TEACHER CHARACTERISTICS THAT PREDICT STUDENTS' MATHEMATICS ACHIEVEMENT IN EUROPEAN COUNTRIES: AN EXAMINATION OF TIMSS 2015 RESULTS USING HIERARCHICAL LINEAR MODELING

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To my parents: Hamdi and Emine Sadak,
To my future children, and
To the future of my home country, Turkey

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One's success is never a wholly self-generated outcome or one that spontaneously occurs in someone's life. No matter what assets one possesses, there are always people helping and alleviating one's burden. While some people in the academic community are entirely consumed by their own ambitions, there are still those who are concerned with the welfare of their students, colleagues, families, relatives, and friends. Fortunately, during my journey to my PhD, I have always been surrounded by great people who reminded me that I was a human being and advised me to be happy first and then be successful, in that order. Thus, I always felt that I should become a humane academic rather than a victim of inflated ambitions. For this insight, I offer my endless gratitude to Dr. Enrique Galindo, Dr. Sarah Theule Lubienski, Dr. Julie Lorah, and Dr. Frank Lester Jr. for helping to be healthily happy during the arduous process of completing a doctoral dissertation.

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Musa Sadak

TEACHER CHARACTERISTICS THAT PREDICT STUDENTS' MATHEMATICS ACHIEVEMENT IN EUROPEAN COUNTRIES: AN EXAMINATION OF TIMSS 2015 RESULTS USING HIERARCHICAL LINEAR MODELING

This study focused on possible relationships between teacher characteristics and students' mathematics achievement in European Union (EU) countries, including Hungary, Italy, Lithuania, Malta, Slovenia, Sweden, and Turkey, after controlling for student and teacher background characteristics. The data consisted of the sample of 31,969 students and their teachers (*n*=1,687) from the seven EU countries that participated in TIMSS 2015 international assessment at the eighth-grade level in mathematics. While the largest sample was Turkey (*n*-students = 6,079, *n*-teachers = 220), the smallest was Malta (*n*-students = 3,817, *n*-teachers = 156). The *Qualities of Effective Teachers* (Stronge, 2007) were used as a conceptual framework for variable selection, and 24 characteristics he identified were tested across these EU countries.

Using a two-level hierarchical linear model (student and teacher), 17 of these 24 teacher characteristics suggested as effective by previous researchers were found to have significant relationships with students' mathematics achievement, while the directionality of these relationships varies. The characteristics found to have non-significant, or significant but negative relationships raised concerns regarding the implementation of these characteristics in the classroom environments, along with the limitations of the study.

This study also revealed some differences among these countries. Eurydice (European Commission, 2011a) indicated in their report that focal EU countries have different implications for six of the 24 variables identified by Stronge (2007). As a result of six individual two-level

interaction models, the relationships between the six teacher characteristics and students' mathematics achievement were found to vary among the countries despite the existence of policies regarding these characteristics in the curriculum and/or steering documents of the countries.

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Chapter 1: Introduction

Statement of the Problem

Mathematics is a fundamental part of the curriculum from elementary to higher education levels around the world (Ugurel, Morali, & Kesgin, 2012). Mathematics has tended to receive more attention than the other subject areas because of many students' low achievement in international assessments (Akyuz & Berberoglu, 2010), which are administered in educational systems around the world to evaluate their students' achievements within a common framework (Bilican, Demirtasli, & Kilmen, 2011). As one of the common components of this globalized framework, mathematics achievement scores enable researchers to make international comparisons of education levels (Ozgun-Koca & Sen, 2002) and analyze circumstances affecting educational outcomes at the country level (Yildirim, Yildirim, Ceylan, Yetisir, & Ajans, 2013) so that improvements can be made to enhance a country's global competitiveness. Therefore, research into ways to increase the effectiveness of mathematics education and solve problems related to under-achievement in this critical subject is receiving greater attention around the world (Incikabi, 2012; Uzun, Butuner, & Yigit, 2010).

As in many other countries, enhancing mathematics achievement has also received attention in the European Union (EU) countries. The EU is a regional integration of the 28 European countries, established by the Maastricht Treaty in 1992, by which member countries jointly address their problems, and evaluate resources, information and technology together (Gedikoglu, 2005; Saglam, Ozudogru & Ciray, 2011). The Union aims to cultivate common culture and values among the member countries and to raise the living standards of the people through cooperation by establishing partnerships in every aspect of the current economic, social and cultural era (Arslan-Cansever, 2009; Gedikoglu, 2005). To pursue these aims, in 2000, the

EU introduced the Lisbon millennial Strategy to promote multi-dimensional cooperation (Arslan-Cansever, 2009; European Commission, 2003). In terms of the educational aspect of the Lisbon strategy, in 2003, the European Council announced a strategic framework, “Education and Training 2010 (ET2010),” which designated benchmarks to be achieved by 2010 (European Commission, 2011b; European Council, 2003). In 2009, the Council updated the strategy in accordance with changes in the countries’ needs, naming it “Education and Training 2020” (ET2020) and declaring one of the five benchmarks as “By 2020, the share of low-achieving 15-years olds in reading, mathematics and science should be less than 15%” (European Council, 2009, p. 7). However, according to the 2015 Trends in International Mathematics and Science Study (TIMSS), there was a wide range of percentages of low achieving students across EU countries, including 5% in Slovenia, 8% in Lithuania, 9% in Sweden, 11% in Italy, 12% in Hungary, 16% in Malta, and 30% in Turkey (Mullis, Martin, Foy, & Hooper, 2016). Therefore, while dealing with the low achievement in general, these differences in the numbers of low achieving students across countries also deserve attention.

On the other hand, in terms of reaching the benchmark of the ET2020 strategy that is related to mathematics achievement, Eurydice, a network of European countries working under the European Commission, published a report called “Mathematics Education in Europe” (European Commission, 2011a). In this report, it was indicated that countries do not only differ in terms of student mathematics achievement scores, but also of the implementation of the mathematics teaching practices. This report examines the possible factors that might be related to students’ low mathematics achievement scores across the EU, including curriculum, assessment, teaching practices, etc. However, it was not clearly indicated how these factors linked to students’ mathematics achievement by providing evidences.

Purpose of the study

While enhancing mathematics achievement has long been a global concern, including within the EU countries, finding ways to raise achievement is not an easy task, especially given the different needs of different populations. Researchers have investigated several factors related to student achievement, such as student- and family-related factors (e.g. Abazaoglu, Yatagan, Yildizhan, Arifoglu, & Umurhan, 2015; Akyuz, 2014; Atar, 2011; Demir, Kilic, & Unal, 2010, Ozer & Anil, 2011; Yildirim, 2011), school-related factors (e.g. Abazaoglu et al., 2015; Demir et al., 2010; Engin-Demir, 2009; Kilic, Cene, & Demir, 2012), and teacher-related factors (e.g. Aaronson, Barrow, & Sander, 2007; Clotfelter, Ladd, & Vigdor, 2007; Clotfelter, Ladd, & Vigdor, 2010; Hill, Rowan, & Ball, 2005; Monk, 1994; Nye, Konstantopoulos, & Hedges, 2004; Stronge, 2007; Stronge, Ward & Grant, 2011; Stronge, Ward, Tucker, & Hindman, 2008) in order to come up with solutions for raising achievement and closing gaps.

In 1966, the Coleman Report emphasized the impact of family background characteristics on student achievement; however, with increases in the availability of data due to changes in assessment strategies and statistical methodologies (Stronge et al., 2011), teachers have also received attention (Aaronson et al., 2007; Rivkin, Hanushek, & Kain, 2005). Indeed, according to researchers, policy makers and parents, teachers are seen as the most significant institutional element of student achievement today (Clotfelter et al., 2010). While the importance of student-related, family- related, and school-related factors cannot be ignored, teachers are as important as any of these in terms of student achievement, especially in mathematics. Given that by its nature, mathematics is a subject that is mostly taught formally in schools under the guidance of the teacher, it may reasonably be assumed that teacher-related factors are primarily influential on students' mathematics achievement (Nye et al., 2004). Accordingly, in the concluding remarks of the EU's Council meetings in 2009 and 2014 and in the report prepared by the Commission (European Commission, 2011a), teacher effectiveness has been emphasized as the means to enhance students' mathematics achievement. Therefore, in addition to the considerable contributions by researchers, the EU also highlighted the importance of teacher effectiveness in student achievement.

Nevertheless, identifying the teacher characteristics that are possibly linked to student achievement has proved difficult for many researchers (Aaronson et al., 2007; Clotfelter et al., 2007; Clotfelter et al., 2010; Jepsen, 2005; Kane, Rockoff, & Staiger, 2008; Nye et al., 2004; Rockoff, 2004; Stronge et al., 2011). Important questions regarding student achievement that researchers have include the extent to which effective teachers matter, the systematic and significant specifications of effective teachers, and the extent to which these specifications differ across different populations (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011). Despite the increase in the quality and availability of data, however, these questions remain hard to answer (Aaronson et al., 2007).

Accordingly, this dissertation study focuses on discovering possible relationships between teacher characteristics and students' mathematics achievement in the European Union (EU) countries. Specifically, it is an investigation of the mathematics achievement of eighth-grade students in a subset of seven EU countries that are the only EU countries participated in Trends in International Mathematics and Science Study (TIMSS) 2015, including Hungary, Italy, Lithuania, Malta, Slovenia, Sweden (member countries), and Turkey (candidate country). As indicated above, these member countries had fewer than 15% of low-achieving students in mathematics, according to the low-international benchmark results in TIMSS 2015, while the candidate country, Turkey, had 30%, considerably higher than the benchmark. Moreover, the difference in the number of low-achieving students in mathematics is not the only difference among these EU countries. In a comparative analysis report, the European Commission (2011a) indicated several differences in terms of the implementation of mathematics teaching in these EU countries that might be related to students' mathematics achievement, especially in terms of national policies and regulations. Therefore, it is worthwhile to examine the differences in the policies governing teaching practices in the focal countries to determine possible differences among them in terms of the relationship between teacher characteristics and students' mathematics achievement. However, even though this report prepared by EURYDICE, a network of countries working under the European Commission, provided an insightful perspective on the differences in the implementations of the mathematics teaching practices, it did not connect these factors to students' mathematics achievement, as indicated before. While it was indicated that these factors might be highly related to students' mathematics achievement, it was emphasized that any inferences or conclusions should be supported by the further analyses. Therefore, the present study aims to investigate possible relationships between teaching practices and students' mathematics achievement by employing a multilevel modeling approach. As a result, the possible relationships are examined in a large sample of the EU countries not only with differing policies and regulations, but also with different levels of students' mathematics achievement. Thus, the goal is to predict the effects of teacher characteristics on students' mathematics achievement within a sample of countries with diverse teaching policies and practices as well as the different levels of mathematics achievement. Thus, the findings can enhance understanding of the possible linkages in different circumstances. For a multidimensional perspective, the term "teacher characteristics" is used in this study following Stronge's (2007) definition of the term as inclusive in that it comprises both the personal characteristics of teachers and their teaching practices. In the introduction to his book, which also provides the conceptual framework of this dissertation study, he indicates that "The content is presented within the context of a person—the teacher—as opposed to viewing teaching skills as isolated processes" (p. ix).

In this study, the Hierarchical Linear Modeling (HLM) approach is used to examine possible relationships between teacher characteristics and students' mathematics achievement in the target EU countries as well as across-country differences in terms of these relationships. The data are nested at two levels: student-data within teacher-data across the specific countries. Therefore, this study examined the differences among students' mathematics achievement as related to teacher characteristics across countries in the sample of EU countries, which have different policy regulations, different teaching practices, and different outcomes in students' mathematics achievement.

Research Questions

To address the issues addressed above, this dissertation study is guided by the following research questions:

1. To what extent do teacher characteristics suggested as effective in previous studies consistently predict students' mathematics achievement in the overall focal EU countries, as documented by the TIMSS 2015, after controlling for student and teacher background characteristics as well as the country membership?
2. What are the differences among the focal EU countries in terms of the relationship between students' mathematics achievement and their teachers' characteristics as these are demonstrated differently in the national strategies and initiatives across these countries?

Background Information

In the previous section, the problem of enhancing students' mathematics achievement, and the purpose of this study to shed light on possible relationships between teacher characteristics and students' mathematics achievement in EU countries that are the only EU countries participated in the TIMSS 2015 international assessment were discussed. Therefore, as context for the problem and purpose of the study, the following discussion provides background information concerning the TIMSS assessment, from which the data are drawn, and mathematics education policy developments and teaching practices in the European Union (EU), from which the sample is selected. Also, the rationale for using TIMSS assessment results and selecting these EU countries as the sample is explained.

TIMSS Assessment. International assessments, such as TIMSS, generated by the International Association for the Evaluation of Educational Achievement (IEA), and the Programme for International Student Assessment (PISA), generated by the Organization for Economic Co-operation and Development (OECD), give countries the opportunity to benchmark their performances in mathematics and science among other participant countries (Akyuz, 2014; Akyuz & Berberoglu, 2010; Dogan & Baris, 2010; Incikabi, 2012). These assessments have been used since the 1960s (Yildirim et al., 2013). The results from the international assessments of education also provide countries with insights and ideas for shaping their educational policies to improve students' performances depending on how the results are interpreted (Akyuz, 2006; Akyuz, 2014; Akyuz & Berberoglu, 2010; Bilican et al., 2011; Dogan & Baris, 2010; Incikabi, 2012). Thus, countries participate in these international assessments to monitor the progress of their students' achievement in the international setting and to investigate factors having impact on their achievement (Akyuz, 2014; Dogan & Baris, 2010; Incikabi, 2012). By understanding these factors and comparing their education systems with those of others, educational policy makers can evaluate their decisions, identify issues, and develop more effective policies (Akyuz & Berberoglu, 2010; Bilican et al., 2011).

TIMSS, an international assessment of fourth and eighth grade students' mathematics and science knowledge, is a comprehensive, ongoing study (Dogan & Tatsuoka, 2008) that provides valuable data to participating countries for their own further investigations (Akyuz, 2006). It is administered every four years to provide regular updates of longitudinal data (Akyuz, 2014; Akyuz & Berberoglu, 2010; Dogan & Baris, 2010; Erkan, 2013; Incikabi, 2012; Guner, Sezer, & Ispir, 2013; Yildirim et al., 2013). The IEA was established by UNESCO in 1958 to meet the need to examine and evaluate mathematics education programs at both local and national levels, and it has worked with ministries of education and other representations of education systems (Dossey & Wu, 2013). The IEA released the findings of the First International Mathematics Study (FIMS) in 1967 and of the Second International Mathematics Study (SIMS) in 1981. In 1995, the IEA released the findings in the Third International Mathematics and Science Study (TIMSS), which began its dual focus on both mathematics and science. And after 1995, TIMSS was carried through the years 1999, 2003, 2007, and 2011 with the same acronym now standing for Trends in International Mathematics and Science Study (Bilican et al., 2011; Dossey & Wu, 2013). In the last TIMSS assessment in 2015, 57 countries and seven regional jurisdictions participated to monitor their performance in mathematics (Mullis et al., 2016b), including the present study's focal EU members (Hungary, Italy, Lithuania, Malta, Slovenia, Sweden) and EU member candidate (Turkey).

TIMSS uses a curriculum model that reflects how students are provided with educational opportunities and the resulting achievement outcomes. There are three phases of this model:

Intended curriculum, in which national, social, and educational contexts are defined; implemented curriculum, referring to how school, teacher, and classroom contexts implement the intended curriculum; and attained curriculum, in which students' outcomes in relation to their characteristics reveal the final product. TIMSS collects information for mathematics for the two major elements of this continuum: students' mathematics achievement through the mathematics assessment, and the factors impinging on this achievement through context questionnaires (Mullis, 2013).

The other major international assessment, PISA, is administered every three years, and 2015 was the year both TIMSS and PISA assessments took place in the participating countries. However, PISA alternates the overall emphasis of the assessment among the three domains of mathematics, reading literacy, and science, so while the main focus was on mathematics in 2003 and 2012, it was on science in the 2015 PISA (Dossey & Wu, 2013). Also, it was indicated in one of the European Commission reports that TIMSS collects broader background information about the students' learning circumstances than PISA by focusing on the curriculum as well as assessment outcomes (European Commission, 2011a). Therefore, in order to work with the most comprehensive data on students' mathematics achievement and its possible linkages to the teacher characteristics identified as effective in previous studies, TIMSS assessment results are used in this study.

As discussed before, EU countries that participated in TIMSS 2015 performed differently in terms of the low international achievement benchmark defined by TIMSS 2015. On the other hand, 2009 EU Council defined the mathematics achievement benchmark as 15% or fewer low-achieving 15-year old students in mathematics by 2020 across the EU countries (European Council, 2009). In regard to benchmark student achievement at the international level, TIMSS creates benchmarking achievement scores to provide additional information for policy and curriculum developers. Four achievement scores are specified as international benchmarks: advanced international benchmark (625), high international benchmark (550), intermediate international benchmark (475), and low international benchmark (400) (Mullis, Cotter, Centurino, Fishbein, & Liu, 2016; Mullis et al., 2016b). To determine these international achievement benchmark scores, TIMSS worked with an expert international committee and Science and Mathematics Item Review Committee (SMIRC) on an analysis to make a scale for country-level analyses. Through this analysis, experts identified the items at the international benchmarks on which students gave correct responses, and investigate the skills and knowledge required to answer correctly (Mullis et al., 2016a). The skills and knowledge specified for each international benchmark by TIMSS are provided below (Table 1.1) along with information concerning how the low international achievement benchmark is distinguished from the other benchmarks.

Table 1.1. *TIMSS 2015 International Mathematics Achievement Benchmarks*

Score	International Achievement Benchmark and Description
625	*Advanced International Benchmark* Students can apply and reason in a variety of problem situations, solve linear equations, and make generalizations. They can solve a variety of fraction, proportion, and percent problems and justify their conclusions. Students can use their knowledge of geometric figures to solve a wide range of problems about area. They demonstrate understanding of the meaning of averages and can solve problems involving expected values.
550	*High International Benchmark* Students can apply their understanding and knowledge in a variety of relatively complex situations. They can use information to solve problems involving different types of numbers and operations. They can relate fractions, decimals, and percentages to each other. Students at this level show basic procedural knowledge related to algebraic expressions. They can solve a variety of problems with angles including those involving triangles, parallel lines, rectangles, and similar figures. Students can interpret data in a variety of graphs and solve simple problems involving outcomes and probabilities.
475	*Intermediate International Benchmark* Students can apply basic mathematical knowledge in a variety of situations. They can solve problems involving negative numbers, decimals, percentages, and proportions. Students have some knowledge of linear expressions and two- and three-dimensional shapes. They can read and interpret data in graphs and tables. They have some basic knowledge of chance.
400	*Low International Benchmark* Students have some knowledge of whole numbers and basic graphs.

Source: (Mullis et al., 2016b, p.65).

In terms of the TIMSS 2015 low international achievement benchmark results, six member countries in the present study (Slovenia 5%; Lithuania, 8%; Sweden, 9%; Italy, 11%; Hungary, 12%; and Malta, 16%) had low-achieving students around or less than 15%, while candidate Turkey (30%) had more low-achieving students than the benchmark in terms of the TIMSS 2015 international benchmarking (Mullis et al., 2016b).

Mathematics Education in the European Union

Rapid changes in the field of science and technology have not only prompted members of the EU to cooperate in the economic, political and cultural spheres, but also to develop their own policies in addition to common policies, including those concerning education (Arslan-Cansever, 2009; European Council, 2003; European Parliament, 2000; Saglam et al., 2011). Indeed, education is one of the most important agenda items of the governments of all EU countries, including differences in the structures of their educational systems. Therefore, the EU is a forum in which there is no single set of policies governing education but rather an open mutual exchange of views among member countries. Thus, while cooperating within the EU, member countries are free in terms of the content and organization of their national education systems (Arslan-Cansever, 2009; European Council, 2009; European Council, 2014), which is in keeping with the importance attached to the principle of respect for diversity in education while working toward some shared principles for the common good of Europe (Caliskan-Maya, 2006). That is, EU seeks to balance common educational principles with respect for diversities among the member countries. At the same time, it also aspires to increase the stature and power of the Union in the globalized world (European Parliament, 2000).

The European Commission (2013) indicated that, in this technological era, the development of the European societies is fundamentally based on the development of their citizens' basic skills. It was further stated that individuals' life circumstances are unduly challenging without essential literacy and numeracy skills, and a minimum level of skills in mathematics, science, and technology is necessary for the advancement of modern European society both socially and economically. With regard to the interest of this study, therefore, the following section discussed how the EU has determined the importance of mathematics education, the mathematics performance of their students, and strategies to increase their performance, especially with regard to teaching practices. This explanation follows the chronology of policy changes within the Union and how they were justified.

EU Council in 2000: The Lisbon Strategy. In March 23-24, 2000, the European Council had a very special millennial meeting in Lisbon to discuss a strategic agenda for the

Union to strengthen the economies of the member countries by implementing consistent economic reforms that would provide more employment opportunities across Europe (European Parliament, 2000). Through exchange of the ideas within the leadership of the European Parliament, the Union agreed upon the Lisbon Strategy to fulfill millennial aspirations (European Commission, 2003; European Parliament, 2000). The Lisbon Strategy reflects the pressures of the economic challenges of globalization on the European Union to transform its policies through knowledge-driven strategies (European Parliament, 2000). In this process of transformation, the Union also considers the changes relevant to both fitting in with the values and societal norms of the European countries and confronting global necessities (European Commission, 2003; European Parliament, 2000). Therefore, the Lisbon Strategy plays a crucial role in building a general framework for the progress of the Union through knowledge-driven strategies based on its endemic cultural values, which require advanced educational systems capable of helping to improve the economy in a global context (European Parliament, 2000).

One of the most important dimensions of the Lisbon Strategy is the European Union's global-competitive, power-focused emphasis on human development and investment in human capital as a prescriptive education policy. With the Lisbon Strategy, therefore, the EU has aimed for information-age cooperation with the most serious educational policies to make European society more competitive and achieve sustainable development in the 2000’s (Arslan-Cansever, 2009). The Union has aspired to be the most sustainable and knowledge-driven economy by providing better job opportunities that maintain social consistency. In order to achieve the goal of having knowledge-driven socio-economical cohesion, the Union has planned to invest in their people through education. Toward this end, the EU Council asked the Educational Council to focus guiding the future purposes its members’ educational systems by considering their common issues as well as their national diversities in keeping with the Lisbon Strategy (European Parliament, 2000).

EU Council in 2003: Education and Training for 2010. With regard to the Lisbon European Council's 2000 mandate to the Educational Council to coordinate the future objectives of the EU members' educational systems, the European Council meeting held in March 20-21, 2003 focused on finalizing the benchmarks for sustaining and monitoring more efficient investment in human resources (European Council, 2003). In order to determine these benchmarks, the Council proposed that countries cooperate by exchanging their best practices while respecting national diversities, as suggested by the 2000 Lisbon Council (European Parliament, 2000). While emphasizing the importance of using comparable data, the Council also indicated that they would avoid specifying national targets or directly suggesting actions but rather leave these decisions to the individual countries using the 2003 EU Council's European performance indicators to monitor their progress in education and training, a policy called the Education and Training for 2010 Strategy (ET2010) (European Council, 2003). Within this strategy, the following benchmarks for the EU were proposed to be achieved by 2010 (European Council, 2003, p. 2):

> "By 2010,
>
> i. an EU average rate of no more than 10% early school leavers should be achieved;
> ii. the total number of graduates in mathematics, science and technology in the European Union should increase by at least 15% by 2010 while at the same time the level of gender imbalance should decrease;
> iii. at least 85% of 22-year-olds in the European Union should have completed upper secondary education;
> iv. the European Union average level of participation in Lifelong Learning should be at least 12.5% of the adult working age population (25 to 64 age group); and
> v. the percentage of low-achieving 15-years old in reading literacy in the European Union should have decreased by at least 20% compared to the year 2000."

According to a Commission communication in February 22, 2007, the Union had targeted achieving these benchmarks between the years 2004 and 2006; however, they needed further development to enhance their quality assurance. Therefore, it was proposed to update the benchmarks (European Commission, 2007). After this communication, in May 24-25, 2007, the European Council determined that there was a need for updates of the ET2010 Strategy, a process that should entail open collaboration among the countries in the selection of new benchmark indicators that reflected their priorities and concerns (European Council, 2007).

EU Council in 2009: Education and Training for 2020. In 2009, the European Council emphasized the importance of the ET2010 Strategy as the first compact framework in response to the call in 2000 Lisbon Strategy for the Union to support European educational systems by formulating common objectives. As in the Council meeting in 2003, the essentiality of respecting national developments of the countries was also highlighted while exchanging good practices to provide mutual enrichment of learning across the European countries was encouraged (European Council, 2009). However, the Council also agreed with the European Commission (2007) and the European Council (2007) on the need for upgrading the ET2010 Strategy for development of education and training to make it more effective by enhancing sustainable cooperation across the countries by the year 2020 (European Council, 2009). While the Council recognized that the ET2010 Strategy had held to its long-term objectives of extending the more general perspective of the 2000 Lisbon Strategy in the field of education and training, it recognized the importance of making it more flexible for the needs of the new decade following 2010 by updating ET2010 to ET2020 (European Commission, 2011b; European Council, 2009).

Therefore, European Council (2009) formulated new objectives in the ET2020 Strategy, acknowledging that higher quality of education and training systems are essential for the enhanced employability qualifications and to hold the EU's strong global position. The key factors were European citizens' attainment of such key competences as literacy and numeracy and the implementation of effective teaching practices that would enable wider acquisition of these basic skills.

As a result, the following updated version of the Education and Training 2010 benchmarks (Education and Training 2020 benchmarks) were declared (European Council, 2009, p. 6):

> "By 2020,
>
> i. an average of at least 15% of adults should participate in lifelong learning;
> ii. the share of low-achieving 15-years olds in reading, mathematics and science should be less than 15%;
> iii. the share of 30-34 year olds with tertiary educational attainment should be at least 40%;
> iv. the share of early leavers from education and training should be less than 10%; and
> v. at least 95% of children between 4 years old and the age for starting compulsory primary education should participate in early childhood education."

One of the benchmarks in the ET2010 Strategy, to decrease the percentage of low-achieving 15-year olds in reading literacy by 20% (European Council, 2003), was updated to reducing the percentage of low-achieving 15-year olds in reading to 15%. In addition, unlike the 2010 benchmark for 15-year olds, the 2020 benchmark took mathematics and science into consideration (European Commission, 2011b; European Council, 2009).

In 2013, however, the thematic working group of the European Commission on mathematics, science, and technology indicated that policies of European countries were paying attention to low achievers in reading literacy, but not to low achievement in mathematics, science, and technology (European Commission, 2013). Further, they indicated that while educational policies targeted the socio-economic circumstances and special needs of low achieving students, their actions to decrease low achievement were not commensurate with their policies. Based on Hanushek and Woessmann's (2010) simulated estimation study of the effects of educational achievement on European countries' economic growth, achieving the ET2020 Strategy would bring the Europe's overall GDP to €21 trillion if all member countries could reach the benchmark of having less than 15% low achieving students in mathematics, science, and reading. Moreover, according to the same study, if all countries reached the top level in mathematics, science, and reading, as in Finland's case, the economical volume of the Union would reach seven times of its current GDP, which is €87 trillion. In addition, it was emphasized that specifically focusing on educational outcomes rather than attainment would produce more effective long-term results for the Union.

