support to develop reading, writing, and oral proficiency in the language of instruction (August & Shanahan, 2006).

In addition to preparing students for primary education, early childhood development programs are viewed as one of the most effective intervention approaches provided for disadvantaged children (Field, Kuczera, & Pont, 2007; OECD, 2009;

Wobmann & Schutz, 2006). In Turkey, the schooling ratio for preprimary education, which is optional in the country, is a source of considerable concern. As shown in Figure 2.1 in chapter 2, a 13% gross schooling ratio for preprimary schooling is the lowest ratio among the EU member and candidate states and lags far behind the 85% average. Consistent with this grim picture of the status of access to preprimary schooling in Turkey, Progress in International Reading Literacy Study (PIRLS) 2001 results showed that only in Turkey and Iran, of the 35 countries that participated in the study, “did the majority of students not attend preschool” (76% and 70%, respectively) whereas “almost all countries make provision for at least one year of preprimary education” (Mullis et al., 2003, p.129). Moreover, the already low numbers of children that have access to preprimary schooling are mostly located in urban areas and in the western part of the country (MoNE, 2005). The government’s target is to increase the gross enrollment ratio to 50% (up from 20% as of 2005 figures) in preschool by 2013, the year that Turkey is expected to become a full member of the EU (DPT, 2006). Given the importance of preprimary schooling for achieving equity in student achievement, initiatives need to be formulated to prioritize preschool education in Southeastern and Eastern Anatolia.

The results of this study also indicated that schools in the eastern regions of Turkey may have fewer resources than those in other regions. In TIMSS 2007, science teachers in the eastern regions reported nearly three-fourths of students were in schools with inadequate instructional resources such as equipment for teacher use in demonstrations, computer hardware and software, and other instructional equipment for student’s use. Adequacy of school resources in teaching was a significant explanatory variable in the HLM analyses of regional disparities. To better combat the unfavorable characteristics of school learning contexts in the east of Turkey, perhaps, the Ministry of National Education's resource allocation policies need to be revisited. The ministry currently allocates funds to schools on an incremental budgeting basis. That is, "through a percentage increase on a school's prior year budget" (OECD, 2007b, p.134). Compensatory financing that is tailored according to the information on key indicators, such as enrollment and percentage of socioeconomically disadvantaged students, may ensure better resource allocation as well as enhance the physical infrastructure and instructional resources for teachers.

Significant increases in educational outcomes in disadvantaged regions are essential for those regions and for improving the overall education quality in Turkey. Therefore, elimination of the educational barriers in Southeastern and Eastern Anatolia is critical to raising overall achievement level in Turkey. Consequently, to raise the overall educational quality in the country, some educational policies and strategies should be developed specifically for low performing regions. The results of this study suggest that a number of targeted policies could be crafted with the aim of compensating for some of the disadvantageous home background factors such as low parental education levels and lack of fluency in speaking Turkish as well as aspects of the unfavorable school characteristics of students in disadvantaged regions such as fewer instructional resources and less academic rigor.

Without a doubt, the reality of establishing and implementing educational policies aiming to raise overall educational quality and provide equal educational opportunities to all students in the nation would be enormously challenging. In addition to the massive scale, addressing these issues also has a sense of urgency as Turkey pursues full membership in the EU in upcoming years. The government's *Ninth Development Plan 2007-2013*, the primary strategy plan aimed at coordinating the efforts involved in the EU accession process, documents that Turkey seeks to be "globally competitive" and "sharing more equitably". Considering these national goals of the country, progress in increasing the quality and equity in student achievement is imperative.

Given the scale, significance, and urgency of the issues in educational quality and equity in Turkey, political determination is fundamental for progress. The government's latest development plan addresses the socioeconomic equity issues across the regions and between rural and urban settings. Elimination of regional disparities in socioeconomic indicators is viewed as one of the key elements in Turkey's path to the EU. The government's commitment to alleviate regional gaps in human development is expected to provide direction to other national programs, including the public policies, strategic goals, and priorities in the Ministry of National Education. The ministry can contribute to the efforts in tackling persistent regional development issues via ensuring that comprehensive educational policies are formulated and implemented for *all* Turkish students. However, the ministry may also need to specifically address the unfavorable conditions in the low performing regions with special initiatives.