In order to give life to the new benchmarks and maintain coordination, the Council has invited member states to openly collaborate in the adaptation of the new updated benchmarks into each national education system according to that nation's unique needs (European Council, 2009). However, to decrease the number of low-achieving students, it is essential for the EU to enhance the framework for research on mathematics, science, and technology education (European Commission, 2013). It is emphasized that the new actions must be supported by comparable data driven research; however, the updated benchmarks are not solid targets for individual member countries. Instead, member countries are strongly encouraged to prioritize achievement at the national level while incorporating the collective achievement of the whole Union into their national actions (European Council, 2009).

EU Commission in 2011: Eurydice Math Education Report. Up to this point, the policies generated by Council meetings held in 2000, 2003, and 2009, especially those related to mathematics education in the Europe have been discussed, but apart from locating common principles among the countries, no solutions to the problem of raising mathematics achievement across Europe while respecting each country's autonomy, a benchmark developed through this process, had been proposed. Therefore, in 2011, following the updated ET2020 plan, The Eurydice Education Information Network in Europe published "Mathematics Education in Europe," a report with a special focus on decreasing the number of low-achieving students in mathematics across European countries to less than 15%, one of the five new benchmarks in ET2020 (European Commission, 2011a). Eurydice was established by the European Commission in 1980 as mandated by the Ministries of National Education in a meeting held in 1976 (European Commission, 1976; Eurydice, 2018). It is a network of 38 Europe-affiliated countries[1] established to collaborate in the field of education to provide policy makers with Europe-level analyses (Eurydice, 2018). In this report, the goal was to use comparative analysis to demonstrate differences in mathematics education among the European countries and determine successful implementations to help to achieve the mathematics-related goal in the ET2020 Strategy. The researchers investigated the differences in mathematics education among the countries under the following six main categories: i) mathematics curriculum, ii) assessment in mathematics, iii) addressing low achievement in mathematics, iv) improving student motivation, v) teaching approaches, methods, and class organization, and vi) education and professional development of mathematics teachers (European Commission, 2011a). As indicated in the European Council (2009), this Eurydice report also emphasized effective teaching practices to enhance students' mathematics performance.

The benchmark for ET2020, which is to decrease the number of low-achieving students in mathematics, science, and reading to 15% or less across Europe, corresponded to one of the

[1] The Eurydice Network consists of 28 EU member countries, and Albania, Bosnia and Herzegovina, the former Yugoslav Republic of Macedonia, Iceland, Liechtenstein, Montenegro, Norway, Serbia, Switzerland and Turkey.

four strategic objectives, “improving the quality and efficiency of education” (European Commission, 2011a; European Council, 2009). The Eurydice report aimed to identify the challenges in teaching and learning mathematics by highlighting the common issues, to determine the obstacles responsible for low performance, to suggest successful implementations, and to support educational policy making mechanisms by providing evidence on which to base decisions (European Commission, 2011a). Although the Eurydice network includes 38 EU affiliated countries (Eurydice, 2018), the analyses in this report included only 31 countries (27 EU member states and Iceland, Liechtenstein, Norway, and Turkey) (European Commission, 2011a). This report indicated that the discussions across the six main categories were useful to predict the reasons behind low mathematics achievement in the EU countries; however, the report provided no statistical evidence to confirm that these elements may be related to achievement. The main aim of the report was to provide the comparative results of the countries in terms of their implementation of mathematics education from a broad perspective. Therefore, the need to conduct further analysis of the categories provided in the report was emphasized to yield more meaningful implications of ways to raise student achievement in the EU countries (European Commission, 2011a). So, while the report discussed the mathematics education in the EU countries in general under headings that are mostly relevant to educational policy making, such as the curriculum, assessment, etc., it also discussed the implementations of the teaching practices in mathematics. Therefore, based on the main interest of the present study, the discussions related to differences in teaching practices and their possible linkages to students' mathematics achievement are benefited from this report by supporting a multilevel analysis. Therefore, the relevant differences in mathematics teaching practices as indicated in the report are discussed in the next section.

Content and Pedagogical Knowledge. First, the report indicated that in general the preparation of the teachers at the lower secondary level differs among the EU countries. Table 1.2 shows the differences in required courses in subject knowledge and teaching skills for generalist and specialist teachers in the sample countries of this study.

Table 1.2. *Central Regulations of Minimum Percentages of Content and Pedagogical Courses in the Teacher Education Programs in the Focal EU Countries*

	Hungary	Italy	Lithuania	Malta	Slovenia	Sweden	Turkey
Generalist teachers							
Math subject	-	5	2-3	5	-	-	4
Math teaching	-	3	2-3		-	-	5
Specialist teachers							
Math subject	-	10	56	33	-	-	50
Math teaching	-	10	25	23	-	-	30

- No central regulation of the course loadings of content and pedagogical courses
Source: (European Commission, 2011a).

As showed in Table 1.2, in some countries, such as Hungary, Slovenia, and Sweden, there are no central regulations in terms of the course loadings of the content and pedagogical courses. However, in the countries where course loadings are centrally regulated, Italy, Lithuania, Malta, and Turkey, the differences in course loadings among these teachers were mainly caused by the teacher education programs they attended, becoming a generalist or a specialist teacher. The European Commission (2015) indicated that teachers can either complete a unified teacher education program that provides both subject and pedagogical aspects or begin teaching with a non-education degree in the subject they teach and then acquire an educational specialization. With regard to the regulations for teaching mathematics at the lower secondary level, in almost half of the EU countries, completing a teacher education program provides both content knowledge and pedagogical training aspects is not mandatory, even though the completion of an educational specialization programs is quite high. Moreover, it was found that 62.3% of the teachers who completed teacher education programs compared to 47.6% of those with a non-education degree felt adequately prepared to teach the subject matter, while 41.4% of the teachers with an education degree and only 27.5% of those with a non-education degree felt sufficiently pedagogically skilled. (European Commission, 2015). Therefore, it was suggested that mastery of the content to be taught is not a sufficient in itself, and completion of a preparatory teacher education program or acquisition of a subsequent educational specialization should be supported. Therefore, the teacher education programs that teachers attended, especially in terms of majoring in mathematics or in education, is the first difference among the teachers within different focal EU countries in this study.

Classroom management. The Eurydice report indicated that EU countries had different regulations concerning classroom management (European Commission, 2011a). In this regard, Kyriacou and Goulding's (2006) study highlighting the grouping of students not only for managing misbehaviors in the classroom but also for maintaining the students' motivation is referenced. However, fewer than half of the EU countries had central regulations in terms of grouping students in classrooms (Figure 1.1). On the other hand, in some countries, such as the Czech Republic, grouping regulations were determined even for specific subjects. However, among the seven EU countries included in this study, while the different types of grouping were centrally recommended or prescribed in Malta, Lithuania, Slovenia and Turkey, there were no central guidelines on grouping of students in Hungary, Italy, and Sweden (Figure 1.1). The report also indicated that several different approaches exist in terms of grouping students in the classrooms in the EU countries. The most common approach used by the countries is to group pupils according to their abilities, though. For example, 25% of the lessons in years four to seven may be provided in the ability groups in Slovenia while it may be provided either in the ability groups or in the smaller heterogeneous groups in the years eight to nine.

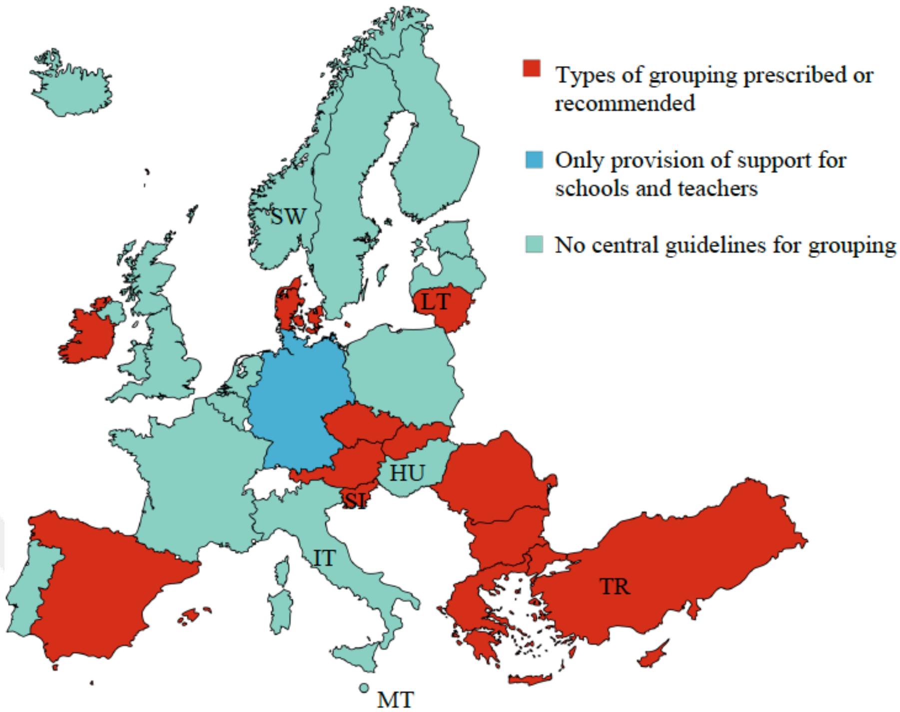

Figure 1.1[2]. Central Guidelines for Classroom Management in the EU Countries
Source: (European Commission, 2011a)

Motivation. Another difference among the countries in centrally regulated teaching practices was in emphasis on motivating students to learn mathematics in connection to the classroom management. According to the report (European Commission, 2011a), in addition to new teaching approaches, curriculum revisions, and enhanced teacher education programs, EU countries emphasized the implementation of national strategies and initiatives to encourage teachers to promote higher student motivation to learn mathematics as a way to enhance mathematics achievement. However, in practice, fewer than half actually implemented national strategies or initiatives to promote higher student motivation, mainly in the areas of mathematics, science, and technology (Figure 1.2). In terms of the seven EU countries included in this study, which were the only EU countries that participated in TIMSS 2015, according to the Eurydice

[2] The map in Figure 1.1 and the following figures illustrating mathematics teaching initiatives in the EU countries were produced using a computer software called "Mapchart" (Mapchart, 2018) for this study.

report and as Figure 1.2 illustrates, there were "national strategies and centrally coordinated initiatives" to promote students' motivation to learn mathematics in Italy, Malta, and Sweden but not in Hungary, Lithuania, Slovenia, and Turkey.

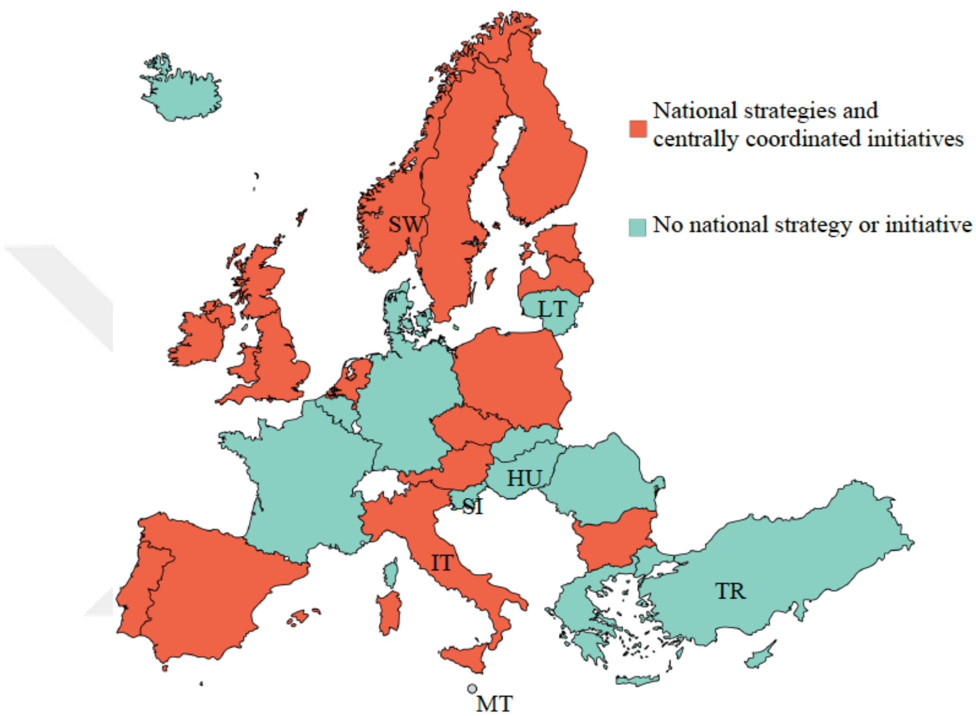

Figure 1.2. Central Guidelines for Enhancing Students' Motivation to Learn Mathematics in the EU Countries
Source: European Commission (2011a)

Even though strategies are different across countries, when exist, it is provided some examples in the report from some countries. For instance, in Finland, there is an umbrella institution called "LUMA centre" in University of Helsinki to organize collaboration between the schools, universities, business, and industry. This center is not only organizing activities for students to increase their motivation, for example math-science-technology camps, but also provide training and workshop opportunities to the teachers including the supply of teaching and learning materials so that they better conduct the instruction to motivate students in learning mathematics.

Teaching Complexity (Making mathematics relevant). In addition to motivate students, another difference in mathematics teaching practices among the EU countries was related to references in the curriculum and/or steering documents to teachers' skill in making mathematics relevant to the students (European Commission, 2011a). Applying mathematics in the real-life contexts is emphasized in the report as one of the essential skills for students. The report highlighted that while the idea of making mathematics relevant to students' daily lives was included in almost all the EU countries' curriculum or steering documents, specific teaching strategies and/or assessment methods for this purpose were provided in only some countries. In terms of the seven EU countries of this study, skill of applying mathematics to students' daily lives was only generally referenced in the curriculum and/or steering documents of Hungary, Italy, Slovenia, and Sweden. However, in Malta's documents, the use a specific assessment for this purpose was also recommended, while in Lithuania and Turkey's documents, the use of both a specific assessment method and specific teaching strategies for making mathematics more relevant to students' daily lives were recommended (Figure 1.3).

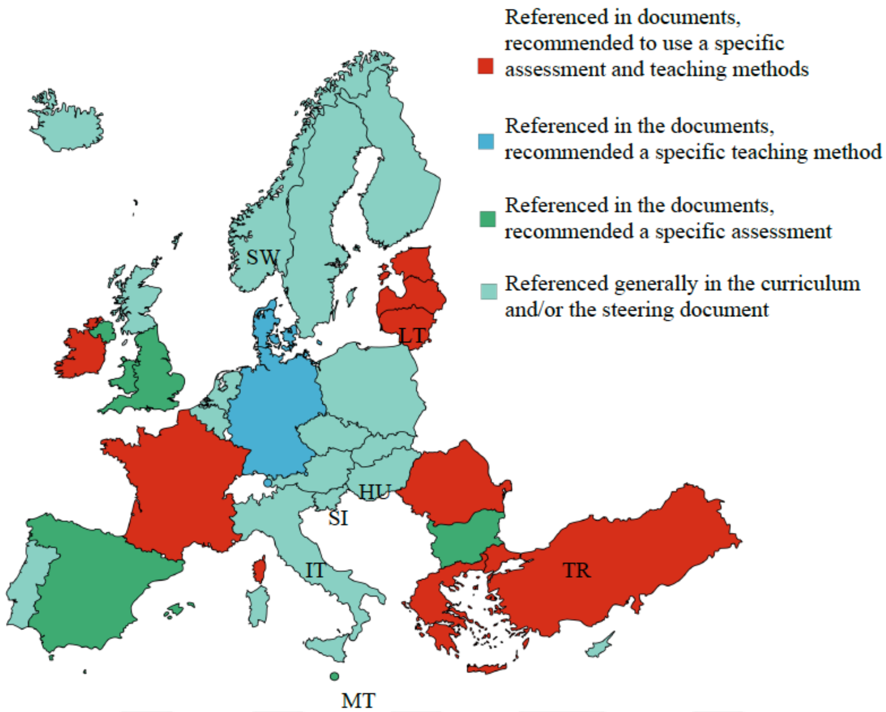

Figure 1.3. Central Guidelines for Making Mathematics Relevant to Students in the EU Countries
Source: European Commission (2011a).

Enhancing student engagement. It was highlighted that countries have different regulations in terms of the implementations of teaching practices in motivating students and making mathematics relevant to the students; however, another difference among the EU countries was in regulations for enhancing student engagement in learning mathematics. In addition to motivate them, and making mathematics relevant, teachers may also make sure that students engage with the instruction in the classroom. In general, about a third of the EU countries intended to promote specific teaching methods for enhancing student engagement in mathematics learning, including the use of educational technologies (Figure 1.4). However, according to the report, there was a large difference between central recommendations of specific teaching methods for engaging students and the implementation of these methods in the classrooms (European Commission, 2011a). Moreover, in the majority of the countries, student engagement was only referenced in the curriculum and/or the steering documents without specific recommendations. In terms of the seven countries included in this study, specific teaching methods to increase student engagement were centrally supported in Lithuania, Malta, and Slovenia but not in Hungary, Italy, Sweden, and Turkey (Figure 1.4). The report indicated that it is mostly used ICT (information and communication technologies) to increase the engagement. While teaching methods could differ, the essential point is to raise the interactions and discussions among the students. On the other hand, in addition to the teaching methods, most EU countries also promoted extra-curricular activities to increase students' engagement in mathematics. Among the seven countries included in this study, Hungary, Italy, Lithuania, Malta, and Slovenia centrally promoted extra-curricular activities for student engagement while Sweden and Turkey did not (Figure 1.4). According to the report, mathematics competitions, for example, are organized as extra-curricular activities to increase the student engagement in mathematics in most EU countries, such as local or national competitions or mathematics Olympiads. On the other hand, it was also promoted mathematics classes outside the normal instructional time to increase students' engagement with mathematics in some countries, such as Estonia and Spain, especially through the summer classes that consists both recreation and mathematics learning activities.

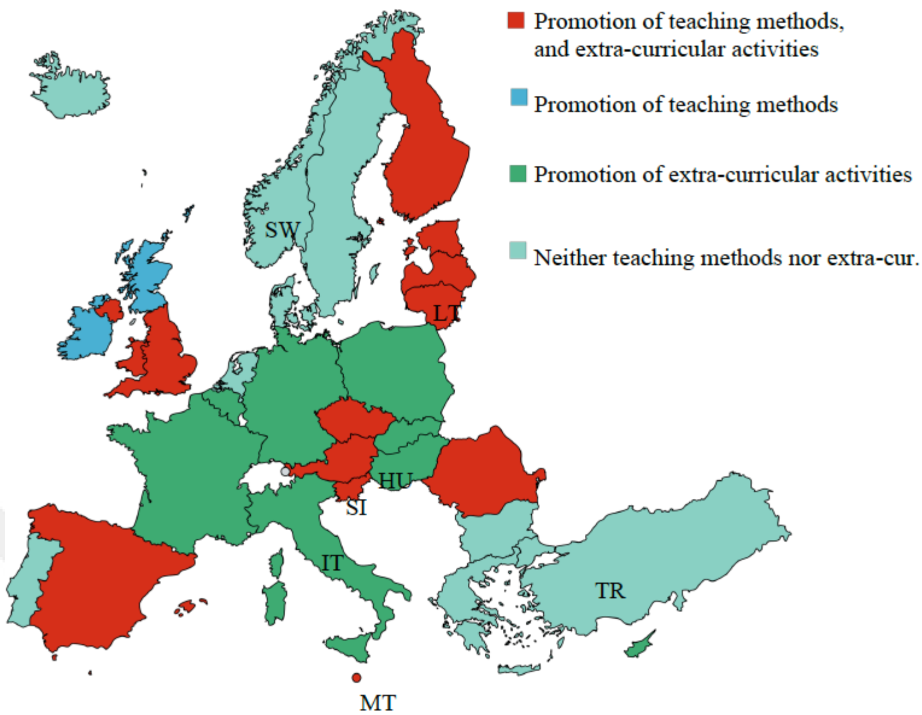

Figure 1.4. Central Guidelines for Enhancing Student Engagement in the EU Countries
Source: European Commission (2011a)

Use of homework. With regard to the use of homework, in general, most EU countries did not provide guidelines in their steering documents for assigning mathematics homework at the lower secondary level (Figure 1.5), while among the countries in this study, five had no guidelines, Lithuania had general homework guidelines applicable to all subjects, and only Turkey had specific guidelines for assigning mathematics homework in the lower secondary level based on individual students' levels of readiness and motivation. For instance, research projects should be given to students whom teacher considers ready to engage in critical thinking (European Commission, 2011a).

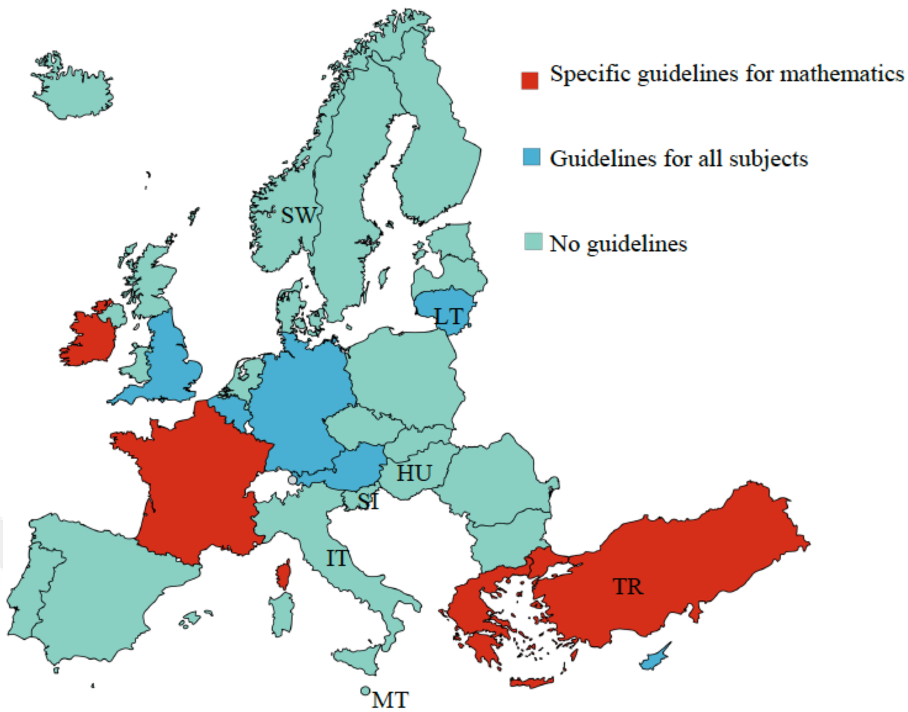

Figure 1.5. Central Guidelines for Assigning Homework in the EU Countries
Source: European Commission (2011a)

Possible reasons for why homework is not promoted in the steering documents of the EU countries are also provided in the report. For instance, it is suggested parents to involve students' homework assignments in Scotland so that it allocates interaction between parents and students even though the parental involvement is not suggested in some countries. On the other hand, it is not allowed to give homework assignments in France even though parents request teachers to assign homework. Another possible reason for why homework assignments are not preferred in most EU countries is the time spent on homework. Especially in Romania, where the time spent on homework by students is one of the largest, it is recommended to restrict the homework assignments to 30-45 minutes because it was revealed in a national report in Romania that homework assignment is one of the reasons of the decreasing student motivation.

To sum up, the EU has aimed to enhance the educational strategies used by teachers in the member countries, especially since the Council meeting that generated the millennial Lisbon

Strategy in 2000 (European Parliament, 2000). Council meetings held in 2003 and 2009 were also important in terms of defining decade-long benchmarks for countries to achieve in the ET2010 and ET2020 Strategies. While the ET2010 Strategy aimed to decrease the number of low-achieving students in reading to less than 20% by 2010, the updated ET2020 Strategy further enhanced this benchmark by aiming to decrease the number of low-achieving students in reading, mathematics, and science to less than 15% (European Council, 2003; European Council, 2009). However, these reports also emphasized that while the EU takes into account common challenges and implementation of common principles across Europe, national approaches to achieving these benchmarks must be respected. Also it was highlighted by the EU that effective teaching practices are essential to achieving higher student learning outcomes (European Commission, 2013; European Council, 2009). In addition to the general policy implications provided in these three Council meetings, the Eurydice report (European Commission, 2011a) provided insightful results related to the goal of achieving the benchmark of decreasing the number of low-achieving students in mathematics. The comparative analysis provided in this report aimed to reveal the differences among the EU countries in their regulations and teaching practices with regard to the mathematics education and help to raise achievement; however, no direct evidence was given for how these differences could be related to students' achievement. Therefore, conducting further analyses using the categories provided the report was recommended to determine their possible linkages to the students' mathematics achievement. As a foundation for further research, the report revealed possible relationships between the teachers' characteristics and students' mathematics achievement within the different EU countries, as suggested by the millennial Lisbon Strategy (European Parliament, 2000), which inspired subsequent developments the EU countries. Based on the differences among countries indicated in this report in terms of the teaching practices, the present study examined the possible relationships of relevant variables as they are differently implemented in the EU countries to students' mathematics achievement.

Significance of the Study

Enhancing mathematics achievement has been a concern for many countries, especially in terms of increasing individuals' knowledge and skills to advance national development. However, with regard to how to raise mathematics achievement, researchers have addressed different factors related to achievement, such as student and family-related factors (e.g. Abazaoglu, Yatagan, Yildizhan, Arifoglu, & Umurhan, 2015; Akyuz, 2014; Atar, 2011; Demir et al., 2010, Ozer & Anil, 2011; Yildirim, 2011), school-related factors (e.g. Abazaoglu et al., 2015; Demir et al., 2010; Engin-Demir, 2009; Kilic, Cene, & Demir, 2012), and teacher-related factors (e.g. Aaronson et al., 2007; Clotfelter et al., 2007; Clotfelter et al., 2010; Hill et al., 2005; Kane & Staiger, 2008; Kane et al., 2008; Monk, 1994; Nye, Konstantopoulos, & Hedges, 2004; Stronge et al., 2008; Stronge et al., 2011). Among these, this study focuses on teacher-related factors, with a main emphasis on the teacher characteristics that have found to be effective in previous studies.

The studies mentioned above that addressed teacher-related factors confirmed that effective teachers matter in students' mathematics achievement. However, beyond this agreement, identifying teacher characteristics that might be related to student achievement has been challenging. Researchers have found different results based on the sample they worked with, all of which were in the US. Aaronson et al. (2007) worked in the Chicago public high schools, Clotfelter et al. (2007 and 2010) used North Carolina's statewide data, Hill et al. (2005) studied a sample of 115 elementary schools in the U.S., Kane and Staiger (2008) worked in a unified school district in Los Angeles, Kane et al. (2008) worked in New York City public high schools, Monk (1994) used the data from the Longitudinal Study of American Youth released in 1991, Nye et al. (2004) used data from elementary schools in Tennessee, Stronge et al. (2008) focused on an assessment applied in Virginia, and Stronge et al. (2011) worked with teachers in a southeastern state of the U.S. In terms of providing in-depth analysis in the relationships between the teacher characteristics and students' mathematics achievement, their contribution to the literature cannot be ignored, but the extent of the comparability of their data with those obtained in the EU may be limited. This is not to say that their results have no implications for the different samples in the different countries rather than the sample they worked with; however, it is essential to acknowledge possible differences among the different populations in the relationships between teacher characteristics and students' mathematics achievement. Therefore, further studies investigating these characteristics are needed to inform pre-service and in-service education programs of ways to prepare teachers to increase students' learning outcomes. Toward this end, the present study contributes to the literature by reporting results based on the differences within the sample, as suggested by the several researchers (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2008; Stronge et al., 2011) with the recognition that, however desirable, a meaningful synthesis of the implications of all these studies based on different settings and participants would be impossible. For example, Aaronson et al. (2007) found that whether the teachers in their sample had a college major in mathematics or education was a predictor of student achievement, while Jepsen (2005) found that teachers' enthusiasm was related to student achievement when controlling for students' prior achievement. However, it is impossible to infer whether college major was a predictor of student achievement in Jepsen's (2005) sample, or whether teacher enthusiasm could be related to student achievement in Aaronson et al.'s (2007) sample. If the relationship between different teacher characteristics and student achievement could be identified in these two different samples with respect to their differences in teaching practices, it would be possible to understand the relationship between teacher characteristics and student achievement in the different instructional contexts. Therefore, because the results from the different samples in these studies cannot be combined to shed light on the possible relationships between the teacher characteristics and students' mathematics achievement, this dissertation study may play an important role not only in identifying possible relationships between teacher characteristics and students' mathematics achievement from a very large sample of seven EU countries, but in revealing the differences among these relationships with regard to the countries' different policies and regulations in terms of teaching practices, and different mathematics achievement levels.

On the other hand, because this dissertation study employs cross-sectional multi-country level representative data from the EU countries that participated in TIMSS 2015 assessment, it may reveal more generalizable results from a large sample, but it also has limitations in comparison with other studies. The most important limitation that should be highlighted is its lack of powerful causal inferences because it snapshots the situation of a single year; however, it might imply the possibility of such inferences to provide future directions for researchers, educators, and policy makers in terms of raising student achievement as well as by describing differences in centralized policies and regulations in the mathematics teaching practices and students' mathematics achievement. While the documentation of the numbers of low-achieving students in these countries based on the TIMSS 2015 international benchmarks is benefited for the differences in the student achievement, this study also benefits from the report published by Eurydice, a European network of countries for sharing and analyzing education related information, for the differences in the centralized policies and regulations in the mathematics teaching practices (European Commission, 2011a). This report provided a comparative analysis of the central policies and regulations in mathematics teaching practices among the 28 EU members and the 10 EU affiliated countries. However, even though it provides an insightful perspective on differences in teaching practices, these practices were not linked to students' mathematics achievement. Therefore, identifying possible differences in terms of the linkage between teacher characteristics and students' mathematics achievement in relation to the differences in the regulations in the mathematics teaching practices is also a contribution of this study, by augmenting the useful Eurydice report.

To conclude, this study contributes to the literature in terms of two main aspects. First, it explicates possible relationships between the teacher characteristics and students' mathematics achievement by providing results from a large sample of EU countries whose eighth-grade students participated in an international assessment, TIMSS 2015. Second, because all previous studies reviewed focused on a specific country or region, the relationships between teacher characteristics and student achievement found under different circumstances cannot be compared despite their advantage of providing more causal inferences. Therefore, given the limitation of the previous research on this topic, which is the incomparability of the different populations, this study enhances the literature by providing comparable possible relationships between teacher characteristics and students' mathematics achievement across the different EU countries participating in TIMSS 2015, among which regulations in teaching practices, and students' mathematics achievement are different.

Chapter 2: Literature Review

As indicated in the first chapter, this study aimed to determine the extent to which the teacher characteristics suggested as effective in previous studies would predict the mathematics achievement of students' in the EU countries and how the EU countries have differed among themselves in terms of these relationships with respect to the existence of these characteristics in the national initiatives or strategies. Therefore, the first part of this literature review discusses how previous researchers have explained the importance of teachers to students' mathematics achievement, in particular why they matter in the EU countries. However, indicating the degree to which teachers are important to students' mathematics achievement is not, by itself, sufficient to promote higher student achievement. Educational policy makers, educators, parents, and especially researchers seek better understanding of the ways in which effective teachers are different from ineffective teachers as indicated by student learning outcomes, and how teacher effectiveness differs across student populations with different levels of the achievement (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011). Finding answers to these questions would contribute to the adequate preparation of pre-service teachers and the professional development of practicing teachers.

Thus, in the second part of this literature review, Stronge's (2007) framework, entitled "Qualities of Effective Teachers," which is used to conceptualize the teacher characteristics that are tested in this study, is discussed. This discussion starts with a brief introduction to this conceptual framework followed by an explanation of how Stronge (2007) defined the effective teacher characteristics in his framework by synthesizing them with previous researchers' findings related to these characteristics, and how these characteristics are promoted in the EU countries with the help of the report published by European Commission (2011a). Because the implementation of teaching practices in the EU countries was discussed in the first chapter, in this chapter, these implementations are briefly discussed in order to synthesize them with the teacher characteristics found to be effective by both the conceptual framework and the previous studies. The synthesis of these three sources of the teacher characteristics that have found to be effective helps to conceptualize the HLM models that are tested in the EU countries participating in TIMSS 2015 at the student, and teacher level to help answer the questions of whether teacher characteristics suggested as effective in previous studies consistently predict students' mathematics achievement in the EU countries, and whether there are differences among the EU countries in terms of how consistently teacher characteristics predict students' mathematics achievement, taking into account differences in the existence of these characteristics. In the final section of the second part, some student and teacher background characteristics included by other researchers in their analyses in addition to those found to be effective are also discussed. These include students' gender (Aaronson et al., 2007; Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2005; Clotfelter et al., 2010; Goldhaber & Anthony, 2007; Hill et al., 2005; Jacob & Lefgren, 2002; Rowan, Chiang, & Miller, 1997, Stronge et al., 2011), students' ethnicity (Aaronson et al., 2007; Clotfelter et al., 2010; Goldhaber & Anthony, 2007, Jacob & Lefgren, 2002, Rivkin et al., 2005), students' socio-economic status (Goldhaber & Anthony, 2007; Jacob & Lefgren, 2002; Rivkin et al., 2005; Rowan et al., 1997; Nye et al., 2004), teachers' gender, and teachers' ethnicity (Aaronson et al., 2007; Boyd, Grossman, Lankford, Loeb, & Wyckoff, 2009; Clotfelter et al., 2010). Researchers have included these background variables in their analyses to control their relationship with student achievement in order to obtain more realistic results for the relationships between the variables in which they are interested and student achievement. This study also includes these background characteristics of students and teachers in the HLM models in addition to the teacher characteristics that have been found to be effective by previous researchers. Therefore, the literature review concludes with a discussion of these background characteristics of student and teachers.

Teachers Matter in Students' Mathematics Achievement

In the first chapter, the problem of the low-student achievement in mathematics, especially in the EU countries, was discussed. Many researchers have investigated student factors affecting mathematics achievement, such as attitudes toward mathematics (e.g., Abazaoglu et al., 2015; Guven & Cobakcor, 2013; Uzun et al., 2010), self-confidence (e.g., Akyuz, 2014; Atar, 2011; Demir et al., 2010), and school belonging (e.g., Akyuz & Pala, 2010; Engin-Demir, 2009). Also researchers have investigated school related factors, such as school environment (Abazaoglu et al., 2015; Engin-Demir, 2009), school resources (Demir et al., 2010), and school size (Kilic et al., 2012). Finally, the role of teachers and particularly the importance of effective teaching practices for mathematics achievement have received considerable attention by researchers as well as EU policy makers. Therefore, while all the mentioned factors have a significant impact on mathematics learning, the characteristics of teachers that predict students' mathematics achievement and how these may differ among diverse populations (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011) are actually concerned in this dissertation study despite the enormous interests on the other factors to investigate students' mathematics achievement.

Beginning with the fundamental question of whether or not teachers matter in terms of student achievement, according to Clotfelter et al. (2010), researchers, policy makers and parents view teachers as the most significant institutional factor affecting student achievement. As empirical support for this perception, Clotfelter et al. (2007) found that having a teacher who scored two standard deviations higher than an average teacher on a basic elementary education test and a test focuses on content could result in a student achievement gain of .068 standard deviations. Aaronson et al. (2007) measured teacher quality based on the effects of the teacher's instruction on students' math test scores in a semester by controlling students' prior achievement scores and student characteristics. They matched student and teacher data in specific classrooms in the Chicago public school system. Through this matched data, they could create simulation scenarios in which students were randomly assigned to the teachers or assigned based on lagged test scores either within or across the schools, to compare the results with the students' original placement and found that variability in teacher effect on student achievement was high enough to imply that having a teacher who was average (estimated as 45 years old with 13 years' experience in the Chicago school system) or one standard deviation higher than average mattered in terms of the student mathematics achievement. They similarly estimated teacher effectiveness by the gain in the students' mathematics achievement, and referred to the average teacher in terms of the estimation of the average test score of the teachers. Kane and Staiger (2008) also addressed the question of teacher effectiveness and found out that over half of the variation in student achievement was explained by the teacher effects after controlling for student characteristic. On the other hand, Nye et al. (2004) indicated that students' mathematics achievement varied by almost half a standard deviation depending on whether students had 25th or 75th percentile teachers. They also found that the effect of having a teacher who was one standard deviation higher in effectiveness than an average teacher was greater than decreasing the number of students in a class from 25 to 15. Based on the normal distribution of teacher effects, they referred to a 25th percentile teacher as "not so effective," a 50th percentile teacher as "average," and a 75th percentile teacher as "effective." Teacher effectiveness was also measured in terms of the mathematics achievement gains of students from kindergarten through third grade on the Stanford Achievement Test. Because they assigned students randomly to teachers, they indicated that students' achievement gains could be attributed to either the treatment they provided or teacher effectiveness. Based on the variance components they generated, they could access the 'between classroom but within-school-and-treatment' variance component, which they described as the teacher effects.

Teachers' instructional practices have been found to matter in student achievement (Stronge et al., 2008). In their meta-analysis of more than 1,300 studies and description of nine, Yoon, Duncan, Lee, Scarloss, and Shapley (2007) indicated that effective classroom teaching practice is the key element in raising student achievement. Kane et al. (2008) also asserted that teachers' instructional practices rather than just their certification levels should be considered when evaluating their effectiveness. Stronge et al. (2011) investigated the differences between more and less effective teachers in terms of the student achievement gains, employing a cross-case analysis of teachers' practices, and found that differences in practice were associated with differences in student outcomes. Nye et al. (2004) specifically pointed out that variances of the teacher effects on achievement was much greater in mathematics than in reading and argued that achievement in mathematics, as a subject that is learned mainly in school, depends directly on the guidance of the teacher, suggesting that mathematics by its nature explains the large variation in teacher effectiveness, but that how teachers teach mathematics is also a cause of this variation.

The European Union (EU) has been concerned to raise student achievement in mathematics, especially in connection with the benchmark declared in the 2020 Education and Training Strategy Plan, which is to decrease the number of low-achieving 15-year old students in mathematics to less than 15% across the EU countries by 2020 (European Council, 2009), as explained in Chapter 1. To find effective ways to raise students' mathematics achievement, in 2011 the EU Commission published a report by Eurydice, a network of 38 EU affiliated countries working under the European Commission, entitled *"Mathematics Education in Europe"* (European Commission, 2011a), which emphasized that effective teaching practices are essential to enhance the students' mathematics achievement, as was also stated the EU Council meeting reports (European Council, 2009; European Council, 2014). However, while the Eurydice report included an analysis of teaching practices, there was no clear EU-wide definition of teacher effectiveness because the Union respects the national diversities of member countries and so emphasizes adhering to common educational principles without specifying what individual countries should do (European Council, 2003; European Council, 2009; European Parliament, 2000).

Teachers do matter. Teachers particularly matter in mathematics. And finally, teachers matter in mathematics in the EU countries. Therefore, taking into account previous researchers' questions concerning how much they matter, what teacher characteristics may be systematically and significantly related to student achievement, and the extent to which these characteristics differ in their effects on mathematics achievement in different student populations, this study also pursues answers to these questions. And in light of the importance the EU places on raising students' mathematics achievement, this study seeks answers to these questions in the sample of EU countries that participated in TIMSS 2015 by investigating potential relationship between teacher characteristics that have been found to be effective by the previous researchers and students' mathematics achievement in the EU countries, along with documenting differences across the countries.

Toward this end, a Hierarchical Linear Modeling (HLM) statistical technique is used to investigate and model the nested relationships among different hierarchical levels by employing different variables at each level (Hox, 2010; Raudenbush & Bryk, 2002). In the HLM method, a hypothesized model with variables drawn from relevant researches is tested on a target sample to indicate the direction and strength of the relationships between the variables both within and between these hierarchical units. Thus, the framework provided in Stronge's (2007) *Qualities of Effective Teachers* is applied in configuring the variables to include in this hypothesized model to measure teacher characteristics that potentially predict students' mathematics achievement (see Chapter 3 for detailed discussion). To address the first research question, i.e., whether teacher characteristics previously found to be effective consistently predict the students' mathematics achievement in the EU countries and the predictive strength and direction of each characteristic, the teacher characteristics identified as effective by Stronge (2007) are tested across the sample of all students and teachers in the EU countries that participated in TIMSS 2015. Addressing the second research question of this study, whether differences in the predictability of these characteristics across the EU countries might be triggered by differences in the prevalence of these characteristics among individual them, benefited from the Eurydice report, *"Mathematics Education in Europe"* (European Commission, 2011a). As discussed in Chapter 1, this report provides a comparative analysis of the issues related to mathematics achievement across the EU countries, including the differences in the implementation of mathematics education across these countries, such as curriculum, assessment, and teacher professional development, as well as the teaching practices in terms of policies and implementations. Therefore, this Eurydice report is helpful in deciding what teacher characteristics to test across the countries in the HLM model so that the differences among these countries in terms of the relationship between the teacher characteristics and students' mathematics achievement can be estimated.

Conceptual Framework of the Study: "Qualities of Effective Teachers"

In his book, Stronge (2007) observed that teacher characteristics strongly affect student achievement because "teachers have a powerful, long-lasting influence on their students. They directly affect how students learn, what they learn, how much they learn, and the ways they interact with one another and the world around them" (p. ix). Therefore, developing his framework of the characteristics of effective teachers, he systematically reviewed relevant studies conducted across several decades, specifically focusing on such factors under teachers' control, such as preparation, personality, and practice, rather than factors out of their control, such as student demographics, school and district administration, or organizational decision making. However, the book provides a systematic review of previous studies rather than a meta-analysis of research results. Therefore, this dissertation study may contribute to the literature by delivering empirical evidence based on a large sample drawn from EU countries on the teacher characteristics Stronge (2007) identified as effective in terms of student achievement.

Stronge (2007) categorized these characteristics under six main themes, "prerequisites for effective teachers, the teacher as a person, classroom management and organization, planning and organizing for instruction, implementing instruction, and monitoring student progress and potential" (Figure 2.1) and identified the elements of each category. This framework represents his synthesis of previous research findings in terms of the effective teaching practices that are linked to student achievement, which was the exclusive focus of his study. His framework includes both teachers' characteristics as well as their practices because he considered teacher as a person who brought his/her personal characteristics formed in out-of-school experiences into the classroom.

Lester (2005) stated that "A conceptual framework is an argument that the concepts chosen for investigation, and any anticipated relationship among them, will be appropriate and useful given the research problem under investigation" (p. 460). Therefore, these effective teacher characteristics defined in Stronge's (2007) framework comprised the conceptual framework of this dissertation study to achieve the aim of identifying the teacher characteristics that may predict students' mathematics achievement in the target EU countries. However, based on the availability of the items to measure these elements in TIMSS 2015 dataset, three of the 27 elements in his study are excluded in this dissertation study (Figure 2.1), which are the verbal abilities and certification status in the first category of 'prerequisites for effective teachers', and time allocation in the fourth category of 'planning and organizing for instruction'.

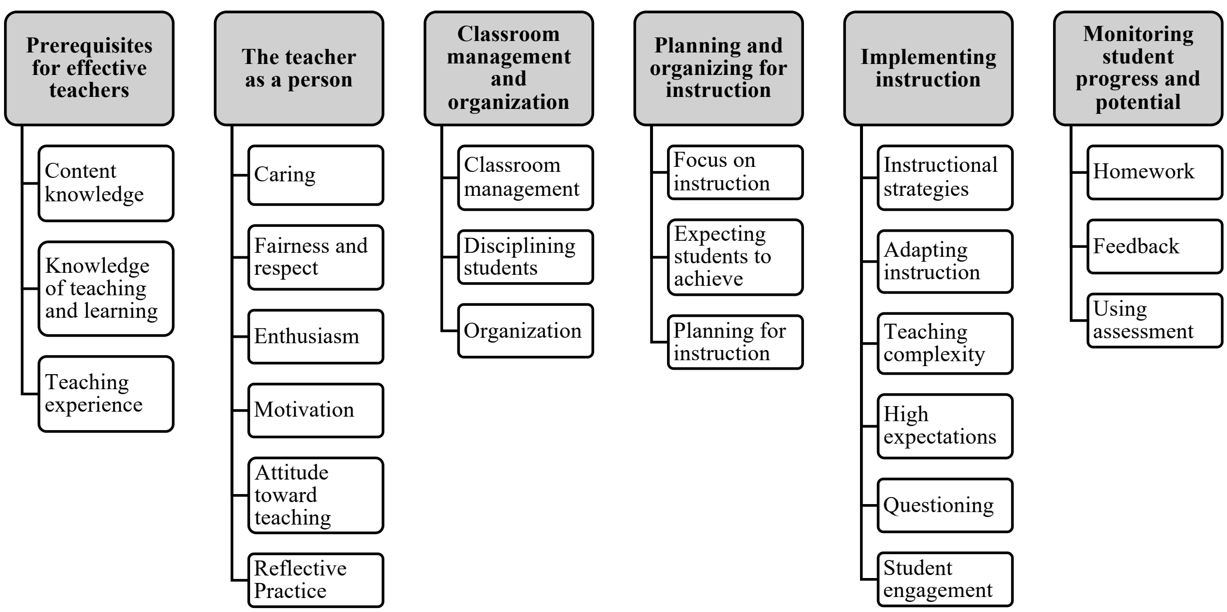

Figure 2.1. Qualities of Effective Teachers Derived from Stronge (2007)

The following discussion is a synthesis of the definitions of elements provided by Stronge (2007), previous researchers' relevant findings related to each element, and the differences reported in the by European Commission's (2011a) Eurydice report concerning the relevant elements among the seven countries of this dissertation study. The literature review for the previous studies revealed that the studies focusing on the relationship between the teacher characteristics and student achievement were limited. In addition, these studies were mostly interested in this relationship in the country or regional level. Nevertheless, their findings related to the elements provided by Stronge (2007) were discussed simultaneously with the explanations Stronge (2007) provided and the differences reported in the EU countries by the European Commission (2011a). The list of the studies related to each element is provided in Appendix B. In addition, the certain elements discussed by the European Commission (2011a) in terms of the differences across the countries were also indicated (Appendix B).

Effective Teacher Characteristics

Prerequisites for Effective Teachers. Stronge (2007) indicated that taxpayers, educators and policy makers keenly interested in whether teachers' preparation is adequate for their in-service teaching practices to will raise student achievement. Accordingly, research on teacher education programs, especially in terms of the content and pedagogical knowledge of teachers, has increased. He further indicated that teachers' content knowledge factor affecting student achievement; however, it is not sufficient in itself. Teacher preparation programs with a strong focus on content at the expense of pedagogical development of the teachers are not more effective than programs preparing teachers in both areas. Therefore, the first two effective teacher characteristics defined by Stronge (2007) are the content and pedagogical knowledge of the teachers.

Long interested in enhancing teacher preparation (Monk, 1994), researchers have investigated elements teachers bring into the classroom from their teacher education backgrounds to increase student achievement (Boyd et al., 2009; Hill et al., 2005; Jacob & Lefgren, 2002). Teacher education, as expected, has a positive impact, but the nature and the extent of this effect may differ (Monk, 1994). While Boyd et al. (2005) indicated that teachers' effectiveness could differ according to their teacher education experiences, it is important to determine a common core of teacher education attributes likely to increase student achievement.

Accordingly, while some researchers have investigated teachers' college majors and/or the highest degree they obtained (Aaronson et al., 2007; Betts, Zau, & Rice, 2003), others have focused on teaching certification requirements (Goldhaber & Anthony, 2007; Hill et al., 2005; Kane et al., 2008), and the coursework pre-teachers complete (Boyd et al., 2005; Hill et al., 2005; Monk, 1994), and some studies have focused the content and pedagogical knowledge teachers attained in their teacher education programs (Boyd et al., 2009; Bruce, Esmonde, Ross, Dookie, & Beatty, 2010; Clotfelter et al., 2007; Hill et al., 2005; Monk, 1994; Rowan et al., 1997; Stronge et al., 2011). There is no direct way of assessing what teachers have learned in their teacher education programs; however, the specific areas they studied could provide hints about the effects of their knowledge on their students' performance (Monk, 1994). For assessing teacher education backgrounds, Rowan et al. (1997) described a shift from using levels of teachers' degrees of to using the subjects they studied in their pre-service education. On the other hand, Betts et al. (2003), investigating school and classroom factors in San Diego schools that had an impact on student achievement, included teachers' college majors in their model to explain student achievement in a K-12 public database. From their mathematics achievement model, they found that teachers with a bachelor's degree in mathematics were not significantly more effective than teachers with an education degree but noted that having a mathematics degree gave teachers an advantage in the job market over teachers who majored in education. It was also likely that mathematics graduates might find more profitable jobs than teaching and so were not kept in the data. Aaronson et al. (2007) also included teachers' college major in their model to explain teacher effectiveness. They found that having an education or mathematics degree was related to an estimate of teacher quality; however, the extent of the relationship was quite small.

On the other hand, Stronge (2007) argued that a teacher's coursework while in college is one of the strong predictors of student achievement, stating that both pedagogical and content knowledge are essential components of teacher education and including them in his framework as prerequisites for teacher effectiveness. Accordingly, they are also assessed in this study, although, despite Stronge's (2007) emphasis on coursework, college major is a proxy for the content and pedagogical knowledge teachers bring into their classrooms. In addition to the established use of this proxy by other researchers, college major the only variable available for this construct in the TIMSS 2015 data. Therefore, based on the availability, and the other researchers' suggestions, college major of the teachers is used to estimate their content and pedagogical knowledge.

In addition to the content and pedagogical knowledge of teachers, third prerequisite for the effective teachers defined by Stronge (2007) is teaching experience. He emphasized that teachers gain relevant experience over time, not only in their classrooms but also in their lives. Experienced teachers are more knowledgeable about different instructional strategies in terms of both the content and the students they teach. In the literature review for this study, the relationship of teaching experience, especially in years, to student achievement has been the most frequently investigated aspect of effective teaching practices (Aaronson et al., 2007; Boyd et al., 2005; Bruce et al., 2010; Clotfelter et al., 2007; Clotfelter et al., 2010; Goldhaber & Anthony, 2007; Hill et al., 2005; Jacob & Lefgren, 2002; Jepsen, 2005; Monk, 1994; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011). However, the nature of this relationship has varied across studies.

Aaronson et al. (2007) indicated that teaching experience is of substantial interest to researchers investigating the effects of observable teacher characteristics and student achievement outcomes, while Hill et al. (2005) stated that using teaching experience to investigate teachers' effect on student achievement might serve a proximate purpose for some researchers, but they found it to be a poor proxy for assessing teachers' knowledge and skills for promoting students' learning growth. Jacob and Lefgren (2002) also pointed out that there is little consensus on the relationship between teaching experience and student achievement. Because researchers have different perspectives on this topic, it is advisable to report their justifications along with their findings.

More than two decades ago, Monk (1994) drew attention to a different aspect of teaching experiences, which is that more experienced teachers received their teacher education longer ago than teachers with less experience and may have less current mathematical and pedagogical knowledge and being older less impetus to update themselves. As a result, he argued that there is little evidence that teaching experience promotes student achievement. In addition, he found that the relationship between teaching experience and student achievement could differ depending upon the students' year in school. He found no effect of teaching experience on student achievement for second-year high school students but a positive effect for third-year high school students. Similarly, at the elementary level, Hill et al. (2005) found that teaching experience was not related to student achievement in the first-grade, but positively and significantly related in the third-grade. Nye et al. (2004) also found a significant relationship between teaching experience and student achievement is significant only in third-grade students' results. These findings indicate that there is not a stable relationship between teaching experience and student achievement across grade levels.

Rather than conceptualizing teaching experience in terms of number of years, Boyd et al. (2005) focused on the year in the teacher's career and found that student mathematics achievement gain was .05 standard deviation (7.6% of the standard deviation) with teachers in their second year of teaching while it was .067 with the teachers in their third year of teaching, after which gains in students' mathematics achievement diminished despite the increase in experience. On the other hand, Rivkin et al. (2005) indicated that teachers gained in quality throughout their first three years of teaching, but there was little evidence of change in the years after that. Clotfelter et al. (2010) supported this perspective by reporting a significant difference in gains between teachers with one or two years of teaching experience and those with three to five years of experience. They also indicated that beyond the first five years, there was little effect of any additional years of teaching experience on teacher effectiveness.

However, Goldhaber and Anthony (2007), regardless of the time period, asserted that the relationship between teachers' years of experience and student achievement is commonly significant and positive. Similarly, Jepsen (2005), working with teachers and students in cohorts in which the more experienced teachers were in the third grade cohort and the less experienced in the first grade cohort, found .02 standard deviation increase in teaching effectiveness for each year of teaching experience and that one standard deviation increase in teaching experience of a teacher yielded 13 percentage points increase in mathematics teaching effectiveness. Clotfelter et al., (2007) also found clear evidence that teachers with more teaching experiences were more effective in that the effect of teaching experience yielded to .092 standard deviations in the levels model and .119 standard deviation in the gains model in their investigation of teacher effects through these two approaches.

In addition to content knowledge, knowledge of teaching and learning, and teaching experience, Stronge (2007) included the elements of teachers' verbal ability and their certification in his framework of prerequisites for effective teacher characteristics. However, based on the data available and the relevance of variables to the sample countries, the prerequisites for teacher effectiveness included in this study are content knowledge, knowledge of teaching and learning, and teaching practices. Because of unavailability of data, unfortunately, three of the 27 characteristics of effective teachers that Stronge (2007) defined had to be excluded from this study, two which were among the prerequisites for the effective teachers construct.