Limitations of the Study

Although this study used highly reliable data and sophisticated statistical analyses, there are some inherent limitations of the study. It should be noted that TIMSS is an observational study and not a randomized experiment. That is, students tested in TIMSS were already enrolled in their schools and not randomly assigned to schools by TIMSS. Effects of the predictors estimated using observational data, such as TIMSS, should not be interpreted in terms of causal relationships because it is not possible to determine the extent to which pre-assignment differences in student populations might affect the estimated effects.

In addition, the results of this study are based on statistical models that are constrained by the available data. Even though TIMSS collected a vast array of background information from students, teachers, and school principals, there most certainly is other information related to student achievement that was not fully captured in the data. For example, in reference to this study, it may be the case that the students in the low performing regions are also overly represented among students with low or no preprimary education. Because information on students' preprimary education was not in the dataset, the statistical models of this study could not investigate the role of preprimary education on regional achievement differences.

Despite these limitations of the study, the findings are consistent with other findings in the literature reporting associations between student achievement and characteristics of home background and school context. Moreover, the results of this study provide empirical evidence for policy makers to establish targeted educational policies that increase low student achievement outcomes in Turkey, in general, and diminish achievement disparities between its regions, in particular.

Suggestions for Future Research

Further research on student achievement will be possible as Turkey continues to participate in international studies such as TIMSS and PIRLS. These international studies of educational achievement provide Turkey an opportunity to compare its national achievement to other countries as well as to identify the major factors involved in national achievement in reading, mathematics, and science. Gathering evidence about students' achievement in core academic subjects provides researchers opportunities for secondary data analysis. Analysis of national data allows for in-depth investigation of factors related to achievement, which in turn, helps educational policy makers make informed decisions to increase the quality of education. It would be especially worthwhile to conduct such research in the context of monitoring trends in achievement.

It also is important to initiate small-scale studies or programs in Turkey on the basis of theories generated from TIMSS and PIRLS, especially if these theories are substantiated by experiences in other countries. If new programs provide compelling evidence about the effects of the intervention on student achievement, a broad-scale implementation of the intervention could then be initiated. For example, using the findings from this dissertation study, a possible intervention for students in eastern

Turkey may be a Turkish language support program to provide compensatory education for students who do not frequently speak Turkish at home.

Turkey participated in TIMSS 1999 and TIMSS 2007 at the eighth grade and, currently, is planning to participate in TIMSS 2011 both at the fourth and eighth grades. In the absence of trend data at the fourth grade, participating in TIMSS 2011 at the fourth grade would provide Turkey a baseline to measure trends in future TIMSS cycles. Turkey will benefit even further by participating in TIMSS 2011 at the eighth grade and examining the trends in educational progress. New curricula in all core subjects in primary education were implemented beginning in the 2005/06 academic year. That is, when TIMSS 2011 is conducted, Turkish students assessed at the eighth grade will be the ones who were exposed to the revised curricula in mathematics and science. This would provide Turkey a unique opportunity to assess the contribution of its curricular reforms in student achievement trends at the eighth grade. Moreover, Turkey's participation in TIMSS 2011 at both grades would allow conducting further research on regional disparities in student achievement to investigate the extent to which regional gaps in achievement exist at the fourth grade and determine whether progress has been made in narrowing the gaps in achievement at the eighth grade as students progress through school.

Because Turkey participated in PIRLS 2001, participating in PIRLS 2011 would allow Turkey to assess trends in reading achievement at the fourth grade. A unique aspect of PIRLS is its home questionnaire, which collects information from parents about their employment situations and students' preparations for primary schooling, including attendance in preschool. Therefore, participating in PIRLS 2011 would provide Turkey information about students' preprimary education, and as a result, analysis of Turkey's data from PIRLS 2011 could investigate the role of preprimary education on achievement, an investigation that could not be conducted in this dissertation study.

Measuring, assessing, and monitoring student achievement during the primary school years (grades 1 to 8) is particularly important for Turkey. In 2007, the net schooling ratio in compulsory primary education was very high (97%), but decreases substantially as students move on to optional secondary education (57%). As a result, nearly half of the secondary school age children are excluded from the picture that is portrayed by studies that collect data from Turkish students in secondary education. Because a high percent of the dropouts in Turkey are usually low performing students who come from disadvantaged home backgrounds, such studies are limited since they may underestimate the distribution of disadvantaged background characteristics, while overestimating the achievement. However, studies that sample Turkish students in primary school do not have such limitations as these studies have the advantage of collecting data that is representative of almost all primary school age children in the country. The ministry's plans to participate in TIMSS 2011 demonstrate Turkey's commitment to monitor progress in educational quality which is greatly needed in Turkey's historic path to the European Union.