Turning now to the EU perspective, the European Commission (2011a) and the European Council (2014) indicated that initial teacher education programs should prepare teachers in both the subject they taught and the pedagogical aspects of the subject. These two aspects are in fact the base elements in classroom environments that originate in teachers' preparatory education. It was also indicated that teacher candidates should receive practicum teaching opportunities, in addition to their subject and pedagogical education. However, in almost half of the EU countries, policy regulations provide two ways to become a teacher. As the European Commission (2015) indicated, in these countries prospective teachers may go through either a unified teacher education program providing both subject and pedagogical aspects, or a non-education degree in the subject they will teach with subsequent acquisition of an educational specialization. Thus, completing a unified teacher education program providing both content and pedagogical training is not mandatory; nevertheless, the completion rate for educational specialization programs is high. Moreover, as indicated in Chapter 1, 62.3% of the teachers who completed teacher education programs feel ready to teach their subjects compared to 47.6% of those with a non-education degree. In addition, 41.4% of the teachers with an education degree feel prepared in terms of the pedagogical aspects of their teaching compared to 27.5% of those with a non-education degree (European Commission, 2015). These findings support the completion of a teacher education program or acquisition of an educational specialization.

In addition, as indicated before, the Eurydice report, "Mathematics Education in Europe" (European Commission, 2011a), documents several differences across the EU countries and comparatively analyzes the circumstances in the countries in specifically relation to mathematics achievement, which support allowing some teacher level variables to test across the country level in the HLM model of this study. For example, there are differences in the central regulation of the minimum percentage of the course loadings in subject and pedagogical knowledge in both generalist and specialist teachers' preparation among the sample countries of this study. While there is no regulation in Hungary, Slovenia, and Sweden, the course loadings for generalist and specialist teachers are considerably different in Italy, Lithuania, Malta, and Turkey, as discussed in Chapter 1. Therefore, because of the potential differences across the countries in terms of the content and pedagogical knowledge variables within the prerequisites of effective teacher category, the variables related to content and pedagogical knowledge of the teachers (college major variables) are tested across the countries to reveal the differences.

The Teacher as A Person. Stronge (2007) identified the following six personal characteristics of teachers that, along with their social and emotional behaviors, can even be more effective than their instructional and management skills: Caring, fairness and respect, enthusiasm, motivation, attitude toward teaching, and reflective practices.

First, Stronge (2007) emphasized that effective teachers care for their students, so that students are aware that their teachers listen to their ideas, encourage them, and support their efforts to work on their problems. Encouraging students to share their own ideas or experiences humanizes the teacher from the students' perspective. With regard to teachers' caring, Peart and Campbell, (1999) indicated that of the teachers' interpersonal skills in conveying care contribute to an effective learning environment and allows teachers to know and support their students. After working with four representative secondary teachers from England, Ireland, and the U.S., Collinson, Killeavy and Stephenson (1999) also stated that effective teachers care for their students in a way that encourages students to express their ideas orally and in writing. In addition, Stronge et al. (2008), working with two groups of teachers, one consisting of five teachers selected as effective from the 24 top-quartile teachers in terms of student learning based and the other consisting of six selected as ineffective from the 21 bottom quartile teachers, found that while effective teachers produced higher student learning gains than expected, ineffective teachers produced lower learning gains. Based on their exploratory cross-case analysis, they found a considerable mean caring score difference between effective and ineffective teachers in terms of enhancing student achievement. Stronge et al. (2011) again worked with 17 top-quartile and 15 bottom-quartile teachers to investigate the relationship between teachers' caring acts and student achievement and similarly found that top-quartile teachers significantly surpassed bottom quartile teachers in caring acts, which was associated with their students' higher achievement.

Secondly, in addition to caring for their students, effective teachers also take responsibility for highlighting and demonstrating fairness and respect in their classrooms, which is also emphasized by the students as a prerequisite of teaching (Stronge, 2007). Agne (1992), in a study comparing 88 expert teachers with 92 other teachers, found that expert teachers embraced a democratic classroom environment, in which there is a warm relationship between student and teacher. In both Stronge et al.'s (2008) and Stronge et al.'s (2011) studies of effective vs. ineffective and top-quartile vs. bottom-quartile teachers, fairness and respect was also found to be a characteristic of effective teachers.

As a third characteristic, enthusiasm for both teaching and learning has been identified as an essential quality of effective teachers related to better relationships with students as well as enhanced student achievement (Rowan et al., 1997; Stronge, 2007). In terms of the teachers' enthusiasm for teaching, Hill et al. (2005) stated that researchers addressing this aspect found that what teachers did in their classrooms affected student achievement. On the other hand, Jepsen (2005) found that teachers' enthusiasm and their effectiveness in teaching mathematics were negatively related in the sample he worked, with a .05 standard deviation difference. However, he also indicated that this relationship could depend upon the cohorts they worked with and the subject that students were being taught because he thought the more enthusiastic teachers were matched with the more difficult classrooms. Thus, when controlling for the students' previous mathematics achievement, he found that this effect became slightly more significant. Rowan et al. (1997) also suggested that future researchers should study the relationship between teachers' enthusiasm and student achievement in specific classrooms. In this dissertation study, teachers' enthusiasm is investigated in connection with student achievement at the classroom and country level through the hierarchical nature of the structure of the data used, as Jepsen (2005) and Rowan et al. (1997) suggested.

Stronge (2007) also indicated that effective teachers have strong skills for motivating students to learn mathematics. More effective teachers encourage their students to reach their potential while ineffective teachers cause students to lose interest in the subject they are learning. Therefore, he identified the ability to motivate as the fourth personality characteristic of an effective teacher. In their factor analysis of attributes of teachers in Connecticut, Covino and Iwanicki (1996) also found that effective teachers use variety of methods to support students' extrinsic and intrinsic motivations to learn as well as adapt their methods based on students' prior levels of motivation for learning. Stronge (2007) supported the idea that by motivating students to learn, teachers brought out the best in students by making them excited and receptive to learn at their own pace while acknowledging that every student had a different level of motivation. Rowan et al. (1997), addressing researchers' interest in the linkage between teachers' ability to motivate and their instruction, found that teachers' motivation of students to learn mathematics had especially large effects on lower achieving students.

The fifth personality characteristic of effective teachers described by Stronge (2007) is attitude toward teaching, which bilaterally affects both student and teacher learning. While Stronge (2007) focuses only on positive attitude toward teaching, Mitchell (1998) contended that an effective teacher should have a positive attitude toward both teaching and life. In the two studies by Stronge et.al (2008) and Stronge et.al (2011) in which the framework developed by Stronge (2007) was partly employed, attitude toward teaching was among the effective teacher characteristics in terms of the student achievement.

Stronge (2007) identified the sixth and last of the personal characteristics of effective teachers as reflective practice, which he described as teachers' cautious self-criticism and introspection about their own teaching practices to continue learning and improving their teaching to meet more students' needs by the improved teaching approaches. When reflecting on their teaching, effective teachers seek feedbacks from the other educators. In their factor analysis of the characteristics of effective teachers, Covino and Iwanicki (1996) also indicated that effective teachers analyze and improve their teaching practices and share them with other teachers.

With regard to the "teacher as a person" construct, the EU countries differed in their policies in the area of motivation. In its analysis of central policies, the European Commission (2011a) reported that in Italy, Malta, and Sweden there were "national strategies and centrally coordinated initiatives" to motivate lower secondary level students to learn mathematics, but not in Hungary, Lithuania, Slovenia, and Turkey (see Chapter 1). Therefore, the variable of teachers' motivation of students are tested across the countries in the HLM model to reveal differences in the relationship between the teachers' motivation of students and student achievement in mathematics.

Classroom Management and Organization. Stronge (2007) described effective teachers as capable of not only designing good quality lessons, but also organizing the learning environment and maintaining good classroom management, which includes disciplining students as necessary and planning the delivery of lessons, teaching methods, and materials so as to maintain their flow.

Stronge (2007) emphasized that classroom management skills, especially the coordination of student behaviors, are essential for effective teaching. He indicated that effective teachers are preemptive in averting disruptive behaviors in the classroom by creating a positive and engaging learning environment. In their meta-analysis of around 11,000 statistical results, Wang, Haertel, and Walberg (1993) indicated that students' propensity to behave in particular ways was one of the most important influences on their learning, so an effective teacher directs students' behaviors in productive ways.

Second, Stronge (2007) stated that it is also essential to prevent or stop students' negative behaviors, which could arise when students felt neglected in favor of other students. Thus he identified the second element of classroom management and organization as disciplining students. Covino and Iwanicki (1996) also found that interfering with students' misbehaviors to maintain focus on the lesson was be an important factor in effective teachers' instruction.

Finally, Stronge's (2007) third element of classroom management is organization of classroom routines, of student behaviors as mentioned above, and of the materials of instruction, which maximizes instructional time.

In terms of, and their relationship to the student achievement, Stronge et al. (2008) investigated the relationship of these three sub-dimensions of classroom organization and management (management, organization, and behavioral expectations) to student achievement with 11 teachers, and found that effective teachers have higher mean scores in these three sub-dimensions. Stronge et al. (2011) examined the sub-dimensions of classroom management and classroom organization, sub-dimensions of the construct of learning environment, with 32 teachers and found that top-quartile teachers had significantly higher mean scores in classroom management and classroom organization than the bottom-quartile teachers, although the sample size (32) was small. However, these dimensions are investigated in a broader sample of mathematics teachers in the EU countries in this dissertation study.

With regard to classroom management and organization, in its comparative analysis, the European Commission (2011a) found some differences across countries in the sub-dimension of disciplining students, specifically, regulations concerning the grouping of students in classrooms in the EU countries for both managing their misbehaviors and increasing their motivation (see Chapter 1). While different types of grouping are only recommended in Lithuania, Slovenia and Turkey, there are specific central guidelines for grouping students in Hungary, Italy, Malta and Sweden (European Commission, 2011a). Therefore, in this study, the teacher level variable of "disciplining students" across the EU countries is tested across the countries to reveal differences among these countries.

Planning and Organizing for Instruction. Stronge (2007) emphasized that effective teachers are also good at planning the objectives and activities of the instruction, promoting higher student achievement, and putting the emphasis of the classroom activities on students' learning. Accordingly, the central elements of planning and organization for instruction were identified as "focusing on instruction, expecting students to achieve, and planning and preparing for instruction."

First, he indicated that a central focus on instruction helps not only the teacher in terms of planning and managing lessons, but also the students in terms of experiencing the accomplishment of meeting the challenges of the instruction. Focus on learning was also described as an effective instructional attribute by Cotton (2000), who provided 15 effective contextual and five effective instructional schooling practices. Expecting students to achieve is another characteristic of effective teachers. Stronge (2007) argued that behavioral expectations of the students must be supported by achievement expectations, as Peart and Campbell (1999) also emphasized. And, lastly, under the organization component of the planning and organizing for instruction construct, Stronge (2007) again emphasized the importance of preparing instruction in advance. He also indicated that, in contrast with effective teachers, novice teachers often struggle with this aspect, especially with accommodating the different needs of students.

Based on these dimensions, Stronge et al. (2008) found that effective teachers scored higher than less effective teachers in all these dimensions except “achievement expectations.” In addition, Stronge et al (2011) found a difference between the top- and bottom-quartile teachers, favoring the top-quartile teachers. In terms of the achievement expectations, Rowan et al. (1997) found out that teachers’ expectations of their students had a significant effect on students’ mathematics achievement. In addition, Peart and Campbell (1999) made the point that by communicating clear achievement expectations, effective teachers remind students of their responsibility and commitment to achieve these expectations. On the other hand, McKown and Weinstein (2008), investigating the relationship between the teachers’ achievement expectations and student achievement in ethnically diverse classrooms found that when teachers are biased in their expectations due to students’ ethnic backgrounds, students’ achievement was affected negatively.

In the report published by European Commission (2011a), however, there were no differences reported regarding the three elements of the “planning and organizing for instruction” construct among the seven EU countries included in this study.

Implementing Instruction. Teachers’ educational backgrounds, their teaching personalities, and their classroom management, planning and organization skills are all associated with Stronge’s (2007) characteristics of effective teachers discussed so far. However, he indicated that they could not be more important than how teachers implement instruction in the classroom. In terms of this construct, he included six characteristics of effective teachers that enhance student learning: instructional strategies, adapting the instruction, teaching complexity, high expectations, questioning, and enhancing student engagement.

First, he explained that implementing instruction starts with selecting a range of instructional strategies for two main reasons: accommodating diverse students (Peart & Campbell, 1999) and enabling students to reach maximum understanding of the concepts being taught (Stronge, 2007). With regard to accommodating different students, therefore, it is also highlighted that effective teachers not only have different strategies for reaching all students, but also differentiate instruction in response to the needs and abilities of students at their own levels (Covino & Iwanicki, 1996; Stronge, 2007). Adapting instruction, therefore, is the second characteristic of effective teachers under implementing instruction. Third, high expectations, as highlighted previously, are stressed, but now in terms of managing the challenges in lessons so as to support these high expectations (Stronge, 2007). Thus, high achievement expectations should be supported by the implementation of instructional activities. Mason, Schroeter, Combs and Washington (1992) placed 34 averagely-achieving eighth-grade students into a higher-level pre-algebra class and found that the challenging content along with high expectations could result in high mathematics achievement. In addition, teachers should also be aware of the complexities of teaching while managing these strategies to accommodate student diversity and communicate high expectations. Stronge (2007) described teaching as a complex action that involves complex subject matter along with the complexity of learners from different backgrounds. He further explained that recognizing the individuality students and their in- and out-of-the-classroom experiences as well as making the content relevant to all these different learners is of bilateral importance to both teacher and students. Therefore, his fourth element is understanding the complexity of teaching so as to make subjects relevant to all students. Stronge's (2007) fifth element under implementing instruction is the use of questioning techniques in combination with the use of different strategies, differentiation of instruction, making the subject relevant to different learners, and challenging learners to meet high expectations. Questioning techniques are crucial for the teacher's interactions with students as well as feedback while managing student and lesson differences in the classroom (Covino & Iwanicki, 1996). The quality of interactions between teacher and students highly depends on the quality of the questioning strategies that teacher uses to understand each student as an individual. The last element of implementing instruction is student engagement. Stronge (2007) indicated that there is not just one strategy to ensure student engagement in the classroom; in this regard, Cotton (2000) specified "flexible in-class grouping" as one of 15 effective contextual methods that help to increase the students' engagement with the instruction.

The above mentioned studies of effective vs. ineffective (Stronge et al., 2008) and top- vs. bottom-quartile (Stronge et al., 2011) included the construct of implementing instruction to identify differences between these different types of teachers. They included instructional strategies, adapting instruction, teaching complexity, questioning, and student engagement under the categories of instructional delivery and student assessment. Despite the small sample sizes in these two studies, based on mean score differences, they concluded that these elements of implementing instruction were characteristic of effective and top-quartile teachers though not at a significant level. Therefore, the large sample of teachers across the seven EU countries in this dissertation study may yield more robust results for these characteristics developed by Stronge (2007).

In terms of the construct of implementing instruction, the European Commission (2011a) report indicates some differences among the seven target EU countries in the areas of "teaching complexity" and "student engagement." In terms of teaching complexity, making mathematics relevant to the students was highlighted, particularly the skill of applying mathematics to students' daily lives, which was referenced generally in the curriculum and/or the steering documents of Hungary, Italy, Slovenia, and Sweden. However, in Malta's curriculum and/or steering documents, in addition to a general reference, the use of a specific assessment for this purpose was also recommended. On the other hand, in Lithuania and Turkey, in addition to general references and recommendations to use a specific assessment, the use of specific teaching methods for making mathematics more relevant to students' daily lives was also recommended. Therefore, the teacher level variable of teaching complexity (making mathematics relevant) is allowed to test across the countries to reveal the differences across the focal EU countries.

In the European Commission's (2011a) report, another variable that differed among countries was student engagement. Central educational authorities promoted specific teaching methods to increase student engagement at the lower secondary level in Lithuania, Malta, and Slovenia but not in Hungary, Italy, Sweden, and Turkey. Thus, the student engagement variable is also tested across the countries in the final HLM model (see Chapter 1 for a more detailed discussion).

Monitoring Student Progress and Potential. Effective teachers assess their students' individual learning placing importance on aligning their instruction with state standards and increases in graduation requirements linked to the high-stakes tests. In this regard, teachers use different strategies to assess students' learning as they do in implementing the instruction, such as using homework assignments, adapting assessments to meet students' needs, and providing feedback (Stronge, 2007).

Stronge (2007) stated that assigning homework as an extension of the work done in class remains an essential tool for the teachers to assess students' learning and support them accordingly despite the controversy concerning the value of using homework. He further indicated that the benefits of the homework assignments are not related to the quantity of the work assigned to the students. Rather, the role of homework assignments should be to provoke students' thinking before they come to class, and it is meaningful when it is supported by classroom discussions. Cotton (2000) agreed that assigning homework, especially after the fourth-grade, is important to let students know their progress. Jepsen (2005) also indicated that student achievement modestly increases in tandem with the amount of homework assigned and is rises to significance only when students' prior achievement is controlled. However, in this dissertation study, unfortunately, there is no possibility to control students' prior achievements because of limitations of the data used.

Another characteristic of effective teachers is using assessment to meet students' needs by monitoring their progress in terms of their potential (Stronge, 2007). Through student assessments, teachers can accumulate information on student learning and use this information for shaping the further instruction. Rowan et al. (1997) also indicated that teachers may use proper assessment of student learning to adjust their achievement expectations for individual students.

The last element in this construct as defined by Stronge (2007) is to provide feedback to students in a timely manner, which has an important impact on student achievement. In addition to assigning homework so students can monitor their progress, Cotton (2000) highlighted the importance of efficiently grading and returning homework assignments for this purpose to be achieved.

Stronge et al. (2008) and Strong et al. (2011) included the elements of homework, assessment, and feedback in their analysis of the characteristics of effective and ineffective teachers and reported that effective and top-quartile teachers had higher mean scores on using assessment and providing feedback to their students, but unexpectedly ineffective teachers had higher mean scores for using homework, though the difference was not significant. However, their study included only 11 classrooms (five effective and six ineffective teachers). Therefore, an analysis of a much larger dataset would yield more robust results. Therefore, the variable related to homework is examined cautiously in this study.

In addition to Stronge's (2007) definitions derived from previous researchers' findings related to the homework, assessment, and feedback, it is also important to describe the potential differences among the countries in this study. The EU Commission report (European Commission, 2011a) indicated that EU countries may differ in the element of homework. There are no central guidelines on assigning mathematics homework in Hungary, Italy, Malta, Slovenia, and Sweden while there are guidelines but for all subjects in Lithuania. Among the countries in this study, only Turkey has specific guidelines on assigning mathematics homework at the lower secondary level. Therefore, in the final HLM model of this study, the use of homework is the last teacher level variable that is tested across the countries.

Student and Teacher Background Characteristics

In addition to the characteristics of effective teachers, it is also essential to mention some student and teacher background characteristics that researchers have employed in their analyses. As demonstrated so far, teachers matter in students' mathematics achievement, and this study investigates this relationship in the sample of EU countries, the teacher characteristics that may predict student' mathematics achievement, and how these predictions differ among these EU countries, where the prevalence of the characteristics vary. However, in investigating this relationship, background characteristics of both teachers and students should be taken into account. The relationship between the teacher characteristics and students' mathematics achievement can be assessed more realistically after controlling the relationships between these background characteristics and the students' mathematics achievement. According to the researchers discussed in this literature review, students' gender (Aaronson et al., 2007; Boyd et al., 2005; Clotfelter et al., 2010; Goldhaber & Anthony, 2007; Hill et al., 2005; Jacob & Lefgren, 2002; Rowan et al., 1997, Stronge et al., 2011), students' ethnicities (Aaronson et al., 2007; Clotfelter et al., 2010; Goldhaber & Anthony, 2007, Jacob & Lefgren, 2002, Rivkin et al., 2005), and students' socio-economic status (Goldhaber & Anthony, 2007; Jacob & Lefgren, 2002; Rivkin et al., 2005; Rowan et al., 1997; Nye et al., 2004) are student level background characteristics that should be included in analyses of the student and/or teacher level relationships within relevant concepts. However, there is no available data in TIMSS 2015 results to directly measure students' socio-economic status. In this case, it is essential to know how TIMSS itself approximates this variable. As stated in the TIMSS 2015 framework, students' socio-economic status mostly measured by the two proxy variables, parents' highest educational level and home educational resources (Bradley & Corwyn, 2002; Dahl & Lochner, 2005; Davis-Kean, 2005; Martin, Foy, Mullis, & O'Dwyer, 2013; Sirin, 2005; Willms, 2006; as cited in Hooper, Mullis, & Martin, 2013). Therefore, both of these characteristics are included in this study as student-level background variables to estimate students' socio-economic status, through a special variable. In TIMSS 2015 data set, the variable called *BSBGHER* already included information regarding the number of books students have their home, home study supports their home, and their parents' highest educational level (Martin, Mullis, & Hooper, 2016). As a result, the scaled variable for the home educational resources in TIMSS consists the information for the socio-economic status of the students and was used in this study to measure students' socio-economic status. On the other hand, there is neither an actual nor a proximal variable to measure students' ethnicities in the dataset. Actually, including a variable for assessing the ethnic background of the students and its relationship with their mathematics achievement would be very helpful, either for controlling or directly examining its relationship with achievement, especially considering the concerns of the previous researchers. As a result, student level background variables used in this study are students' gender, and students' socio-economic status as measured by a scaled variable, BSBGHER.

Researchers have also indicated that teacher level background variables should be controlled in analyses investigating the relationships of teacher and student constructs with student achievement. Researchers cited in this literature review suggest that teachers' genders and ethnicities are background characteristics that are related to student achievement (Aaronson et al., 2007; Boyd et al., 2009; Clotfelter et al., 2010). Especially considering the teachers in their sample, ethnicity can be a good variable to be included in an analysis; however, as with students' ethnicity, no data on teachers' ethnicity are available in TIMSS 2015. Therefore, only the variable of teachers' gender is included in this study to control for teacher background in the relationship of teacher characteristics with students' mathematics achievement. The descriptive statistics for the student and teacher background characteristics variables are included in Table 4.1 in the fourth chapter.

In addition to the student and teacher background characteristics, a variable called "country membership" is also included in the analysis so that the results of the estimations for the teacher characteristics are revealed more realistically after controlling the differences caused by the membership of the students and teacher into the different countries.

Summary

To find ways to increase students' mathematics achievement, several researchers have investigated student related factors (e.g., Abazaoglu et al., 2015; Akyuz, 2014; Akyuz & Pala, 2010; Atar, 2011; Demir et al., 2010; Engin-Demir, 2009; Guven & Cobakcor, 2013; Uzun et al., 2010) while others have focused on school related factors (e.g., Abazaoglu et al., 2015; Demir et al., 2010; Engin-Demir, 2009; Kilic et al., 2012). Teacher related factors, specifically teacher characteristics, have also received considerable research attention with emphasis on effective teaching practices (e.g., Aaronson et al., 2007; Clotfelter et al., 2007; Clotfelter et al., 2010; Kane & Staiger, 2008; Kane et al., 2008; Nye et al., 2004; Yoon et al., 2007). The EU has also highlighted the importance of effective teachers to students' achievement (European Commission, 2011a; European Council, 2009; European Council, 2014). However, because the Union emphasizes having common principles while respecting national diversities (European Council, 2003; European Council, 2009; European Parliament, 2000), there are no clear specifications of the characteristics of effective teachers across the EU countries. Therefore, among the many factors affecting students' mathematics achievement as indicated, the focus of this study is on the extent to which teachers matter in students' mathematics achievement, the characteristics of the teachers that predict students' mathematics achievement, and the differences in the predictive power of these characteristics in light of the varied existence of these characteristics among the EU countries in their national initiatives and strategies (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011).

In this study, Stronge's (2007) framework as explicated in his book, *Qualities of Effective Teachers,* is used to identify the teacher characteristics that are potentially related to students' mathematics achievement in the EU countries. The teacher characteristics he defined to be effective in student achievement, which is the conceptual framework of this study in terms of the selection of variables, are tested to determine the extent to which they predict students' mathematics achievement in the overall focal EU countries that participated in TIMSS 2015. In addition, the strength and direction of these predictions are investigated through the HLM statistical technique used in this study. Therefore, how Stronge (2007) defined these characteristics of effective teacher were discussed to clearly explain the procedure for selecting TIMSS 2015 items for these characteristics. In addition to his definitions of these characteristics, their descriptions by other researchers in relation to student achievement were also referenced. However, because the main focus of this study is to identify the teacher characteristics that are potentially related to students' mathematics achievement, the few studies that investigated this particular relationship were also discussed. The integration of the findings of these researchers provides different perspectives on the relevant characteristics of effective teachers. However, these studies were limited, which also gives an importance to this dissertation study in terms of contributing to the literature by providing empirical evidence on the teacher characteristics that may predict students' mathematics achievement with a very large sample of seven EU countries. In addition, the prevalence of certain teacher characteristics was different across these countries. Therefore, this study may not only contribute to the literature by providing empirical information on the teacher characteristics that can predict students' mathematics achievement, but also reporting the differences in this relationship from the different populations where implementations of some teaching practices are different.

In addition to the teacher characteristics that are possibly linked to students' mathematics achievement in the EU countries, another interest of this study is to find the differences among these countries in terms of these linkages. In deciding the variables to test across the countries in the HLM model to reveal the differences, it is benefited from the report published by Eurydice, *Mathematics Education in Europe* (European Commission, 2011a), which provided the results of a comparative analysis of the implementation of teaching practices most likely to be related to students' mathematics achievement in the 38 EU countries light of the EU Council's benchmark, set forth in its Education and Training 2020 Strategy Plan, of decreasing the number of low-achieving 15-year-old students in mathematics, science, and reading to 15% by 2020 (European Council, 2009). Therefore, the results provided in this report are also interactively discussed with the definitions Stronge (2007) provided and the findings of other researchers to determine the teacher characteristics that are potentially differently related to students' mathematics achievement in the different countries in this study, to be tested by the HLM model, in addition to the determination of the general prediction value of these teacher characteristics for students' mathematics achievement in the sample of seven EU countries. Appendix B shows the variables (characteristics of effective teachers) that are tested within all the focal EU countries with the research related to each. In addition, it also illustrates the variables that are tested between the countries in terms of the differences documented in the European Commission's (2011a) report.

And finally, as indicated by previous researchers, some student and teacher background characteristics variables are included in the conditional models of this study to control for their relations with students' mathematics achievement. As discussed, these include students' gender, their home educational resources, and their country membership as well as the teachers' gender for more realistic estimates both within and between the seven EU countries.

Chapter 3: Method

The aim of this dissertation study was to answer the following research questions: a) To what extent do teacher characteristics suggested as effective in previous studies consistently predict students' mathematics achievement in the overall focal EU countries, as documented by the TIMSS 2015, after controlling for student and teacher background characteristics as well as the country membership, and b) what are the differences among the focal EU countries in terms of the relationship between students' mathematics achievement and their teachers' characteristics as these are demonstrated differently in the national strategies and initiatives across these countries? To address these questions, the following TIMSS 2015 data were used: eighth-grade students' mathematics achievement according to the mathematics assessment, and students' and teachers' responses to the background context questionnaire.