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Appendix

Information About Student and School Background Variables

Table A.1. *Information About Student Background Variables*

	Frequency of Speaking Turkish at Home
Source	Based on students' responses to the following question in the Student Questionnaire: How often do you speak Turkish at home?
Original categories	1= Always; 2= Almost always; 3= Sometimes; 4= Never
Recoded categories	0= Always or almost always (Original categories 1 and 2) 1= Sometimes or never (Original categories 3 and 4) *Note*: For multi-level analysis, 0.2% missing cases replaced using conditional mean imputation method.
	Parents' Highest Education Level
Source	Variable provided in Turkey's student data file. TIMSS derived the variable from students' responses to the following questions in the Student Questionnaire: What is the highest level of education completed by your mother? What is the highest level of education completed by your father?
Original categories	The education level of the parent with more education was used in assigning students to the following categories: 1= Completed university or higher (including master's or doctorate) 2= Completed post-secondary education but not university 3= Completed upper-secondary/secondary 4= Completed lower-secondary/primary 5= Less than lower-secondary/primary 6= Do not know
Recoded categories	0= Higher than primary school (Original categories 1 to 3) 1= Primary school or less (Original categories 4 to 6) *Note*. For multi-level analysis, 1.0% missing cases replaced using conditional mean imputation method. Students in the "Do not know" category (1.2%) had the lowest performance in Turkey as well as in regions compared to the students in other original categories, hence this category collapsed in "primary school or less" category.

Table A.1. *Information About Student Background Variables (Continued)*

	Index of Home Resources
Source and original categories	Based on students' responses to the following questions in the Student Questionnaire: Do you have any of these things at your home? (1= Yes, 2= No) Computer Study desk/table for your use Internet connection Dishwasher Heating system with radiator DVD/CD player About how many books are there in your home? 1= None or very few books (0-10 books) 2= Enough to fill one shelf (11-25 books) 3= Enough to fill one bookcase (26-100 books) 4= Enough to fill two bookcases (101-200 books) 5= Enough to fill three or more bookcases (more than 200 books)
Index categories	The six home possessions recoded: 0= No 1= Yes The book variable recoded: 0= 25 or less books (Original categories 1 and 2) 1= More than 25 books (Original categories 3 to 5) The index is computed by averaging the responses to the seven source questions: 0= High = Average is 0.5 or more (On average, 4 or more home resources) 1= Low = Average is less than 0.5 (On average, 3 or less home resources) Scale reliability: 0.76 Total scale variance accounted for by component variables: 41% *Note*. For multi-level analysis, missing cases for source questions (max. 1.7%) replaced using conditional mean imputation method.

Table A.1. *Information About Student Background Variables (Continued)*

	Index of Self-confidence in Learning Science
Source and original categories	Based on students' responses to the following questions in the Student Questionnaire: How much do you agree with these statements about learning science? 1= Agree a lot; 2= Agree a little; 3= Disagree a little; 4= Disagree a lot I usually do well in science I learn things quickly in science Science is more difficult for me than for many of my classmates (Reversed) Science is not one of my strenghths (Reversed)
Index categories	The index is computed by averaging the responses to the four source questions: 0= High = Average is less than or equal to 2 (Agreeing to source questions) 1= Low = Average is greater than 2 (Disagreeing to source questions) Scale reliability: 0.72 Total scale variance accounted for by component variables: 55%

	Index of Valuing Science
Source and original categories	Based on students' responses to the following questions in the Student Questionnaire: How much do you agree with these statements about science? 1= Agree a lot; 2= Agree a little; 3= Disagree a little; 4= Disagree a lot I think learning science will help me in my daily life I need science to learn other school subjects I need to do well in science to get into the university of my choice I need to do well in science to get the job I want
Index categories	The index is computed by averaging the responses to the four source questions: 0= High = Average is less than or equal to 2 (Agreeing to source questions) 1= Low = Average is greater than 2 (Disagreeing to source questions) Scale reliability: 0.72 Total scale variance accounted for by component variables: 55%

Table A.1. *Information About Student Background Variables (Continued)*

	Index of Positive Affect Toward Science
Source and original categories	Based on students' responses to the following questions in the Student Questionnaire: How much do you agree with these statements about learning science? 1= Agree a lot; 2= Agree a little; 3= Disagree a little; 4= Disagree a lot I enjoy learning science Science is boring (Reversed) I like science
Index categories	The index is computed by averaging the responses to the three source questions. 0= High = Average is less than or equal to 2 (Agreeing to source questions) 1= Low = Average is greater than 2 (Disagreeing to source questions) Scale reliability: 0.74 Total scale variance accounted for by component variables: 68%

	Students' Educational Expectations
Source	Based on students' responses to the following question in the Student Questionnaire: How far in school do you expect to go?
Original categories	1= Finish <ISCED 3> 2= Finish <ISCED 4> 3= Finish <ISCED 5B> 4= Finish <ISCED 5A, first degree> 5= Beyond <ISCED 5A, first degree> 6= I don't know
Turkey's national adaptation	1= Finish secondary school 3= Finish first stage of tertiary education (2 or 3 years) 4= Finish tertiary education (first degree, B.A.) 5= Finish tertiary education (second degree, M.S./M.A., Ph.D.) 6= I don't know *Note*. According to Turkey's national adaptation to the source questions, Turkey did not administer the original Category 2 (Finish <ISCED 4>).

Table A.2. *Information About School Context Variables*

	Region
Source	Explicit stratum categories provided in Turkey's data file
Original categories	1= Marmara 2= Central Anatolia 3= Aegean 4= Mediterranean 5= Black Sea 6= Eastern Anatolia 7= Southeastern Anatolia
Recoded categories	Central Anatolia: 0= Marmara; 1= Central Anatolia Aegean: 0= Marmara; 1= Aegean Mediterranean: 0= Marmara; 1= Mediterranean Black Sea: 0= Marmara; 1= Black Sea Eastern Anatolia: 0= Marmara; 1= Eastern Anatolia Southeastern Anatolia: 0= Marmara; 1= Southeastern Anatolia
	School Community Type
Source	Principals' responses to the following question in the School Questionnaire: How many people live in the city, town, or area where your school is located?
Original categories	1= More than 500,000 people 2= 100,001 to 500,000 people 3= 50,001 to 100,000 people 4= 15,001 to 50,000 people 5= 3,001 to 15,000 people 6= 3,000 people or fewer
Recoded categories	0= Urban (Original categories 1 to 3, i.e., population greater than 50,000) 1= Rural (Original categories 4 to 6, i.e., population less than or equal to 50,000) *Note*. For multi-level analysis, 2.1% missing cases replaced using conditional mean imputation method.

Table A.2. *Information About School Context Variables (Continued)*

	Index of Principals' Reports on Positive School Climate for Academic Achievement
Source and original categories	Based on principals' responses to the following questions in the School Questionnaire: How would you characterize each of the following within your school? 1= Very high; 2= High; 3= Medium; 4= Low; 5= Very low Teachers' expectations for student achievement Parental support for student achievement Parental involvement in school activities Students' desire to do well in school
Index categories	The index is computed by averaging the responses to the six source questions: 0= High = Average is less than 3 (High or very high positive school climate) 1= Low = Average is 3 or more (Medium, low, or very low high positive school climate) Scale reliability: 0.81 Total scale variance accounted for by component variables: 64% *Note*. For multi-level analysis, missing cases for source questions (max. 0.7%) replaced using conditional mean imputation method.

Table A.2. *Information About School Context Variables (Continued)*

	Index of Teachers' Reports on Adequacy of School Resources in Teaching Science
Source and original categories	Based on science teachers' responses to the following questions in the Science Teacher Questionnaire: In your view, to what extent do the following limit how you teach science to the TIMSS class? 1= Not applicable; 2= Not at all; 3= A little; 4= Some; 5= A lot Shortage of computer hardware Shortage of computer software Shortage of support for using computers Shortage of other instructional equipment for students' use Shortage of equipment for teachers' use in demonstrations and other exercises Inadequate physical facilities
Index categories	Original categories to the source questions recoded: 1= A lot; 2= Some; 3= A little; 4= Not applicable or Not at all The index is computed by averaging the responses to the six source questions: 0= High = Average is more than 2.5 (No or little impact) 1= Low = Average is 2.5 or less (Some or a lot impact) Scale reliability: 0.89 Total scale variance accounted for by component variables: 65% *Note*. For multi-level analysis, missing cases for source questions (max. 1.4%) replaced using conditional mean imputation method.