This chapter consists of three main sections: Setting – TIMSS 2015 Database, Research Design Phase, and Data Analysis Phase. In the first section, the target population and sampling procedures are described. Then the two main data sources of the study, the mathematics test and the background questionnaires, and how they were used to provide data from TIMSS 2015 are explained. Finally, how student achievement and background context questionnaire data are reported in this study are explained. In the second section on research design, how Hierarchical Linear Modeling (HLM) was employed to analyze the data is explained as well as the nature of HLM in terms of its fit for this research. Following, the structures of the unconditional and conditional models throughout the student and teacher levels are described. In this study, there were only one unconditional and seven conditional models (one conditional model for the entire sample, a random intercept model, and six conditional models for the differences between the countries, interaction models). Because these models consisted of the hierarchically structured elements from the student and teacher levels, how they were structured across these different hierarchical levels is also explained.

Setting – TIMSS 2015 Database

TIMSS collects information in 57 countries participating countries and 7 jurisdictions to reflect trends in the mathematics and science achievement of fourth- and eighth-graders for comparisons across different educational systems, school organizations, and instructional practices (Foy, 2017). While students' mathematics' learning can be influenced by community environments, most of their learning takes place at school and at home (Hooper et al., 2013). Therefore, the TIMSS 2015 database includes student, teacher, and school context questionnaire data as well as students' mathematics achievement data. Students' mathematics achievement data and their class and school background contextual data constitute the two main dimensions of the TIMSS 2015 data (Foy, 2017). Before discussing these two main instruments, it is important to explain the target population of the TIMSS and how sampling procedure was carried out. Following explanation of these aspects in the next section, the data sources for the two main dimensions of the TIMSS are discussed.

Population and Sampling. TIMSS is an international study that is used to compare the mathematics and science achievement of fourth and eighth grade student populations of the participating countries (LaRoche, Joncas, & Foy, 2016). The mean age is 9.5 years at the fourth-grade and 13.5 at the eighth-grade levels. Students who are enrolled in these grades in the participant countries are automatically the part of the target population to take the assessment (LaRoche et al., 2016). However, for TIMSS 2015, countries could decide to assess students in either one or both of these target populations according to their intentions for using the results (LaRoche et al., 2016; Martin, Mullis, & Foy, 2013).

Countries must first meet the sampling standards of TIMSS by ensuring that the standard error is not greater than .035 standard deviation of their specific mathematics mean achievement score. This means ± 7 points when the standard deviation is 100 in the TIMSS 2015, with a 95% confidence interval. Countries usually meet this requirement by including around 150 sample schools and 4,000 students in both grade levels. For this task the National Research Coordinator (NRC), a person selected by the participant country to monitor compliance with the TIMSS guidelines (Foy, 2017) works in collaboration with TIMSS (LaRoche et al., 2016).

TIMSS uses a two-stage sampling design. In the first stage, sample schools are selected according to their probabilities, which are based on the proportional sizes of the schools. In the second stage one or more entire classes, in which all students participate in the assessment, are selected with equal probability by the NRC in each participating country (LaRoche et al., 2016). Because TIMSS emphasizes curricular and instructional practices, entire classes rather than individual students are selected from the participating schools. Both school and class sampling procedures ensure that each student has equal probability of being selected. When sampling the classes from the schools, NRC uses a special computer program, Within-School Sampling Software (WinW3S), which was developed by IEA DPC and Statistics Canada.

The sample of this study consisted of eighth-grade students and their teachers from the seven EU countries whose students participated in the eighth-grade mathematics assessment of TIMSS 2015. The pooled sample consisted of 1,687 teachers and 31,969 students. Individual sample sizes for each country are given in Table 3.1.

Table 3.1. *Sample Sizes for the Focal EU Countries*

Countries	Number of Teachers	Number of Students
Hungary	248	4,897
Italy	229	4,481
Lithuania	264	4,347
Malta	156	3,817
Slovenia	370	4,258
Sweden	200	4,090
Turkey	220	6,079
Total	1,687	31,969

Data Sources. In TIMSS 2015, each student received a student achievement booklet containing two blocks of mathematics items, two blocks of science items, and a student questionnaire (Martin et al., 2013b). Each booklet was drawn from a pool of 14 different achievement booklets prepared by TIMSS. In addition, TIMSS administered a questionnaire related to school and classroom instructional practices to teachers and school principals (Martin et al., 2013b; Mullis, 2013). The data collected through this process provided an opportunity to perceive educational policies and practices implemented in the instructional contexts (Mullis, 2013). In this section, it is explained how student achievement booklets and student and teacher questionnaires were organized and implemented. Because the main interest of this study was to investigate the relationship between students' mathematics achievement and teacher characteristics after controlling for certain student and teacher background characteristics, such as gender and socio-economic status (SES) as well as country membership, questionnaires completed by school principals were not included in the analysis. Therefore, this section is structured in two main themes: the mathematics test, and students' and teachers' background questionnaires.

Mathematics Test. Eighth grade students completed the mathematics achievement booklets in two parts, with a short break between the parts. They had 45 minutes to complete each part. After another break, students then completed the student questionnaire within 30 minutes (Martin et al., 2013b). They followed the same pattern with the science achievement component of the booklet. The sequence was alternated among booklets. Table 3.2 explains the time-keeping procedures.

Table 3.2. *TIMSS 2015 Student Testing Time – Eighth-grade*

Activity	**Time**
Student Booklet – Part 1	45 minutes
(Break)	
Student Booklet – Part 2	45 minutes
(Break)	
Student Questionnaire	30 minutes

Source: (Martin et al., 2013b)

As noted, the TIMSS 2015 mathematics and science achievement items were organized in 14 booklets, each containing two blocks of mathematics and two blocks of science items (Martin et al., 2013b). Table 3.3 provides the assessment blocks included in specific student booklets, M represents the mathematics blocks while S represents the science.

Table 3.3. *TIMSS 2015 Student Achievement Booklet Design by Assessment Blocks*

	Assessment Blocks			
Student Achievement Booklet	**Part 1**		**Part 2**	
Booklet 1	M01	M02	S01	S02
Booklet 2	S02	S03	M02	M03
Booklet 3	M03	M04	S03	S04
Booklet 4	S04	S05	M04	M05
Booklet 5	M05	M06	S05	S06
Booklet 6	S06	S07	M06	M07
Booklet 7	M07	M08	S07	S08
Booklet 8	S08	S09	M08	M09
Booklet 9	M09	M10	S09	S10
Booklet 10	S10	S11	M10	M11
Booklet 11	M11	M12	S11	S12
Booklet 12	S12	S13	M12	M13
Booklet 13	M13	M14	S13	S14
Booklet 14	S14	S01	M14	M01

Source: (Martin et al., 2013b)

Each student in the same classroom received one booklet from among the 14 different booklets, in which the mathematics and science items in the TIMSS 2015 assessment pool, which were distributed among the booklets according to a matrix-sampling approach that is explained above in Table 3.3. As shown in Table 3.3, each block of either mathematics or science items appeared in two booklets; thus, each item also appeared in two different booklets. TIMSS ensured that each booklet provided equivalency in terms of student ability level using Item Response Theory (IRT) scaling methods. In each booklet, there were approximately 12-18 mathematics and 12-18 science items, and the distribution of the items in these booklets, according to the content and cognitive domains, as explained below, was similar to the distribution in the overall assessment pool (Martin et al., 2013b).

TIMSS 2015 mathematics items are structured in two dimensions, content and cognitive domains. While the content domain is related to assessment of knowledge of subject matter, the cognitive domain is related to assessment of thinking processes. Each content domain includes the topic areas, which comprise several topics. Table 3.4 shows the target percentages of the content and cognitive domains throughout the mathematics achievement items (Gronmo, Linquist, Arora, & Mullis, 2013).

Table 3.4. *Target Percentages of the TIMSS 2015 Mathematics Assessment Devoted to Content and Cognitive Domains at the Eighth-grade*

Content Domains	**Percentages**
Number	30%
Algebra	30%
Geometry	20%
Data and Chance	20%
Cognitive Domains	**Percentages**
Knowing	35%
Applying	40%
Reasoning	25%

Source: (Gronmo et al., 2013)

The student achievement booklets featured two main types of item formats – multiple-choice (among four options) and constructed-response, each of which accounts for about half of the 18 possible points for each subject area (Martin et al., 2013b). Each multiple-choice item is worth one point while constructed-response items may worth one or two points, based on the tasks and skills required to complete them. Figure 3.1 and Figure 3.2 illustrate sample multiple-choice and constructed-response items, which were released for public use by TIMSS.

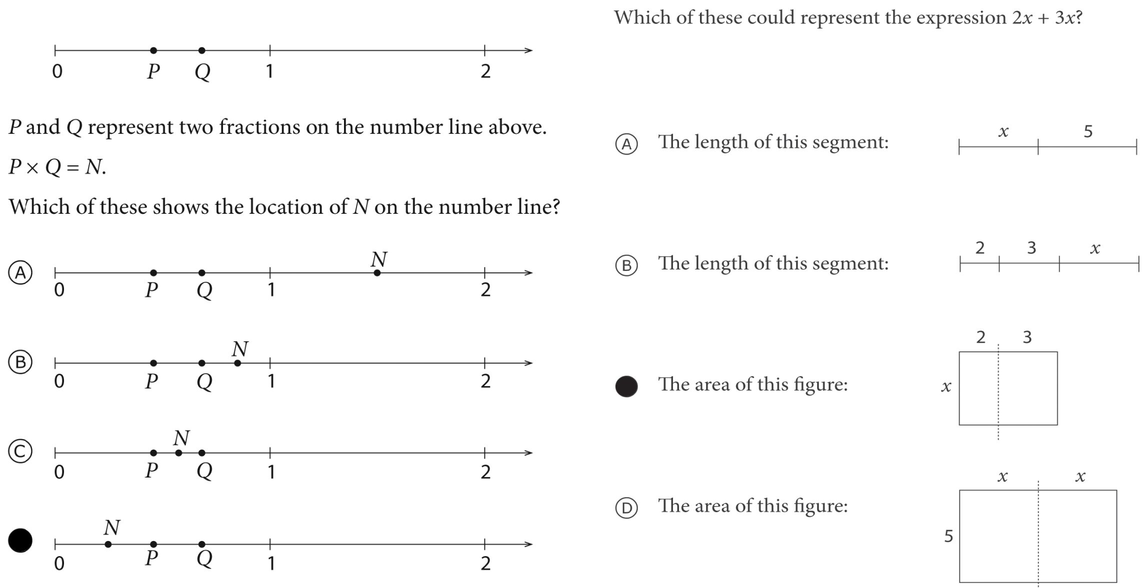

Figure 3.1. Sample Released Multiple-Choice Items in TIMSS 2015 – Eighth-grade
Source: (Martin et al., 2013b)

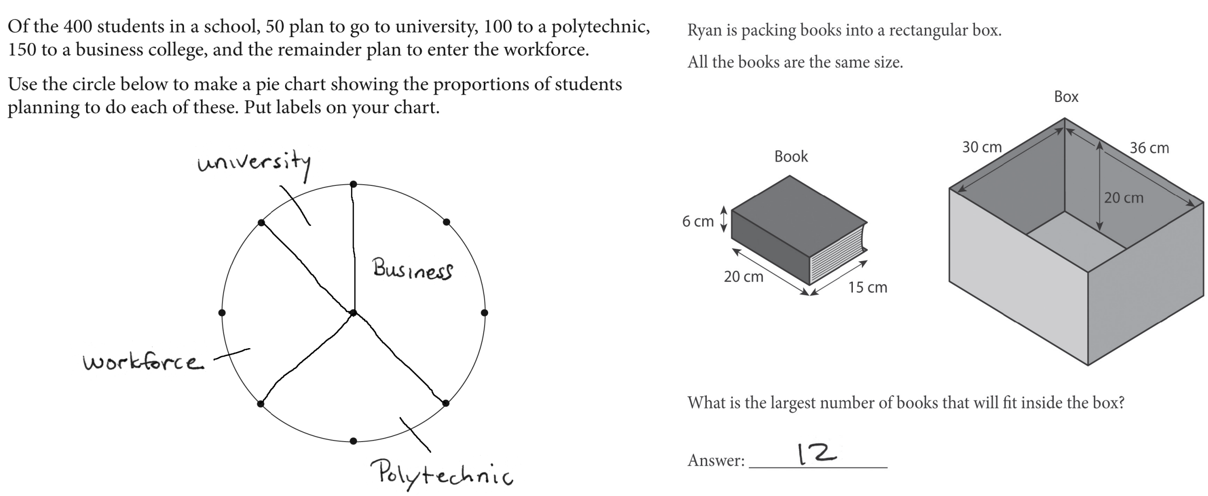

Figure 3.2. Sample Released Constructed-Response Items in TIMSS 2015 – Eighth-grade
Source: (Martin et al., 2013b)

Background Context Questionnaires. Students' mathematics learning mostly occurs at school or at home but is also affected by the experiences that students have outside of school.

Therefore, TIMSS organized its background questionnaires to include five areas: national and community contexts, home contexts, school contexts, classroom contexts, and student characteristics and attitudes toward learning, so the connection of each with mathematics and science achievement could be examined using information elicited from students, their teachers, and school principals (Hooper et al., 2013). Accordingly, three background questionnaires, student, teacher, and school, were used in the TIMSS 2015 general study (Martin et al., 2013b), of which, as mentioned, only the student and teacher questionnaires were relevant to this study.

Student Questionnaires. Student questionnaires, which are completed by students in around 15-30 minutes, include questions related to students' home and school experiences, their home and school environment for learning, their self-perceptions as mathematics and science learners, and their attitudes toward mathematics and science learning as well as their demographic information (Martin et al., 2013b). Figure 3.3 illustrates a sample student questionnaire item used in TIMSS 2015.

How often do you use a computer or tablet in each of these places for schoolwork (including classroom tasks, homework, studying outside of class)?

*Fill **one** circle for each line.*

	Every day or almost every day	Once or twice a week	Once or twice a month	Never or almost never
a) At home	○	○	○	○
b) At school	○	○	○	○
c) Some other place	○	○	○	○

Figure 3.3. Sample Student Questionnaire Item in TIMSS 2015
Source: (IEA, 2014a)

Teacher Questionnaires. Teacher questionnaires are given to mathematics and science teachers whose students take the TIMSS assessment to collect information about their characteristics as teachers, including their backgrounds, their education and training, their professional development experiences, and their job satisfaction; classroom teaching and learning contexts from teachers' perspectives; and the topics taught in their mathematics and science courses. In addition, teachers are asked about their classroom characteristics, instructional activities, time use, student homework, assessments they use, and computer use in their instructional practices (Martin et al., 2013b). Figure 3.4 shows a sample teacher questionnaire item in the TIMSS 2015 teacher background questionnaire

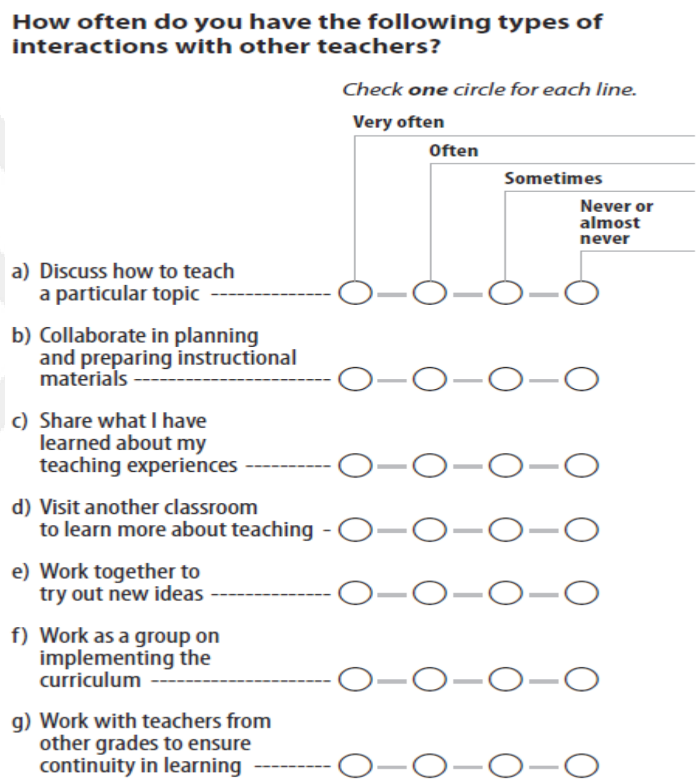

Figure 3.4. Sample Teacher Questionnaire Item in TIMSS 2015
Source: (IEA, 2014b)

Reporting Achievement and Background Data. In terms of the two main indicators, student achievement and background characteristics, it is first essential to establish the reliability of the data collected from the countries and of the scoring within and between countries. As one test of the reliability, TIMSS uses Cronbach's Alpha coefficient across countries (Foy et al., 2016). Table 3.5 illustrates the median Cronbach Alpha coefficients of the all the mathematics assessments of countries included in this study:

Table 3.5. *Cronbach's Alpha Reliability Coefficients of the Focal EU Countries – TIMSS 2015 Eighth-grade Mathematics*

Country	**Reliability Coefficient**
Hungary	.91
Italy	.86
Lithuania	.88
Malta	.88
Slovenia	.87
Sweden	.86
Turkey	.91

Source: (Foy et al., 2016)

As seen on Table 3.5, the reliability coefficients of the countries are very close to each other and considerably high at around .9, indicating interval consistency of the test across the countries. Following is an explanation of how mathematics achievement and students' and teachers' background information are reported in TIMSS 2015.

Reporting Mathematics Achievement – Plausible Values. As mentioned earlier, TIMSS has a large mathematics and science achievement items pool from which as many selected items are given to students as is practical in a testing session (Martin et al., 2013b). Most cognitive and skill-based tests have the issue of whether or not they accurately assess, diagnose, or select students for placement. In order to increase the accuracy of the test, the number of items could be reduced, which will also reduce the measurement error. However, the students' ability on the construct that the test aims to measure must still be estimated, even with the reduced number of items. For this purpose, plausible values methodology is used by TIMSS. Instead of interpreting the population parameters through estimations of students' abilities, plausible values methodology estimates characteristics of student populations using students' responses on the mathematics items along with their background data (Foy & Yin, 2016; Martin et al., 2016). This connection between the students' responses to the mathematics items and their background data is accounted for in the plausible values obtained by the process of "conditioning." Plausible values are not appropriate for estimating individual student achievement; rather, they are used to estimate the achievement of groups of students who have the similar response patterns and background characteristics in a focal sample (Martin et al., 2016; Wu, 2005).

Reporting Background Data. In this study, the HLM statistical technique was used to investigate possible relationships of teacher characteristics to students' mathematics achievement and differences in terms of these relationships among the seven participating EU countries. As explained in Chapter 2, decisions concerning the variables to include in both student and teacher characteristic constructs were supported by the relevant literature.

Student-level Variables. Based on the relevant literature, *gender* and *socio-economic status (SES)* were identified as two variables to be included in the student-level variables of this study. However, there is no variable that directly measures students' socio-economic status in TIMSS 2015. Instead, SES is measured by the proxy variables of the parents' level of education and home educational resources (Bradley & Corwyn, 2002; Dahl & Lochner, 2005; Davis-Kean, 2005; Martin et al., 2013a; Sirin, 2005; Williams, 2006; as cited in Hooper et al., 2013). Therefore, these two characteristics are both included in this study to assess students' socio-economic status through a special variable called *BSBGHER*, along with students' gender. Appendix A includes these variables with the relevant items in TIMSS 2015 to measure them. In addition, Table 4.1 shows the descriptive statistics for the items in the overall EU sample, which are discussed in detail in the fourth chapter. In addition, the country membership variable is included in the conditional models. The reason for including all these background variables was to control for their relationships with students' mathematics achievement so as to reveal more accurate results for the relationships between teachers' characteristics and students' mathematics achievement.

Teacher-level Variables. As explained in Chapter 2, there are two kinds of teacher level variables: teacher background and teacher characteristics variables. Based on the relevant literature, the only teacher background variable included in the study was *gender*. On the other hand, determination of teacher characteristics was based on the framework provided in Stronge's (2007) book, *Qualities of Effective Teachers,* consisting of such variables as teachers' experience, classroom management, instructional strategies, etc. Appendix A shows the teacher level variables in this study along with the items in TIMSS 2015 used to measure them. And, Table 4.1 provides descriptive statistics for the teacher-level items in the overall EU sample, which are examined in detail in the fourth chapter.

Research Design

In this section, the nature of the HLM analysis approach in terms of its fit for the data structure and the research questions of this study is explained, followed by a step by step explanation of the HLM procedure. In the first step, the unconditional model is employed in order to investigate the partitioning of the variability in students' mathematics achievement at the different levels of student and teacher. In the second step, conditional models are constructed through the addition of the student and teacher level variables to the unconditional model. There are two main kinds of conditional models in this study: a random intercept model and models with interactions (interaction models). While the random intercept model includes all the student and teacher background and teacher characteristics variables (all fixed) as well as country membership, models with interactions extend the random intercept model with an interaction term. The interaction term is used to assess the differences between the countries in regard to one of the specific variables indicated by the European Commission (2011a). Because the Commission indicated six variables, there are six models with interactions. As a result, there is an unconditional model for the variance partitioning, a conditional model (random intercept model) for investigation across all focal EU countries, and six individual conditional models (interaction models) for examination of the differences among the focal EU countries by the six variables indicated by The Commission (European Commission, 2011a), hereafter referred to as the variables of interest unless otherwise specified.

Estimation of Hierarchical Linear Modeling. Social research addresses the affiliation between a society and its constituent individuals on a hierarchical data structure base (Hox, 2010; Raudenbush & Bryk, 2002). The main premise of this relationship is that individuals collaborate with the society to which they belong, and this collaboration results in bilateral influence between the two entities. In other words, individuals and societies influence each other through their reciprocal interactions (Hox, 2010). A society and its members are thus involved in nested hierarchical systems that are based on the conceptualization of these structured relationships. Multilevel studies, therefore, are designed to investigate the nested relationships within these systems at different hierarchical levels through the lenses of the variables defined at each level (Hox, 2010; Raudenbush & Bryk, 2002). The analysis undertaken in these studies aimed to model not only the direct effect of the individual and group level explanatory variables within these hierarchical levels, but also the linkage between these different level variables in terms of whether or not groups are the moderators of the individual level involvements (Hox, 2010). On the other hand, while models of these relationships are titled differently across the literature, such as multilevel linear models, mixed-effects models, random-effect models, random-coefficient regression models, and covariance component models, the term "hierarchical linear models" more accurately represent their main feature of processing hierarchical data (Raudenbush & Bryk, 2002), especially for this study. Given the main focus of this study, to investigate the consistency of teacher characteristics suggested as predictive of student achievement in previous studies to predict student achievement in the focal EU countries and determine the differences among them in terms of the variables of interest, the data used for this purpose are in a structure comprising students (level 1) nested in teachers (level 2), which readily fits the nature of hierarchical linear modeling.

Thus, the main aim of multilevel modeling research is to estimate the relationships within and between different levels of social hierarchies in the societies, but the important question to ask is “how.” Regarding the nature of this procedure, Hox (2010) indicated that the estimations in multilevel analysis are usually made with the maximum likelihood (ML) estimation method. In the ML estimation procedure of multilevel modeling, the parameters of a model that consists of variables at different hierarchical levels are estimated for the population through a unique function termed the “likelihood function.” ML estimates the population parameters through which likelihood function is maximized.

Actually, there are two main likelihood functions: full maximum likelihood (FML), and restricted maximum likelihood (RML). While FML includes both the regression coefficients and the variances at the different levels of the model, RML consists only of the variance components (regression coefficients are actually estimated afterwards). In both, parameter estimates are generated by their standard error along with the overall deviance of the model. While the practical difference in terms of estimating the parameters through these two methods is very small, FML is preferred to RML for two reasons: computation is easier in FML, and the chi-square test to compare the different nested models works only with FML because it also includes the regression coefficients in addition to the variance components. In this study, FML was also preferred in order to generate the best fit model to reveal the teacher characteristics that are related to students' mathematics achievement by comparing different nested models.

Following the explanation of the estimation procedure of the HLM above, in the next section how unconditional and conditional models are hypothesized through the hierarchical levels of student and teacher is explained. The formation of notation for these models benefited highly from Hox's (2010) "Multilevel Analyses: Techniques and applications," Raudenbush and Bryk's (2002) "Hierarchical Linear Models," and Snijders and Bosker's (1999) "Multilevel Analysis: An introduction to basic and advanced multilevel modeling."

Unconditional Model. Unconditional models, which are considered the simplest possible hierarchical linear models, are equivalent to the one-way ANOVA with random effects. Through unconditional models (i.e., empty models because they do not include any predictor variables), the grand mean and the confidence interval as well as the outcome variability at each level (three levels in this study) can be estimated. In this study, an unconditional model was used to determine the partition of the total variability in students' mathematics achievement (the outcome measure) into the two components of students and teachers (which are the two levels in the model) (Hox, 2010; Raudenbush & Bryk, 2002).

In the unconditional model generated for this study, mathematics achievement is modeled for each student as a function of the grand population mean plus random errors at each level of student and teacher. In this model, because students are nested in teachers' classrooms, each student's mathematics achievement score is modeled as a deviation from the mean score of the classroom associated with the teacher, which in turn is modeled as a deviation from the overall mean score for the entire population of EU countries. While Equations 1 and 2 represent the two levels of the unconditional model (student and teacher levels respectively) Equation 3 represents the main unconditional model, which is the final combination of these two levels into one equation by inserting Equation 2 into Equation 1. In other words, the model can be represented by equations 1 and 2, or equivalently by equation 3.

Student-level: $Y_{ij} = \beta_{0j} + r_{ij},$ [1]

Teacher-level: $\beta_{0j} = \gamma_{00} + u_{0j},$ [2]

(Combined) unconditional model $Y_{ijk} = \gamma_{00} + u_{0j} + r_{ij}.$ [3]

where

Y_{ij} is the mathematics achievement of a student i (i=1, 2, …, n_j) in the classroom of teacher j (j=1, 2, …,J),

β_{0j} is the mean mathematics achievement in the classroom of teacher j,

γ_{00} is the grand mean mathematics achievement for the entire population of the study, which is the focal EU countries,

u_{0j} is the random "teacher effect" that is the deviation of teacher j's mean score from the grand mean. It is assumed to have a normal distribution with a mean of 0 and variance $\sigma^2_{u_0}$,

r_{ij} is a random "student effect" that is the deviation of child *ij*'s mathematics achievement score from the teacher mean. It is assumed to have a normal distribution with a mean of 0 and variance σ^2_r,

In Equation 3 (unconditional model), 'γ_{00}' represents the grand mean mathematics achievement score estimated for the overall sample of students in the EU countries. Adding the random teacher effect to the grand mean '$\gamma_{00} + u_{0j}$' provides an estimate of the "true mean" for teacher j (β_{0j}). Similarly, adding the random student effect to the teacher mean '$\beta_{0j} + r_{ij}$' provides an estimated score for the student *ij* in teacher *j*'s classroom (Snijders & Bosker, 1999). These random effects associated with different levels (u_{0j} and r_{ij}) are assumed to have a mean of 0, and a variance of $\sigma^2_{u_0}$ and σ^2_r, with respect to student and teacher. Therefore, variances of the different levels in the unconditional model help to determine the partitioning of the total variance of the student achievement outcome at the teacher level.

As explained above, the random effect variances in the unconditional model help to determine the partitions in the total variability in the outcome Y_{ij} into two components: teacher level, $\sigma_{u_0}^2$; and student level, σ_r^2. Therefore, $\sigma_{u_0}^2 + \sigma_r^2$ automatically represents the total estimated variance in the outcome variable (student achievement) in the model. Therefore, the proportion of the variance at the teacher level to the total variances in student achievement yields a useful parameter, intra-class correlation (ICC), which is represented by ρ (Raudenbush & Bryk, 2002). Snijders and Bosker (1999), asserting that an ICC value represents "the degree of resemblance between micro-units belonging to the same macro-unit" (p.16), provided the following formula (Equation 4) for the ICC value that indicates the resemblance among students in the same teacher's classroom (ρ) in terms of their mathematics achievement:

$$\rho = \frac{\sigma_{u_0}^2}{\sigma_{u_0}^2 + \sigma_r^2} \qquad [4]$$

Hox (2010) indicated that this ICC value also represents the "expected correlation between two randomly drawn units that are in the same group [two students from the same teacher's classroom, in this study]" (p.15).

Conditional Model 1 – Random Intercept Model. As discussed, the unconditional model, which is represented in Equation 3, is used to estimate the partitioned variability at the teacher level. However, part of the variability at the student and teacher levels can also be explained by the explanatory variables (Raudenbush & Bryk, 2002). Therefore, in addition to the contribution of the unconditional model to revealing the resemblance across different groups in terms of the variability in students' mathematics achievement, the first conditional model (random intercept model) contributes to explaining this variability in students' mathematics achievement through the student and teacher level variables, so that the possible relationship between the teacher characteristics previously found to be effective and student achievement might be revealed after controlling for some student and teacher level background characteristics (i.e., gender and socio-economic status), and country membership. Therefore, these were the explanatory variables used in this study as student background variables at level 1, and the teacher background variable of gender and the variables of teacher characteristics found to be effective (caring, classroom management, etc.) at level 2, as discussed in Chapter 2.

In the following section, the formulation of the first conditional model (random intercept model) at the student level (Equation 5) and the teacher level (Equation 6) is discussed, followed by the combination of these into the main conditional model (Equation 7). Equations 5 and 6 are given to explain how the main conditional model (Equation 7) was created through elements from the different levels. In order to derive the main conditional model, Equation 6 was inserted into Equation 5. In other words, equation 7 represents the first conditional model (random intercept model), and equations 5 and 6 together represent an equivalent expression of this model. Equation 5 and 6 specify the general multilevel model, and the specific model estimated for this study is provided in equation 14.

Student level: $$Y_{ij} = \beta_{0j} + \sum_{p=1}^{6} \beta_{pj} X_{pij} + \sum_{p=7}^{8} \beta_{pj} X_{pij} + r_{ij} \qquad [5]$$

Teacher level: $$\beta_{0j} = \gamma_{00} + \sum_{q=1}^{Q_p} \gamma_{0q} W_{qj} + u_{0j} \qquad [6]$$

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

$\beta_{2j} = \gamma_{20}$ (Italy)

$\beta_{3j} = \gamma_{30}$ (Lithuania)

$\beta_{4j} = \gamma_{40}$ (Malta)

$\beta_{5j} = \gamma_{50}$ (Slovenia)

$\beta_{6j} = \gamma_{60}$ (Sweden)

$\beta_{7j} = \gamma_{70}$ (Student gender)

$\beta_{8j} = \gamma_{80}$ (Student HER)

(Combined) conditional model (random intercept model):

$$Y_{ij} = \gamma_{00} + \sum_p \gamma_{p0} X_{pij} + \sum_q \gamma_{0q} W_j + r_{ij} + u_{oj} \quad [7]$$

Where

Y_{ij} is the mathematics achievement of a student *i* in the classroom of teacher *j;*

β_{0j} is the mean mathematics achievement (intercept) in the classroom of teacher *j*;

γ_{00} is the grand mean mathematics achievement for the entire population of the study, which is the focal EU countries.

β_{pj}, *p*=1, 2, ..., 6 are the student level regression coefficients indicating the direction and strength of the relationship between country membership variables (X_{1ij} to X_{6ij}), and the outcome;

β_{pj}, *p*=7, and 8 are the student level fixed regression coefficients (fixed to γ_{70} and γ_{80}) indicating the direction and strength of the relationship between each student characteristic (gender and home educational resources), and the outcome in the classroom of teacher *j*;

γ_{p0} are the student level fixed regression coefficients representing the direction and strength of the relationship between student level variables (X_{pij}) and Y_{ij};

γ_{0q} are the teacher level fixed regression coefficients representing the direction and strength of the relationship between teacher characteristics (W_{qj}) and β_{0j};

X_{pij}, *p*=1, 2, …, 6 are the country membership variables predicting achievement of student *ij*;

$X_{pij,}$ *p*=7, and 8 are student characteristics variables predicting achievement of student *ij*;

W_{qj} are teacher characteristics used as predictor of teacher effect, (*q*=1, 2, …, Q_p);

r_{ij} is a random "student effect" that is the deviation of child *ij*'s mathematics achievement score from the estimated score in level 1. It is assumed to have a normal distribution with a mean of 0 and variance σ_r^2.

u_{0j} is a random "teacher effect" that is the deviation of teacher *j*'s mean achievement score from the predicted grand mean. It is assumed to have a normal distribution with a mean of 0 and variance $\sigma_{u_0}^2$.

To determine the strength and direction of relationships between the explanatory variables and students' mathematics achievement, the regression coefficients are estimated at each level. With Equation 5, the relationships between the student explanatory variables and student achievement are estimated by the student level regression coefficients (β_{pj}). In Equation

6, on the other hand, these student level regression coefficients (β_{pj}) are the outcome variables to be predicted by using the teacher level variables (W_{qj}).

Raudenbush and Bryk (2002) indicated that each of the regression coefficients in the different levels of the conditional model can be considered fixed, non-randomly varying, or randomly varying. While student level intercept (β_{0j}), which is also a student level coefficient, is an outcome variable to be predicted by the teacher level variables, the rest of the student level regression coefficients are fixed ($\beta_{1j}, \beta_{2j}, \dots, \beta_{8j}$). Inserting Equation 6 into Equation 5 yields the first main conditional model of this study (Equation 7), which is called a random intercept model. When the algebraic symbols are replaced with the variable labels that are used in this study, Equation 7 is specified as for this study (Equation 8) as follows:

$$\begin{aligned} MathAch_{ijk} = {} & \gamma_{00} + \gamma_{10}(Hungary_{ij}) + \dots + \gamma_{60}(Sweden_{ij}) + \gamma_{70}(ZStGender_{ij}) \\ & + \gamma_{80}(ZStHER_{ij}) + \gamma_{01}(ZTcGender_j) + \gamma_{02}(ZTcMajor_j) \\ & + \gamma_{03}(ZTcExp_j) + \gamma_{04}(ZTcCaring_j) + \gamma_{05}(ZTcFair_j) \\ & + \gamma_{06}(ZTcEnth_j) + \gamma_{07}(ZTcMotiv_j) + \gamma_{08}(ZTcAttit_j) \\ & + \gamma_{09}(ZTcRefl_j) + \gamma_{010}(ZTcManag_j) + \gamma_{011}(ZTcDisc_j) \\ & + \gamma_{012}(ZTcOrgan_j) + \gamma_{013}(ZTcFocus_j) + \gamma_{014}(ZTcAch_j) \\ & + \gamma_{015}(ZTcPlan_j) + \gamma_{016}(ZTcInstr_j) + \gamma_{017}(ZTcAdapt_j) \\ & + \gamma_{018}(ZTcComplx_j) + \gamma_{019}(ZTcHigh_j) + \gamma_{020}(ZTcQuest_j) \\ & + \gamma_{021}(ZTcEngag_j) + \gamma_{022}(ZTcHw_j) + \gamma_{023}(ZTcFeed_j) \\ & + \gamma_{024}(ZTcAsses_j) + u_{oj} + r_{ij} \end{aligned} \quad [8][1]$$

[1] Variables are labeled in the specified model. The original variables with their labels are as in the following: *StGender*: student gender; *StHER*: home educational resources; *TcGender*: teacher gender; *TcMajor*: content knowledge and knowledge of teaching and learning; *TcExp*: teaching experience; *TcCaring*: caring; *TcFair*: fairness and respect; *TcEnth*: enthusiasm; *TcMotiv*: motivation; *TcAttit*: attitude toward teaching; *TcRefl*: reflective practice; *TcManag*: classroom management; *TcDisc*: disciplining students; *TcOrgan*: organization; *TcFocus*: focus on instruction; *TcAch*: achievement expectations; *TcPlan*: planning for instruction; *TcInstr*: instructional strategies; *TcAdapt*: adapting instrcution; *TcComplx*: teaching complexity; *TcHigh*: high expectations; *TcQuest*: questioning; *TcEngag*: student engagement; *TcHw*: homework; *TcFeed*: feedback; *TcAsses*: using assessment.

Conditional Model 2 – Models with Interactions. The European Commission (2011a) reported differences in mathematics teaching practices across the EU countries. The relationship between these teacher characteristics and student achievement, thus, may differ among the different countries, a phenomenon called as "heterogeneity of regressions across groups [countries in this study]" or "group-by-covariate interaction" (Snijders & Bosker, 1999), which can be modeled with interaction terms. Therefore, country level examination begins with allowing the six level-2 variables (content and pedagogy, motivation, classroom management, teaching complexity [making mathematics relevant], enhancing student engagement, and use of homework) indicated by the Eurydice network (European Commission, 2011a) to interact with the variable called "country membership" to examine the differences in these relationships among the countries. The interaction term for one of these variables is added to the first conditional model (random intercept model) to create six new conditional models (interaction models), each of which already includes the student and teacher background characteristics (student gender, student socio-economic status, and teacher gender), country membership, and teacher characteristics indicated by Stronge (2007); that is, for each conditional model, only the interaction term of one specific variable was added to the random intercept model. Before giving these interaction models, it is worth mentioning how interaction (or moderation) takes place in the multilevel modeling approach.

Interactions. In this study, the "BIFIEsurvey" package (BIFIE, 2018) in the R (R Core Team, 2018) is used to estimate the multilevel models, which is explained in detail in the data analysis section below. While the common approach to analyzing multilevel data is to use the "lme4" package (Bates, Maechler, Bolker, & Walker, 2015), the "BIFIEsurvey" package was preferred for this study, because it has the advantage of estimating the coefficients of the model with more accurate standard errors when one is working with complex datasets, such as the international TIMSS data. In the formation of the interaction terms to examine the relationships between the six teacher characteristics indicated by European Commission (2011a) and students' mathematics achievement in the seven countries, a variable called "country membership" was created and allowed to interact with the six teacher variables. Lorah and Miksza (2019) call such interaction through another variable "moderation," but the term "interaction" is used throughout this study. (Lorah & Miksza, 2019) indicated that

> a *moderation* hypothesis is one prototypical example of a hypothesis that stretches the potential for theoretical explanations beyond the minimum $X \rightarrow Y$ relationship. A moderation hypothesis poses the question of whether the relationship between two variables (i.e., an independent variable X and a dependent variable Y) varies as a function of a third, moderator variable M (p.1).

In the present study, the moderator variable is "country membership," which is a categorical variable and acceptable (Lorah & Miksza, 2019). The relationship between each of the variables of interest (those indicated by the European Commission, 2011a) and students' mathematics achievement is moderated by the country membership variable. Therefore, how being in a particular country moderates the relationships between those variables and mathematics achievement is investigated, which may answer the second research question. Figure 3.5 explains this moderated relationship.

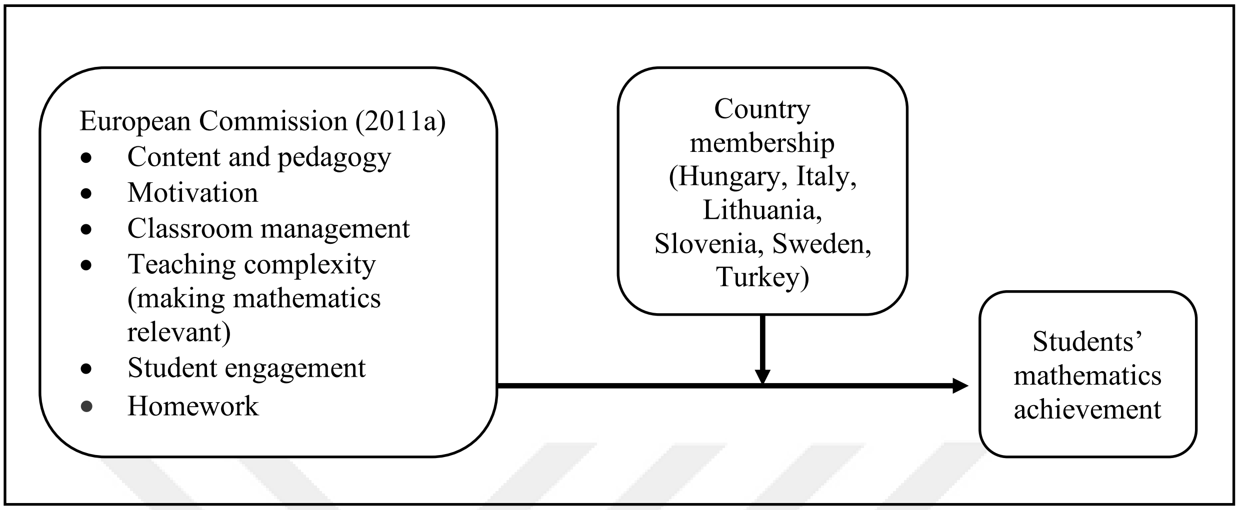

Figure 3.5. The Model of the Interaction between Variables of Interest and Students' Mathematics Achievement Moderated by Country Membership

Lorah and Miksza (2019) also indicated that the decision to include moderations should be conceptually based. Accordingly, in addition to the conceptual framework of the present study, it was decided to base the moderations explained in Figure 3.5 on the Eurydice report (European Commission, 2011a), in which ministries of national education across the focal EU countries have collaboratively determined possible differences in the relationships between mathematics teaching and students' mathematics achievement. Therefore, the relationships between these six variables and students' mathematics achievement were investigated separately for the focal EU countries.

To determine how relationships between the variables of interest and students' mathematics achievement were moderated by country membership, including all these interactions in one model extended from the first conditional model (random intercept model) was first considered. However, it was decided to examine each variable individually so that the associated covariates for the other variables are also controlled. Therefore, an individual model was hypothesized for each of these six variables of interest to interact with country membership variable. In the random intercept model, student and teacher background variables, country membership, and teacher characteristic variables were fixed and tested across the pooled sample of focal EU countries. As a result, there are now six interaction models representing the individual variables of interest that are extended by the random intercept model by including only the relevant interaction of each variable of interest with the variable "country membership." For example, an interaction term "content and pedagogy: country membership" was created for the variable "content and pedagogy" and inserted into the random intercept model to produce the "content and pedagogy interaction model." While Equations 9 and 10 indicate the student- and teacher-level components of this new interaction model, Equation 11, derived by inserting Equation 10 into Equation 9, equivalently expresses the combination of these two equations.

Student level: $$Y_{ij} = \beta_{0j} + \sum_{p=1}^{6} \beta_{pj} X_{pij} + \sum_{p=7}^{8} \beta_{pj} X_{pij} + r_{ij} \quad [9]$$

Teacher level: $$\beta_{0j} = \gamma_{00} + \sum_{q=1}^{Q_p} \gamma_{0q} W_{qj} + u_{0j} \text{ (Reference Turkey)} \quad [10]$$

$$\beta_{1j} = \gamma_{10} + \gamma_{1q} W_{qj} \text{ (Hungary)}$$
$$\beta_{2j} = \gamma_{20} + \gamma_{2q} W_{qj} \text{ (Italy)}$$
$$\beta_{3j} = \gamma_{30} + \gamma_{3q} W_{qj} \text{ (Lithuania)}$$
$$\beta_{4j} = \gamma_{40} + \gamma_{4q} W_{qj} \text{ (Malta)}$$
$$\beta_{5j} = \gamma_{50} + \gamma_{5q} W_{qj} \text{ (Slovenia)}$$
$$\beta_{6j} = \gamma_{60} + \gamma_{6q} W_{qj} \text{ (Sweden)}$$
$$\beta_{7j} = \gamma_{70} \text{ (student gender)}$$
$$\beta_{8j} = \gamma_{80} \text{ (student HER)}$$

(Combined) conditional model (interaction model):

$$Y_{ij} = \gamma_{00} + \sum_{p} \gamma_{p0} X_{pij} + \sum_{q} \gamma_{0q} W_j + \sum_{pq} \gamma_{pq} X_{pij} W_j + r_{ij} + u_{oj} \quad [11]$$

Where

Y_{ij} is the mathematics achievement of a student *i* in the classroom of teacher *j;*

β_{0j} is the mean mathematics achievement (intercept) in the classroom of teacher *j*;

γ_{00} is the mean mathematics achievement score for the entire population of the study, which is the focal EU countries;

β_{pj} p=1, 2, .., 6 are the student level regression coefficients indicating the direction and strength of the relationship between country membership variables (X_{1ij} to X_{6ij}), and the outcome;

β_{pj} p=7, 8 are the student level fixed regression coefficients indicating the direction and strength of the relationship between the student background variables (gender and home educational resources) and the outcome in the classroom of teacher j (they are fixed to γ_{70} and γ_{80});

γ_{p0} p=1, 2, .., 6 are the fixed regression coefficients representing the direction and strength of the main effect of the country membership on outcome (Y_{ij});

γ_{p0} p=7, and 8 are the fixed regression coefficients representing the direction and strength of the relationship between student background variables (gender and home educational resources) and outcome (Y_{ij});

γ_{0q} is the regression coefficients for the interaction terms representing the direction and strength of the relationship between teacher characteristics variables and outcome variable (Y_{ij}) in Turkey (reference);

$\gamma_{pq,}$ p=1, 2, .., 6 are the relative regression coefficients for the interaction terms representing the direction and strength of the relationship between teacher characteristics variables and outcome variable (Y_{ij}) moderated by the country membership;

X_{pij}, p=1, 2, …, 6 are country membership variables predicting achievement of student *ij* in country;

X_{pij}, p=7, and 8 are student characteristics predicting achievement of student *ij*;

W_{qj} are teacher characteristics used as predictor of teacher effect, (q=1, 2, …, Q_p);

$X_{pij}W_{qj}$ are interaction terms;

r_{ij} is a random "student effect" that is the deviation of child *ij*'s mathematics achievement score from the estimated score in level 1. It is assumed to have a normal distribution with a mean of 0 and variance σ_r^2;

u_{0j} is a random "teacher effect" that is the deviation of teacher j's mean achievement score from the predicted grand mean. It is assumed to have a normal distribution with a mean of 0 and variance $\sigma_{u_0}^2$.

Through this general formula, six different models were created for six variables of interests indicated by European Commission (2011a) at the end. To clarify, below is an illustration of how the specified model for one of the variables (content and pedagogy) was created by replacing the algebraic symbols with the variable labels used in this study (Equation

12, the interaction model created for the variable "content and pedagogy"). A similar approach was employed to specify the interaction models for the rest of the variables of interests.

$$\begin{aligned} MathAch_{ijk} = {} & \gamma_{00} + \gamma_{10}(Hungary_{ij}) + \ldots + \gamma_{60}(Sweden_{ij}) + \gamma_{70}(ZStGender_{ij}) \\ & + \gamma_{80}(ZStHER_{ij}) + \gamma_{01}(ZTcGender_j) + \gamma_{02}(ZTcMajor_j) + \gamma_{03}(ZTcExp_j) \\ & + \gamma_{04}(ZTcCaring_j) + \gamma_{05}(ZTcFair_j) + \gamma_{06}(ZTcEnth_j) + \gamma_{07}(ZTcMotiv_j) \\ & + \gamma_{08}(ZTcAttit_j) + \gamma_{09}(ZTcRefl_j) + \gamma_{010}(ZTcManag_j) + \gamma_{011}(ZTcDisc_j) \\ & + \gamma_{012}(ZTcOrgan_j) + \gamma_{013}(ZTcFocus_j) + \gamma_{014}(ZTcAch_j) \\ & + \gamma_{015}(ZTcPlan_j) + \gamma_{016}(ZTcInstr_j) + \gamma_{017}(ZTcAdapt_j) \\ & + \gamma_{018}(ZTcComplx_j) + \gamma_{019}(ZTcHigh_j) + \gamma_{020}(ZTcQuest_j) \\ & + \gamma_{021}(ZTcEngag_j) + \gamma_{022}(ZTcHw_j) + \gamma_{023}(ZTcFeed_j) \\ & + \gamma_{024}(ZTcAsses_j) + \gamma_{12}(ZTcMajor_j StCountry_{1ij}) \\ & + \gamma_{22}(ZTcMajor_j StCountry_{2ij}) + \gamma_{32}(ZTcMajor_j StCountry_{3ij}) \\ & + \gamma_{42}(ZTcMajor_j StCountry_{4ij}) + \gamma_{52}(ZTcMajor_j StCountry_{5ij}) \\ & + \gamma_{62}(ZTcMajor_j StCountry_{6ij}) + r_{ij} + u_{oj} \end{aligned} \qquad [12]^2$$

Interpretations of the Interaction Models. Again, Lorah and Miksza's (2019) conceptualization was helpful in creating the interaction terms in the model, in which main effects for the variables were automatically included in the interaction (main effect of the variables of interest and country membership). They indicated that with significant interaction coefficients, interpretation of the main effects is conditional, meaning that the main effect reflects the effect when the interaction variable equals 0. Therefore, refraining from interpreting these main effects would be appropriate (Lorah & Miksza, 2019). That is, discussions should be based on the interactions rather than the main effects in the case of a significant interaction

[2] *StGender*: student gender; *StHER*: home educational resources; *TcGender*: teacher gender; *TcMajor*: content knowledge and knowledge of teaching and learning; *TcExp*: teaching experience; *TcCaring*: caring; *TcFair*: fairness and respect; *TcEnth*: enthusiasm; *TcMotiv*: motivation; *TcAttit*: attitude toward teaching; *TcRefl*: reflective practice; *TcManag*: classroom management; *TcDisc*: disciplining students; *TcOrgan*: organization; *TcFocus*: focus on instruction; *TcAch*: achievement expectations; *TcPlan*: planning for instruction; *TcInstr*: instructional strategies; *TcAdapt*: adapting instrcution; *TcComplx*: teaching complexity; *TcHigh*: high expectations; *TcQuest*: questioning; *TcEngag*: student engagement; *TcHw*: homework; *TcFeed*: feedback; *TcAsses*: using assessment.

effect. However, because these interactions are difficult to interpret, the researchers suggested that best strategy would be to plot them in order to visualize them clearly. Therefore, in the following section, how the interactions in this study were plotted is explained.

Plotting the Interactions. As explained, main effects are conditional in the event of significant interaction effects. In order to illustrate how different conditions caused by interactions impact the main effect, a simple plotting method was used. In the case of a continuous interaction variable, such as a test score, some of its conditions were picked to plot on a graph, for example, average and one standard deviation above and below the mean to represent medium, low, and high achievement. However, in the case of a categorical interaction term, such as country membership as in this study, these conditions were already defined by the variable itself (focal EU countries), which should be used (Lorah & Miksza, 2019). In order to reveal these conditions (countries) in the analysis, country membership was treated as a "factor variable" in the BIFIE.twolevelreg() function. As a result, estimation of the interaction coefficient is provided individually for each country. However, they are still the different conditions of the main effect. Therefore, main effect now reflects the conditional effect when the interaction variable is the lowest. In other words, one of these countries (the one with the lowest country ID) is now represented by the main effect, and the other countries are picked as the conditional effects by the function. For this study, Turkey is coded as the country with the lowest country ID (conditional main effect) to estimate the coefficient of the other countries referenced by Turkey as the interaction effects. However, it does not matter what country is picked to reference the others.

Because the method is complicated, it is appropriate to provide an example. For the interaction model of the variable "content and pedagogy," the main coefficient (main effect) now represents the coefficient effect of Turkey. And the interaction effects (content and pedagogy:country membership) are estimated for the other countries individually (e.g., content and pedagogy:Hungary). However, these estimated interaction coefficients for the other countries are referenced by the coefficient for Turkey. Therefore, their coefficients need to be added to the main effect (Turkey) to have the real coefficient of that country to plot. As a result of this process, the relationship between the teachers' content and pedagogy knowledge and the students' mathematics achievement is estimated and plotted individually for each country.

It was indicated that interaction effect is interpreted and reported when it is significant. But how is significance decided? In this case, the random intercept model that includes all the teacher characteristics variables as well as the student and teacher background variables will be compared with the interaction model that is created by the inclusion of an interaction term along with the random intercept model to see if adding the interaction term significantly increased the explained variability in the outcome variable (R^2). In other words, the random intercept model is identical with the interaction model except for the interaction term. Therefore, the model with and the one without the interaction term are compared to see if the model with the interaction is a significantly better fit to describe the variability in the outcome variable. Thus, whether or not the interaction term significantly increases the explained variability will be tested. Before explaining this test, it is essential to first describe the explained variance (R^2).

Explained Variance (R^2). Snijders and Bosker (1999) indicated that the term "explained variance" refers to the proportion of the variability of the dependent variable is accounted for by the explanatory variables of the model, which is different from variance partitioning, by which the proportionality of the outcome variable across the different levels (level 1-students and level 2-teachers in this study) is explained. While "explained variance" is used to express the accounted for variability of the explanatory variables in terms of the outcome variable in the conditional model, "variance partitioning" is used to express the proportionality of the total variance in the outcome variable in the unconditional model across the hierarchical levels.

Snijders and Bosker (1999) indicated that the proportion of the variability in the outcome variable explained by the explanatory variables is usually measured by the "squared multiple correlation coefficient" (R^2), formulated as:

$$R^2 = 1 - \frac{\sigma_F^2 + \tau_F^2}{\sigma_E^2 + \tau_E^2} \quad [13]$$

where, while σ_F^2 represents the level 1 random error variance, and τ_F^2 represents the level 2 random error variance of the conditional model; σ_E^2 represents the level 1 random error variance, and τ_E^2 represents the level 2 random error variance of the unconditional model (empty model). Even though interpreting R^2 is useful, attending to the change in R^2 is more useful, because this change refers to the significance of the interaction terms in this study, which is explained below.

Significance of the Interactions (F-ratio test). Now that explained variance has been explicated, its employment to test whether the interaction terms added to the random intercept model provide a better fit to explain the variability in the outcome variable can be described. Tabachnick and Fidell (2013) indicated that whether a block of two or more variables significantly increases the explained variance in the outcome variable be tested with the "F-ratio" (or "F-incremental") test. If the model with the interaction effect fits significantly better, then it is retained to show that the relevant interaction effect is significant. The researchers provided the following formula for this test (Equation 14):

$$F_{\text{inc}} = \frac{(R_{wi}^2 - R_{wo}^2)/m}{(1-(R_{wi}^2)/\text{df}_{\text{res}}} \text{ with df} = m, \text{df}_{\text{res}} \quad [14]$$

Where

F_{inc} is the incremental F ratio,

R^2_{wi} is the explained variance in the outcome variable by the inclusion of the new explanatory variables,

R^2_{wo} is the explained variance in the outcome variable without the new explanatory variables,

m is the number of new explanatory variables included in the model,

df_{res} is residual degrees of freedom in the final analysis of variance table, calculated by $(N - k - 1)$, where N is the total sample size and k is the total number of explanatory variables in the final analysis.

Effect Size. In quantitative research, reporting the effect size is encouraged for more interpretable, practical, and comparable results (Kelley & Preacher, 2012). Providing the effect size is especially useful for conducting a meta-analysis, in which the findings of multiple studies are synthesized. There are two common approaches to determining the effect size: Cohen's d and the f-squared test. Lorah and Wong (2018) indicated that researchers recommend the f-squared test rather than Cohen's d when working on the interaction effects. Lorah and Miksza (2019) explained that the procedure should involve two models, one that does and one that does not include the interaction effect, which is identical with the interaction model except for the interaction term, as being done in the interaction significant test (F-ratio test). In this study, the random intercept model actually includes all fixed effects besides the interaction effects. Change in the R^2 is then determined by the f-squared test (Aiken & West, 1991). Following is the computation of the f-squared test (Equation 15):

$$f^2 = \frac{R_2^2 - R_1^2}{1 - R_2^2} \qquad [15]$$

where R_1^2 represents the variance explained by the model that does not include the interaction term (random intercept model), and R_2^2 represents the variance explained by the model that includes it (interaction model). Aiken and West (1991) provided the following benchmarks for deciding the extent of the effect size: it is small when the f^2 is 0.02, medium when the f^2 is 0.15, and large when the f^2 is 0.35.

Data Analysis

Following the preceding account of the hypothesizing of the estimation of the hierarchical linear models of the analysis, in this part, how the data were handled and analyzed is explained, beginning with obtaining and screening the data. During this process, the variables were also standardized for purposes of interpretation. Then the useful strategies suggested by Lorah (2017) that were used in the analysis, such as imputations by the plausible values and sampling weights are discussed. These strategies were used to derive estimations of the complex structured data with the correct standard errors.

Data Preparation: Data Screening and Standardization. Data for this study were obtained online from the website for the IEA's TIMSS 2015 International Data Sets[3]. However, TIMSS provided separate student and teacher data files for each country. In order to have a single data set containing students' data linked to their teachers' data across the seven focal EU countries, a tool created by IEA, the IDB Analyzer (IEA, 2018), was used to merge the separate files into one data set as an SPSS file. The SPSS statistical program (v. 22.0, IBM Corporation, 2013) was then used to standardize the variables used in this study as explained below. (Descriptive statistics for the unstandardized forms of the variables are given in Table 4.1 and discussed in detail in the fourth chapter.) The standardized data were then uploaded to R (R Core Team, 2018) for analysis. As explained before, in order to minimize the standard errors of the estimations in the hierarchical models, multilevel models were estimated with a special package called 'BIFIEsurvey' (BIFIE, 2018) in R. Before the analysis, 1,687 teachers and 31,969 students

[3] Website link: https://timss.bc.edu/timss2015/international-database/

constituted a pooled sample of the focal EU countries. However, the package omitted cases of missing data with a default list-wise deletion approach. Therefore, at the end of the analysis, results were obtained for 1,399 teachers and 26,021 students across seven EU countries.

Standardization is basically a process of subtracting the mean score from each individual score to fix the mean score at 0 (centering), followed by division by the standard deviation to fix the standard deviation at 1. As a result, each score is now a “z-score,” which makes it possible to compare the estimations for different variables in the analysis across the different units (Lorah & Wong, 2018). Darlington and Hayes (2017) indicated that researchers usually center the predictor and dependent variables to deal with the multicollinearity issues, which is a concern when doing a multilevel analysis. Multicollinearity is defined as the redundancy of the variables because of very high correlations among them (Tabachnick & Fidell, 2013). In other words, because the variables are highly correlated, they explain the same information in the same analysis and cause inflation of the standard errors, which occurs when any pair of observed variables in the correlation matrix has a correlation higher than .90 (Tabachnick & Fidell, 2013). This multicollinearity issue is addressed in detail at the beginning of Chapter 4, where the correlation matrix of the observed variables is discussed. Darlington and Hayes (2017) explained that, when working on the interactions between variables, researchers find that the interaction term is highly correlated with the main effects of the variables, centering the variables helps to reduce the standard errors caused by the multicollinearity. However, they also indicated that the coefficient of the interaction term and its standard error will not be changed. In addition, Lorah and Wong (2018) stated that centering [referred to as standardization in this study] is done only to facilitate interpretation, as in this study, rather than to address mathematical or statistical issues. Because the range of the variables from one (binary gender variables) to 56 (teaching experience) made it very hard to interpret their relations with the dependent variable simultaneously, standardization facilitated interpretation of the results obtained from the different scales.

Lastly, Lorah (2018) pointed out some caveats related to standardization. First, after such binary variables as gender have been standardized, interpretation should be made carefully as one standard deviation unit increase or decrease in gender would not make sense. She suggested using a partial standardization. In the present study, however student and teacher gender variables are both standardized instead of partially standardization because these binary variables are included only to control for their relationship to students' mathematics achievement. Lastly, she cautioned that the possible comparisons through the standardized estimations are based on the standard deviations of a given sample and can change sample to sample. However, she also indicated that it is not an issue with large sample sizes, as in this study, because sampling variability is very small in large samples, so comparability should not be a concern.

Data Analysis Strategies. As indicated, the data were obtained from a large-scale international assessment database, which included the seven focal EU countries in this study. The data collection procedure was complex and so fits with the definition of "complex survey data," which is explained below. Therefore, this study differed from other multilevel analyses studies in its use of certain beneficial strategies for analysis. In the following part, the special multilevel package in R (BIFIEsurvey) used for analyzing the complex survey data is explained. Then the strategies included in this package, such as plausible value imputation, sampling weights, and replication, are discussed in detail.

Analyzing Complex Survey Data: The "BIFIEsurvey" Package. Complex survey data are defined as data obtained from a complex sampling procedure involving clustering the sample from a population instead of randomly deriving the sample (Lorah, 2017; Lumley, 2010), which was the TIMSS 2015 data collection procedure (LaRoche et al., 2016). Lorah (2017) indicated that when the sample is clustered, the assumption of a linear regression, or non-independence of the observations, might be violated. She also indicated that different strategies may be used, such as including plausible values to measure students' achievement, sampling weights to deal with the unequal probability of the selection across different groups, and replication of weights to deal with the violations caused by sampling through multiple stages in the complex survey data. As suggested, these strategies were used as needed in this study and so warrant detailed explanation below.

Hierarchical linear modeling analysis usually conducted using the "lme4" package in R (Bates et al., 2015). However, the data for this study are complex in that they contain different sample sizes across the classrooms, schools, and countries, requiring that special attention be paid to replication, weighted sampling, and imputation, which is possible with the BIFIEsurvey package. The inclusion of these different strategies, therefore, gives this package an advantage over the "lme4" package by estimating the standard errors more accurately. The function "BIFIE.twolevelreg()" was used for the two-level hierarchical modeling. To address the first research question of this study, which targets the seven EU countries as a whole, two-level modeling worked well to accommodate the two levels of students and teachers in that scenario. However, to address the second research question of this study, which targets the focal EU countries individually and the differences among them in terms of specific variables, interactions between these specific variables and country memberships were needed. As a result, the BIFIEsurvey package was used with its two-level modeling function (BIFIE.twolevelreg()), but the variable "country membership" was added into the analysis, and interactions between country membership and the variables of interest were estimated to reveal the differences across the countries. With the help of these interactions, the individual regression coefficients for the specific variables for each country were also revealed.

Plausible Values. Plausible values represent the range of student abilities according to students' responses to the items. Usually five plausible values are computed for each student in the sample, which are the multiple imputations of the achievement construct (Wu, 2005). However, they do not illustrate the individual students' achievement profiles; rather they reflect the performance of representative populations of several students rather than only individuals. Lorah (2017) indicated that inclusion of the plausible values in a regression analysis increases the estimated standard errors for the fixed effects. However, because of the large sample size, despite having larger standard errors, TIMSS authors have to use a limited number of mathematics questions to assess students' mathematics achievement and use plausible values for an estimation of a scenario as if students responded to all the available mathematics items (Foy & LaRoche, 2015), as explained in more detail earlier in this chapter.

Wu (2005) indicated that only one plausible value could be used for each student to claim the parameter estimates of the population; however, it is not recommended. Although having higher standard errors seems negative for the analysis, Lorah (2017) indicated that including all the M plausible values (M=5 for TIMSS 2015) in the analysis yields correct standard errors for the estimations. The question also arises as to how all five plausible values can be included in an analysis. Foy and LaRoche's (2015) answer was that the analysis should be carried out with each of these plausible values, that is five times, and then the results should be aggregated. According to the formula they provided[4], the process actually involves getting the arithmetic means of the

[4] Foy and LaRoche (2015) provided that "… for any given achievement-based statistic t, estimating that statistic

five different estimations of each plausible value to include in the final aggregated estimation for each parameter. In the 'BIFIEsurvey' package, which was used in this study to perform the multilevel analysis, the BIFIE.data.jack() function was used to impute all the five plausible values as suggested. Lorah (2017) indicated that this function imputes five different data sets for each correspondent plausible value by default, and the inclusion of the five plausible values rather than only one in the analysis results in the estimation of more correct standard errors.

Sampling Weights. As mentioned before, TIMSS's school and class sampling procedure ensures that each student has equal probability of being in the sample. And classes are selected with the equal probability within the school. However, large schools have more classes than the smaller schools, so a class from a smaller school has a higher probability of being selected than a class in a larger school. For example, if a small school has a total of seven classes, and a large school has 25 classes, probability of being selected is higher for a class in the small school (1/7) than for a class in the large school (1/25). In this case, application of the sampling weights ensures that students have equal probability of being represented regardless of school size.

The sampling weight represents the weight of the reverse probability of the selection of students at three levels (student, class, and school), with adjustment made for the nonresponses. In TIMSS 2015, several sampling weights variables were calculated. While the overall weighting (TOTWGT) is a combination of the student, class, and school weights, separate weights have also been calculated (LaRoche et al., 2016). In the TIMSS 2015 data, TOTWGT is suggested when working on the student level analyses. In addition, weighting variables called TCHWGT (teacher weight), MATWGT (math teacher weight), and SCIWGT (science teacher weight), are

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from each plausible value yields five estimates t_m, m = 1, ..., 5, … The final estimate of that statistic, t_0, is the average of these five estimates: $t_0 = \frac{1}{5}\sum_{m=1}^{5} t_m$" (p.75).

also created based on TOTWGT. MATWGT has been found useful for dealing with teacher background data in a student level analysis, which was the case in this study. Therefore, this weighting variable was used in this study to avoid the bias of having an unequally selected sample of students (Lorah, 2017). Because there are seven countries in this study, this MATWGT weighting variable was also scaled so that the sum of the weights is equal to the total student sample size, which Lorah (2017) did in her study. The scaled sampling weight was then included in the analysis made with the function “BIFIE.data.jack()” of the BIFIEsurvey package.

Replication. As mentioned before, Snijders and Bosker (1999) indicated that complex survey designs have data whose sample is non-independently clustered across the different units, Ignoring the non-independence of observations in the analysis would yield biased standard errors that cause higher Type I errors. However, they also indicated that if the grouping structure of the multilevel analysis corresponds to the hierarchical sampling cluster design of the data collection, replication weights do not have to be included in the analysis. In this study, there are two levels of grouping units: students and teachers. In the actual sampling structure of the data, schools are selected from the national sample followed by the selection of the classrooms, which are linked to the teachers. Therefore, including the teacher level as the second hierarchical level in this study basically corresponds to the sampling cluster design of the TIMSS 2015 data. Thus, inclusion of the replication weight is not necessary in this present study.

Accordingly, as (Lorah, 2017) suggested, five different data sets were imputed for each plausible value and aggregated to estimate the regression coefficients with more correct standard errors. In addition, a scaled sampling weight was used to deal with the inequality of the selection of the students from the entire population through the help of the BIFIEsurvey package. Lastly, (Lorah, 2017) also suggests using replicate weights in cases of violation of the sampling clustering of the data during the analysis; however, because the analysis for this study did not violate this hierarchical sampling approach, it was unnecessary to include replicate weights, which were likely to inflate the standard errors for no purpose. Therefore, in this study, all possible efforts were made during the analysis to correctly estimate the regression coefficients of the hierarchical linear models with correct standard errors.

Chapter 4: Results

This chapter consists of two main sections. The first section is the process of pre-analysis, which explains the descriptive statistics and the correlations between the observed variables included in the models, before conducting the analysis, to ensure that items used in the models are appropriate for the analysis. After briefly discussing these main issues, the results from the estimation of the unconditional model are given in order to reveal the variance partitioning, which tells if the two-level hierarchical modeling is meaningful for the data of this study. Afterwards, in the second section of this chapter, the results of the two-level conditional model (random intercept model) are given. This model contains teacher characteristics variables, as well as the teacher and student background variables and country membership variable, as fixed explanatory variables, while utilizing student achievement as the outcome variable. Through this model, the possible relationships between these variables and student achievement across the seven focal EU countries included in this study are discussed; therefore, some possible answers for the first research question of this study are provided. Additionally, the results from the six individual conditional models (interaction models) are provided, each of which contains an additional interaction term on top of the random intercept model. In each of these models, one of the six variables of interest, indicated by the European Commission (2011a), is included as an interaction term that interacted with the variable called ‘country membership’. Through these interaction terms, the differences across the focal EU countries in terms of the relationship between each of these variables and student achievement are explained, thereby providing possible answers for the second research question of this study.

Pre-analysis Considerations

Descriptive Statistics and Bivariate Correlations. Descriptive statistics for the outcome variable (mathematics achievement plausible values) and the explanatory variables (teacher characteristic variables, and student and teacher background variables) are given in the following table (Table 4.1) while the descriptions of the items used to measure these variables are given in Appendix A. Since the variable 'country membership' is used as a factor variable only to estimate its interactions with the variables of interests indicated by European Commission (2011a), it is not included the descriptive statistics for that specific variable.

Table 4.1. *Descriptive Statistics of the Items Used in the Study*

Category		Variable	TIMSS Item	N	Min	Max	Mean	S.D.	Skew.	Kurt.
		STUDENT LEVEL VARIABLES								
Outcome variable	Math Ach.	Plausible Value-1	BSMMAT01	31969	77.0	792.7	497.7	86.73	-.326	.142
		Plausible Value-2	BSMMAT02	31969	30.88	793.0	498.1	87.40	-.308	.120
		Plausible Value-3	BSMMAT03	31969	54.71	808.4	498.2	87.85	-.311	.158
		Plausible Value-4	BSMMAT04	31969	69.46	794.8	497.8	88.66	-.331	.182
		Plausible Value-5	BSMMAT05	31969	55.51	809.3	498.4	87.82	-.322	.165
Student Background	Gen.	Female	BSBG01	31863	0	1	.49	.500	.041	-1.998
	SES	Home Ed Res.	BSBGHER	31750	4.23	13.88	10.45	1.779	-.165	.304
		TEACHER LEVEL VARIABLES								
Teacher Background	Gen.	Female	BTBG02	30786	0	1	.69	.461	-.835	-1.302
Prerequisite		Content & Pedagogy*	BTBG05*	30690	0	2	1.34	.636	-.437	-.688
		Experience	BTBG01	30602	1	57	18.66	11.76	.277	-1.057
Teacher as a person		Caring	BTBG14G	30642	1	4	3.48	.722	-1.021	-.289
		Fairness & respect	BTBG07E	30765	1	4	2.99	.694	-.501	.526
		Enthusiasm	BTBG10D	30739	1	4	3.23	.711	-.479	-.498
		Motivation	BTBM17A	30544	1	4	3.14	.701	-.337	-.470
		Attitude tow. Teaching	BTBG10A	30758	1	4	3.22	.700	-.466	-.390
		Reflective practice	BTBG09C	30816	1	4	2.84	.776	-.060	-.696
Class manag. & organiz.		Classroom management	BTBG07D	30737	1	4	2.93	.681	-.486	.598
		Disciplining students	BTBG15D	30270	1	3	2.05	.732	-.081	-1.129
		Organization	BTBG11B	30737	1	4	2.85	.900	-.433	-.560
Planning and organiz. for inst.		Focus on instruction	BTBM17E	30587	1	4	3.13	.692	-.282	-.549
		Achievement expectations	BTBG06C	30612	1	5	3.77	.733	-.417	.482
		Planning for instruction	BTBG11D	30685	1	4	2.68	.881	-.272	-.609
Implement. instruction		Instructional strategies	BTBM17B	30640	1	4	3.31	.648	-.478	-.327
		Adapting instruction	BTBM17D	30623	1	4	3.08	.682	-.226	-.434
		Teaching complexity	BTBM17H	30602	1	4	3.13	.703	-.280	-.632
		High expectations	BTBG14C	30662	1	4	2.52	.801	.435	-.507
		Questioning	BTBG14B	30642	1	4	3.54	.667	-1.175	.200
		Student engagement	BTBG14D	30637	1	4	2.85	.872	.090	-1.294
Monitoring student prog. and potential		Homework	BTBM22CC	28697	1	3	2.67	.521	-1.262	.578
		Feedback	BTBM22CA	28623	1	3	2.25	.660	-.320	-.771
		Using assessment	BTBM23A	29661	1	3	2.79	.420	-1.672	1.465

* This item and variable are derived by combining two variables of "content knowledge" and "knowledge for teaching and learning".
Note: list-wise deletion was used to treat the missing data (N-students=25,365, N-teachers=686, N-countries=7)

Descriptive statistics give information about the scale of the original items before standardization by the minimum and maximum values, as well as the hints regarding the normality of the distribution of the measures across the sample by the mean and standard deviation values. These also include the skewness and kurtosis values of each item that give more information regarding the normality of the distribution. While skewness value indicates the symmetrical form of the distribution around the mean of the item, kurtosis value represents the 'peakedness of the distribution' (Tabachnick & Fidell, 2013). According to Tabachnick and Fidell (2013), normally distributed measures have the skewness and kurtosis values of 0. However, they also indicated that the significance in the skewness and kurtosis values of a variable in a large sample data set is not sufficient enough to deviate the distribution from normality to make a considerable impact in the analysis. Nevertheless, the skewness values of the variables ranged from -1.67 to 0.44, showing that symmetrical form is not damaged across the distributions of each item. In addition, the kurtosis values ranged between -2.00 and 1.47, indicating no peakedness in the distributions of the original forms of the items.

In terms of the bivariate correlations between the outcome variable of student achievement and the explanatory variables, the factor variable 'country membership' also is not included in the bivariate correlation table. However, for rest of the variables, it ranged between very low correlation of -.003 (p>.05) belonging to 'reflective practice' and moderate correlation of .494 (p<.01) that belongs to the variable 'student home educational resources', without taking the sign of the direction into account. Correlation matrix for all the variables used in this study is given in Appendix C. In addition, in terms of the correlations among the explanatory variables, the weakest correlation is observed as less than .000 (p>.05) between the variables 'focus on instruction' and 'teacher gender' while the strongest is observed as .739 (p<.01) between the variables ‘classroom management’ and ‘fairness and respect’, which indicates slightly high correlation. However, it is an outlier in the correlation matrix. The second and third strongest observed correlation values were .650 (p<.01) between ‘attitude toward teaching’ and ‘enthusiasm’, and .574 (p<.01) between ‘motivation’ and ‘adapting instruction’, which are moderate. Correlation is actually a concern in terms of the multicollinearity. Multicollinearity occurs when the correlation matrix of the observed variables consists of any value greater than .90 (Tabachnick & Fidell, 2013). They also indicated that when the multicollinearity occurs (two variables having bivariate correlation greater than .90), deleting one of the ‘redundant variables’ that causes the unusually high correlation can solve the issue. However, since the strongest bivariate correlation in the correlation matrix was found to be .739, multicollinearity is not an issue in this data set.

Results from the Unconditional Model. As indicated in the third chapter, partitioned variance of the outcome variable in the unconditional model at the student and teacher levels gives information about the similarity of the students in the classrooms in terms of their mathematics achievement through Intra-class correlation (ICC). The formula for the ICC was $\rho = \sigma^2_{u_0} / (\sigma^2_{u_0} + \sigma^2_r)$, where $\sigma^2_{u_0}$ represents the teacher level variance and σ^2_r represents the student level variance partitioning of the total variance in the student achievement variable. Through this formula, the ICC coefficient for the unconditional model (Chapter 3, Equation 3) was calculated as 3446.421 / (3446.421 + 4733.214) = *.42* (Table 4.2), which indicates that a considerable amount of variability in students’ mathematics achievement is accounted by the students’ membership within the level 2 units (teachers’ classrooms). In other words, 42% of the total variance in students’ mathematics achievement is accounted for in the classrooms across the pooled sample of seven focal EU countries. Therefore, this coefficient effectively demonstrates that the two-level model is meaningful when examining the relationship between the teacher characteristics and students' mathematics achievement through the specified variables (Table 4.2). Similarly, Kane and Staiger (2008) indicated that over half of the variation in student achievement was explained by the teacher effects after controlling for student characteristic in their study. Therefore, the high resemblance of the students' performance in their teachers' classrooms found in this study across the focal EU countries supports the claims of Kane and Staiger, but with a result from a very different sample.

Table 4.2. *Results from the Empty Model for the Pooled Sample of Focal EU Countries with Mathematics Achievement as the Dependent Variable*

Fixed Effect	*Estimate*	*S.E.*	*t*
γ_{00} = Intercept	473.565	0.79	603.06**
Random Effects	*Variance Component*		
Level-two variance: $\sigma^2_{u_0}$ = var(u_{0j})	3446.421		
Level-one variance: σ^2_r = var(r_{ij})	4733.214		
ICC:	0.421		

** p<0.001

Results from the Conditional Models

Research Question 1 – Conditional Model 1 (Random Intercept Model). The first research question of this study aimed to address the extent to which teacher characteristics suggested as effective in previous studies consistently predict students' mathematics achievement in the focal EU countries, by the directionality and order of these relationships. After proving that a two-level model is meaningful, it is time to shift the focus to examining the results from the two-level random intercept model. In the empty model, there were only the intercept and the residuals whose variances helped to create ICC. In order to find a possible answer to this question, a two-level hierarchical linear model (Chapter 3, Equation 8) was built by adding the teacher characteristics variables derived from Stronge (2007), as well as the student background (gender and SES) and teacher background variables (gender) into the empty model. All these variables were fixed and tested over the pooled sample of 31,969 students and their teachers (*n*=1,687) from seven EU countries that are the only EU countries who participated in the TIMSS 2015 international assessment. The largest country sample size was 6,079 students from Turkey (*n*-teachers = 220), and smallest was 3,817 students from Malta (*n*-teachers = 156). However, during analysis default list-wise deletion was employed by the package used in this study (BIFIEsurvey), and the results are reflected in the 26,021 students and their teachers (*n*=1,399) at the end. Table 4.3 illustrates the results of the model.

Table 4.3. *Hierarchical Linear Modeling Results from the Two-level Random Intercept Model of the Pooled Sample of Focal EU Countries with Students' Mathematics Achievement as the Dependent Variable.*

	Estimate	*S.E.*	*t*
Fixed Effects			
γ_{00} = Intercept (Reference Turkey)	0.007	0.012	0.64
Country membership			
γ_{10} = Hungary	0.043	0.019	1.94
γ_{20} = Italy	0.032	0.019	1.30
γ_{30} = Lithuania	0.048	0.018	2.32
γ_{40} = Malta	-0.030	0.010	-3.60*
γ_{50} = Slovenia	0.149	0.025	5.73**
γ_{60} = Sweden	-0.156	0.021	-7.85**
Student background			
γ_{70} = Female	-0.009	0.007	-1.27
γ_{80} = Home educational resources	0.438	0.005	93.79**
Teacher background			
γ_{01} = Female	0.018	0.005	3.80*
Teacher Characteristics			
- Prerequisites			
γ_{02} = Content & pedagogy knowledge	-0.021	0.004	-5.87**
γ_{03} = Experience	0.050	0.002	25.91**
- Teacher as a person			
γ_{04} = Caring	0.082	0.006	13.39**
γ_{05} = Fairness & respect	0.011	0.008	1.37
γ_{06} = Enthusiasm	0.004	0.004	1.02
γ_{07} = Motivation	0.016	0.006	2.53

γ_{08} = Attitude toward teaching	0.015	0.004	3.38*
γ_{09} = Reflective practice	-0.060	0.003	-23.34**
- *Classroom management and organization*			
γ_{10} = Classroom management	0.026	0.005	5.46**
γ_{11} = Disciplining students	0.103	0.003	37.14**
γ_{12} = Organization	-0.012	0.008	-1.59
- *Planning and organizing for instruction*			
γ_{13} = Focus on instruction	-0.079	0.004	-19.00**
γ_{14} = Achievement expectations	0.066	0.002	31.07**
γ_{15} = Planning for instruction	0.033	0.006	5.81**
- *Implementing instruction*			
γ_{16} = Instructional strategies	0.060	0.010	5.92**
γ_{17} = Adapting instruction	-0.000	0.006	-0.03
γ_{18} = Teaching complexity	0.011	0.008	1.38
γ_{19} = High expectations	0.065	0.004	16.06**
γ_{20} = Questioning	0.015	0.005	3.09*
γ_{21} = Student engagement	-0.071	0.006	-11.28**
- *Monitoring student progress and potential*			
γ_{22} = Homework	-0.033	0.006	-5.91**
γ_{23} = Feedback	0.021	0.011	1.84
γ_{24} = Using assessment	-0.061	0.008	-8.13**
Random Effects	*Variance Component*		
Level-two variance: τ_0^2 = var(U_{0j})	0.158		
Level-one variance: σ^2 = var(R_{ij})	0.580		
R^2:	0.4699		

* $p<0.05$, ** $p<0.01$

Note: The variable called 'country membership' is included in the random intercept model in order to compare it with the interaction models so that the contribution of the interaction terms in the interaction models can be revealed.

Results from the two-level random intercept model indicated that covariates (variables of the student and teacher background and teacher characteristics) explained the 47% of total variance in students' mathematics achievement (R^2 = .4699, $t(31{,}969) = 70.46$, p = <.001). In addition, significant relationships were found between the teacher characteristics variables and students' mathematics achievement when controlling for the associated covariates, except fairness and respect (γ_{04} = .011, $t(1{,}687) = 1.45$, p = .147), enthusiasm (γ_{06} = .001, $t(1{,}687)$ = .14, p = .888), motivation (γ_{07} = .016, $t(1{,}687) = 2.53$, p = .065), organization (γ_{12} = -.011,

t(1,687) = -1.43, p = .153), adapting instruction (γ_{17} = .002, t(1,687) = 0.39 , p = .697), teaching complexity (γ_{18} = .011, t(1,687) = 1.38, p = .240), and feedback (γ_{23} = .021, t(1,687) = 1.84, p = .140). Besides these variables, 10 variables have significant positive relationships with mathematics achievement while six variables have significant negative relationships, which is explained in detail following the explanation of the student and teacher background variables.

Even though student and teacher background variables are included in the model to control their relationship with mathematics achievement, it is also worth to mention their relationship with mathematics achievement. While student gender is not estimated to have a significant relationship with mathematics achievement (γ_{70} = -.009, t(1,687) = -1.27, p = .230), teacher gender is oppositely estimated to have a significant relationship with students' mathematics achievement (γ_{01} = .018, t(1,687) = 3.80, p = .019), indicating that students who have male teachers are estimated to have higher mathematics achievement scores. In addition, students' home educational resources (γ_{80} = .438, t(1,687) = 93.79, p = <.001) also have a significantly positive relationship with students' mathematics achievement. This particular variable was estimated to have the strongest relationship with achievement. One standard deviation increase in students' home educational resources yields around to half standard deviation increase in students' mathematics achievement scores (Table 4.3). Thus, students' socio-economic status is estimated to have a strong relationship with students' mathematics achievement scores in the focal EU countries, according to TIMSS 2015 results.

As mentioned above, most of the teacher characteristics variables have a significant relationship with mathematics achievement, except seven of them, after controlling for the associated covariates. Since regression coefficients are estimated by the standardized measures, it is possible to compare these coefficients amongst each other (Lorah, 2018). When controlling for the associated covariates, the positive coefficients, in order from the strongest to weakest, belong to disciplining students (γ_{11} = .103, *t*(1,687) = 37.14, *p* = <.001), caring (γ_{04} = .082, *t*(1,687) = 13.39, *p* = <.001), achievement expectations (γ_{14} = .066, *t*(1,687) = 31.07, *p* = <.001), high expectations (γ_{19} = .065, *t*(1,687) = 16.06, *p* = <.001), instructional strategies (γ_{16} = .060, *t*(1,687) = 5.92, *p* = <0.05), experience (γ_{03} = .050, *t*(1,687) = 25.91, *p* = <0.001), planning for instruction (γ_{15} = .033, *t*(1,687) = 5.81, *p* = <0.05), classroom management (γ_{10} = .026, *t*(1,687) = 5.46, *p* = <.05), attitude toward teaching (γ_{08} = .015, *t*(1,687) = 3.38, *p* = <.05), and questioning (γ_{20} = .015, *t*(1,687) = 3.09, *p* = <.05). These estimated coefficients indicated the correspondent increases in students' mathematics achievement in standard deviation units while each of these variables increases by one standard deviation unit.

As a result, one standard deviation increase in the teacher characteristics of disciplining students is related to .103 standard deviation increase in students' mathematics achievement. And with the similar sense, one standard deviation increase in caring corresponds to .082 standard deviation increase while achievement expectations corresponds to .066 standard deviation increase, high expectations corresponds to .065 standard deviation increase, instructional strategies corresponds to .060 standard deviation increase, experience corresponds to .050 standard deviation increase, planning for instruction corresponds to .033 standard deviation increase, classroom management corresponds to .026 standard deviation increase, questioning corresponds to .015 standard deviation increase, and attitude toward teaching corresponds to .015 standard deviation increase in students' mathematics achievement scores after controlling for the associated covariates. Therefore, while the strongest significant positive relationship with students' mathematics achievement is estimated with teachers' characteristics to discipline students (.103), the weakest significant positive relationship is estimated in their abilities to attitude toward teaching (.015).

On the other hand, when again controlling for the associated covariates, the negative coefficients, again, from high relation to low, focus on instruction (γ_{13} = -.079, t(1,687) = -17.75, p = <.001), student engagement (γ_{21} = -.071, t(1,687) = -13.98, p = <.001), using assessment (γ_{24} = -.061, t(1,687) = -7.40, p = <.001), reflective practice (γ_{09} = -.060, t(1,687) = -26.82, p = <.001), homework (γ_{22} = -.033, t(1,687) = -4.71, p = <.001), and content and pedagogical knowledge (γ_{02} = -.021, t(1,687) = -7.93, p = <.001). And, again, when considering the original TIMSS items to measure these variables, it was revealed that one standard deviation increase in focus on instruction corresponds to .079 standard deviation decrease in students' mathematics achievement while one standard deviation increase in student engagement corresponds to .071 standard deviation decrease, using assessment corresponds to .061 standard deviation decrease, reflective practice corresponds to .060 standard deviation decrease, homework corresponds to .033 standard deviation decrease, and content and pedagogical knowledge corresponds to .021 standard deviation decrease in students' mathematics achievement after controlling for the associated covariates. Thus, the strongest significant negative relationship found in teachers' characteristic was in relation to focus on instruction (.079), the weakest significant negative relationship found in their content and pedagogical knowledge (.021) in response to students' mathematics achievement.

Research Question 2 – Conditional Model 2 (Six Interaction Models). As indicated in Chapter 1, six of the 24 teacher characteristics indicated by Stronge (2007) are implemented differently in the curriculum and/or steering documents of the focal EU countries of this study, according to Eurydice report (European Commission, 2011a). These characteristics are content and pedagogy knowledge, classroom management, motivation, teaching complexity (making mathematics relevant), enhancing student engagement, and use of homework. Therefore, it is let these six variables to have interactions with the variable called ‘country membership’ (TIMSS labeled it as IDCNTRY) in order to interpret the differentiation of these six variables across the countries, as explained in detail in Chapter 3. Each interaction term is added to the random intercept model individually; therefore, in the following part, the results of these six interaction models are given in order to demonstrate the possible differences in the relationship between each of these variables and students’ mathematics achievement in the focal EU countries.

Interaction Model 1 – Content and Pedagogical Knowledge. When the relationship between the content and pedagogy knowledge of the teachers and students’ mathematics achievement is moderated by the country membership, in other words interaction term called ‘content and pedagogy: country membership’ was added to the random intercept model, F-ratio test was applied (F_{inc} = 3.27), and the results indicated that the change in the explained variability in the outcome variable of student achievement significantly increased when comparing the F-incremental value with the F-critical value of 2.09 at the .05 level (df=6; 25,981); in other words, the interaction model for the content and pedagogy knowledge was found to significantly fit better with the data than the random intercept model. Therefore, results from the interaction model is provided below.

As a result of the interaction model including the interaction between the content and pedagogy and country membership variables, the effect size of the interaction term is estimated to be .009 by the formula ($f^2=(R_2^2 - R_1^2) / (1 - R_2^2)$), which indicates a small effect size. However, Aguinis, Beaty, Boik, and Pierce (2005) reviewed the articles published between 1969 and 1998, in which the effect size of the interaction effects of the categorical variables reported and indicated that the mean effect size (f^2) of the 261 analyses was .009, and the median was .002. Therefore, it demonstrated a typical interaction effect size. In addition, the interaction coefficient of Turkey (reference) is estimated to be significantly different than zero (γ_{02} = -.040, t(1,687) = -9.09, p = <.001), indicating that the relationship between the content and pedagogical knowledge of the teachers and students' mathematics achievement is estimated to be significant when controlling for the associated covariates, but in a negative way (Table 4.4). Since the variable 'country membership' is used as a factor variable, this coefficient of the interaction for Turkey represents the reference value. The coefficients of the other countries indicate the relatively estimated values when using Turkey as a reference. Therefore, the coefficients and their statistical significance for those countries indicate their difference from Turkey in terms of the interaction term. Keeping this in mind, while the coefficients for Italy (γ_{22} = -.008, t(1,687) = 4.49, p = <.001), Lithuania (γ_{32} = .024, t(1,687) = 18.35, p = <.001), Malta (γ_{42} = .011, t(1,687) = 11.20, p = <.001), and Sweden (γ_{62} = .049, t(1,687) = 13.57, p = <.001) are estimated to be significantly different than the coefficient for Turkey in terms of the relationship between content and pedagogical knowledge of teachers and students' mathematics achievement, the ones for Hungary (γ_{12} = -.044, t(1,687) = -.61, p =.542) and Slovenia (γ_{52} = -.045, t(1,687) = -.92, p =.358) do not show significant difference when controlling for the associated covariates (Table 4.4).

Table 4.4. *Hierarchical Linear Modeling Results from the Interaction Model between Content and Pedagogical Knowledge and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries*

	Estimate	*S.E.*	*t*
Fixed Effects			
γ_{00} = Intercept (reference Turkey)	0.014	0.012	1.19
Country membership			
γ_{10} = Hungary	0.035	0.017	1.24
γ_{20} = Italy	0.046	0.020	1.61
γ_{30} = Lithuania	0.031	0.018	0.94
γ_{40} = Malta	-0.046	0.010	-5.84**
γ_{50} = Slovenia	0.151	0.025	5.46**
γ_{60} = Sweden	-0.166	0.021	-8.60**
γ_{02} =Content & Pedagogy (Reference Turkey)	-0.040	0.004	-9.09**
γ_{12} =*Content & Pedagogy:Hungary*	-0.044	0.006	-0.61
γ_{22} =*Content & Pedagogy:Italy*	-0.008	0.007	4.49**
γ_{32} =*Content & Pedagogy:Lithuania*	0.024	0.003	18.35**
γ_{42} =*Content & Pedagogy:Malta*	0.011	0.005	11.20**
γ_{52} =*Content & Pedagogy:Slovenia*	-0.045	0.005	-0.92
γ_{62} =*Content & Pedagogy:Sweden*	0.049	0.007	13.57**
Random Effects	*Variance Component*		
Level-two variance: τ_0^2 = var(U_{0j})	0.157		
Level-one variance: σ^2 = var(R_{ij})	0.580		
R^2:	0.4703		
Effect size (f^2):	0.009		
F-incremental:	3.27		

Note: This table only shows the main and interaction effects of the content and pedagogy knowledge and country membership on students' mathematics achievement when controlling for the associated covariates. Since all other predictors in the model were standardized, prediction equations refer to having all other predictors at the mean, which is zero, when graphing these relationships. Therefore, since they don't appear in the interaction prediction equations, they also are not included in this table. In addition, coefficients for main and interaction effects for other countries were estimated by the reference of Turkey by default during the analysis.
* p<0.05, ** p<0.001

In order to visualize and interpret these differences between the countries, both main and interaction effects were taken into consideration to plot the relationships (Hox, 2010). When including the interaction term 'content and pedagogy: country membership', the coefficients of these interactions and the main effects of these two variables 'content and pedagogy' and ‘country membership’ are different across the different countries; however, the coefficients for the associated covariates (other variables besides these) are the same. Therefore, only the main and interaction effects are included in the table (Table 4.4), and the following tables unless otherwise specified. Since all variables are standardized (means are fixed to 0, and standard deviations to 1), the coefficients of the other variables besides the main and interaction effects of these two variables that are interacted in this model (content and pedagogy and country membership) are automatically the same across the countries. Thus, the following figure (Figure 4.1), plots the relationship between teachers’ content and pedagogy knowledge and students’ mathematics achievement moderated by the focal EU countries.

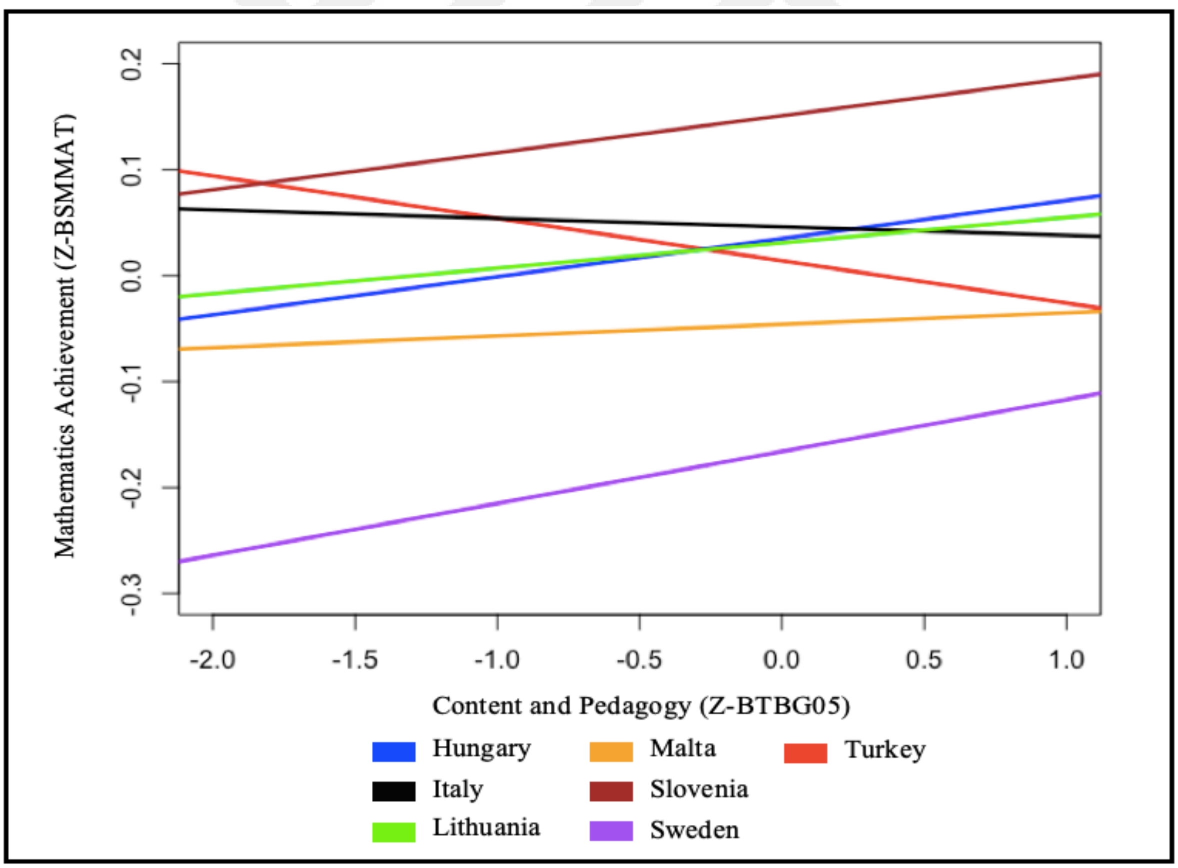

Figure 4.1. The Relationship between the Observed Variables of Content and Pedagogical Knowledge and Students’ Mathematics Achievement Moderated by Country Membership in the Focal EU Countries

According to Figure 4.1, when the content and pedagogical education background of teachers in mathematics increased, students' mathematics achievement also increased, in all countries except Turkey and Italy. Even though the relationship between the content and pedagogical background of teachers and students' mathematics achievement is positive in these countries, there are still noticeable, yet slight differences between them. In Sweden, the difference between the mathematics achievement of the students whose teachers have more content and pedagogical background in mathematics and the ones with less background is slightly higher than the other countries. However, this same difference is very low in Malta despite it being positive. On the other hand, in Turkey and Italy, the relationship between the content and pedagogical knowledge of the teachers and student achievement is negative. In Turkey, when students have teachers with more content and pedagogical background, their mathematics achievement decreased respectively. The situation is the same in Italy; however, the difference between the achievements of these two groups of students is not high as in Turkey. As a result, when the teachers have more content and pedagogical background, students' mathematics score increase more in Sweden, and decrease more in Turkey than the other countries, establishing the two ends of the spectrum for the focal EU countries.

Interaction Model 2 – Classroom Management. When the relationship between the teachers' classroom management characteristic and students' mathematics achievement is moderated by the country membership (interaction term: 'classroom management: country membership' was added), F-ratio test was applied (F_{inc} = 8.19), and results indicated that the change in the explained variability in the outcome variable of student achievement significantly increased when comparing the f-incremental value with the F-critical value of 2.09 at the .05 level (df=6; 25,981); in other words, the interaction model for the classroom management fitted significantly better with the data than the random intercept model. Therefore, results for this interaction model is provided below.

As a result of the interaction model for the classroom management, the effect size of the interaction found to be ($f^2 = 0.010$), which is small but typical (Aguinis et al., 2005). It was observed that the interaction coefficient for Turkey (reference) is significantly different than zero (γ_{10} = .009, *t*(1,687) = 2.82, p = .005), indicating that the relationship between the teachers' classroom management characteristic and students' mathematics achievement is estimated to be significant in Turkey when controlling for the associated covariates (Table 4.5). In addition, when estimating the coefficients for the other countries when referencing Turkey, it was found that all the coefficients for other countries are also estimated to be significantly different than the coefficient for Turkey in terms of the relationship between teachers' classroom management characteristic and students' mathematics achievement. These are the estimates for Hungary (γ_{110} = .133, *t*(1,687) = 14.18, p = <.001), Italy (γ_{210} = .081, *t*(1,687) = 6.50, p = <.001), Lithuania (γ_{310} = .086, *t*(1,687) = 8.65, p =) <.001), Malta (γ_{410} = .082, *t*(1,687) = 11.40, p = <.001), Slovenia (γ_{510} = -.027, *t*(1,687) = -4.07, p =<.001) and Sweden (γ_{610} = -.021, *t*(1,687) = -3.97, p =<.001) when controlling for the associated covariates (Table 4.5).

Table 4.5. *Hierarchical Linear Modeling Results from the Interaction Model between Classroom Management and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries.*

	Estimate	*S.E.*	*t*
Fixed Effects			
γ_{00} = Intercept (Reference - Turkey)	0.007	0.011	0.58
Country membership			
γ_{10} = Hungary	0.033	0.019	1.34
γ_{20} = Italy	0.042	0.018	1.97*
γ_{30} = Lithuania	0.035	0.018	1.58
γ_{40} = Malta	-0.044	0.011	-4.45**
γ_{50} = Slovenia	0.139	0.024	5.49**
γ_{60} = Sweden	-0.142	0.021	-7.17**
γ_{10} = Classroom management (Reference Turkey)	0.009	0.003	2.82*
γ_{110} = Classroom management:Hungary	0.133	0.009	14.18**
γ_{210} = Classroom management:Italy	0.081	0.011	6.50**
γ_{310} = Classroom management:Lithuania	0.086	0.009	8.65**
γ_{410} = Classroom management:Malta	0.082	0.006	11.40**
γ_{510} = Classroom management:Slovenia	-0.027	0.009	-4.07**
γ_{610} = Classroom management:Sweden	-0.021	0.007	-3.97**
Random Effects	*Variance Component*		
Level-two variance: τ_0^2 = var(U_{0j})	0.016		
Level-one variance: σ^2 = var(R_{ij})	0.580		
R^2:	0.4709		
Effect size (f^2):	0.010		
F-incremental:	8.19		

Note: This table only shows the main and interaction effects of the classroom management and country membership on students' mathematics achievement when controlling for the associated covariates. Since all other predictors in the model were standardized, prediction equations refer to having all other predictors at the mean, which is zero, when graphing these relationships. Therefore, since they don't appear in the interaction prediction equations, they also are not included in this table. In addition, coefficients for main and interaction effects for other countries were estimated by the reference of Turkey by default during the analysis.

* $p<0.05$, ** $p<0.001$

When considering both main and interaction effects corresponding to each individual country to plot the relationships, following figure (Figure 4.2) illustrates the relationship between teachers' classroom management characteristic and students' mathematics achievement moderated by the focal EU countries.

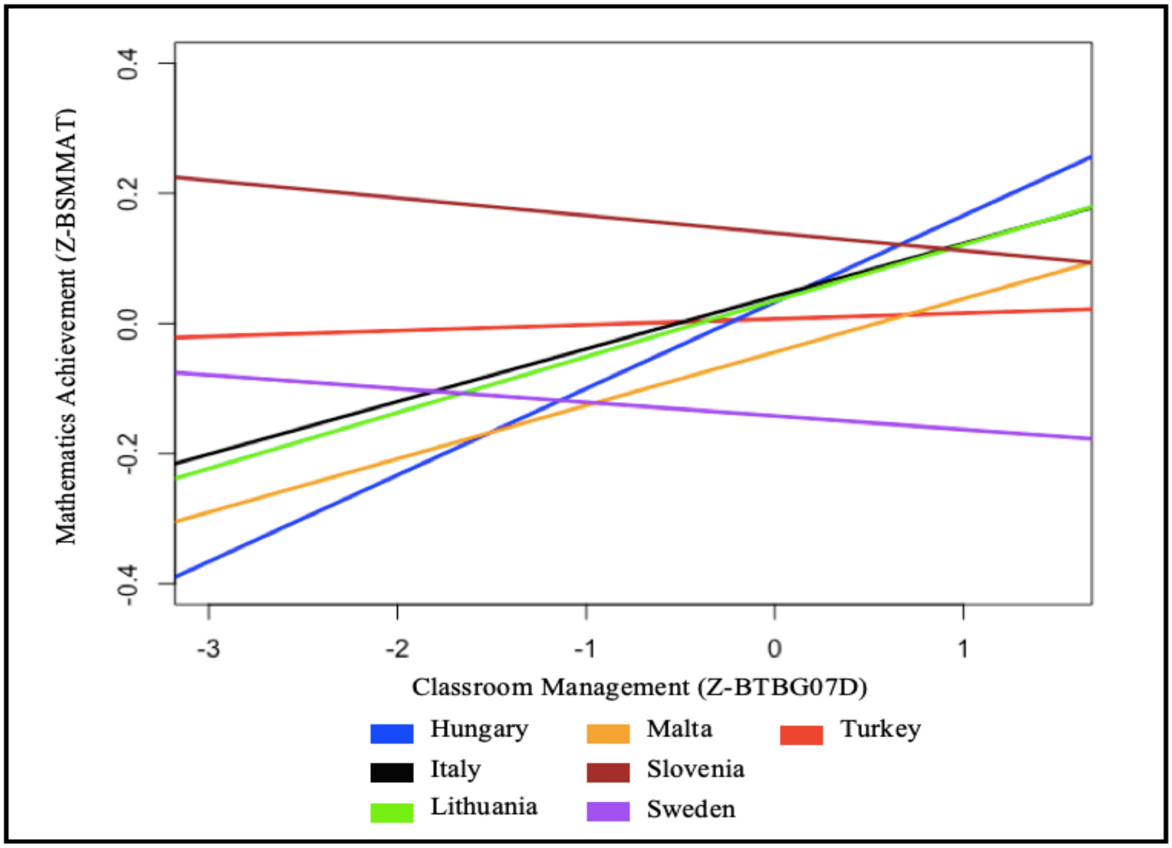

Figure 4.2. The Relationship between the Observed Variables of Classroom Management and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries

According to Figure 4.2, there are three distinct relationships, highly positive, slightly positive, and slightly negative between teachers' classroom management characteristic and students' mathematics achievement. These terms (slightly, moderately, highly) do not indicate any statistical meaning; rather, they are given to describe the differences among the countries. This wording is also used in the following interaction plot figures (Figure 4.3-4.6). In Hungary, Italy, Lithuania, and Malta, while teachers' classroom management characteristic increased, students' mathematics achievement highly increased as well when comparing with the other countries, indicating highly positive relationship. In Turkey, the direction of this relationship is still positive; however, the difference between the mathematics achievement of the students whose teachers have higher classroom management characteristic and the ones with lower is very little, indicating a slightly positive relationship. On the other hand, in Slovenia and Sweden, when the teachers' classroom management characteristics increased, students' mathematics achievement decreased, but very slightly, indicating a slightly negative relationship.

Interaction Model 3 – Motivation. Another difference between the countries is in the teachers' ability to motivate students to learn mathematics, according to the European Commission (2011a). When the relationship between the teachers' characteristic of motivating students to learn mathematics and students' mathematics achievement is moderated by the country membership (interaction term: 'motivation: country membership' was added), F-ratio test was applied (F_{inc} = 3.27), and the results indicated that the interaction model for the motivation fitted significantly better than the random intercept model (F_{critical}=2.09, *df*=6; 25,981, α=.05). Thus, results from the interaction model is indicated below.

As a result of the analysis of the interaction model, the effect size of the interaction found to be (f^2 = 0.009), which is small but, again, normal (Aguinis et al., 2005). It was also observed that the interaction coefficient for Turkey (reference) is not significantly different than zero (γ_{07} = .012, *t*(1,687) = 1.43, p = .153), indicating that the relationship between the teachers' characteristic of motivation and students' mathematics achievement is not estimated to be significant in Turkey when controlling for the associated covariates (Table 4.6). In addition, when estimating the coefficients for the other countries when referencing Turkey, it was found that while the coefficients for Hungary (γ_{17} = .070, *t*(1,687) = 4.53, p = <.001), Malta (γ_{47} = .059, *t*(1,687) = 4.31, p = <.001), and Slovenia (γ_{57} = -.037, *t*(1,687) = -3.10, p = .002) are estimated to be significantly different than the coefficient for Turkey in terms of the relationship between teachers' characteristic of motivation and students' mathematics achievement, those for Italy (γ_{27} = .004, *t*(1,687) = -1.12, p =.263), Lithuania (γ_{37} = .024, *t*(1,687) = 1.28, p =.201), and

Sweden (γ_{67} = .020, t(1,687) = 0.71, p =.478) do not show significant difference when controlling for the associated covariates (Table 4.6).

Table 4.6. *Hierarchical Linear Modeling Results from the Interaction Model between Motivation and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries.*

	Estimate	*S.E.*	*t*
Fixed Effects			
γ_{00} = Intercept (Reference – Turkey)	0.007	0.012	0.65
Country membership			
γ_{10} = Hungary	0.051	0.018	2.45*
γ_{20} = Italy	0.032	0.019	1.32
γ_{30} = Lithuania	0.048	0.019	2.25*
γ_{40} = Malta	-0.033	0.011	-3.60**
γ_{50} = Slovenia	0.167	0.028	5.69**
γ_{60} = Sweden	-0.155	0.021	-7.68**
γ_{07} = Motivation (Reference Turkey)	0.012	0.008	1.43
γ_{17} = Motivation:Hungary	0.070	0.013	4.53**
γ_{27} = Motivation:Italy	0.004	0.007	-1.12
γ_{37} = Motivation:Lithuania	0.024	0.010	1.28
γ_{47} = Motivation:Malta	0.059	0.011	4.31**
γ_{57} = Motivation:Slovenia	-0.037	0.016	-3.10*
γ_{67} = Motivation:Sweden	0.020	0.011	0.71
Random Effects	*Variance Component*		
Level-two variance: τ_0^2 = var(U_{0j})	0.158		
Level-one variance: σ^2 = var(R_{ij})	0.580		
R^2:	0.4703		
Effect size (f^2):	0.009		
F-incremental:	3.27		

Note: This table only shows the main and interaction effects of the motivation and country membership on students' mathematics achievement when controlling for the associated covariates. Since all other predictors in the model were standardized, prediction equations refer to having all other predictors at the mean, which is zero, when graphing these relationships. Therefore, since they don't appear in the interaction prediction equations, they also are not included in this table. In addition, coefficients for main and interaction effects for other countries were estimated by the reference of Turkey by default during the analysis.
* p<0.05, ** p<0.001

When considering both main and interaction effects corresponding to each individual country, following figure (Figure 4.3) illustrates the plotted relationship between teacher characteristic of motivating students to learn mathematics and students' mathematics achievement moderated by the focal EU countries.

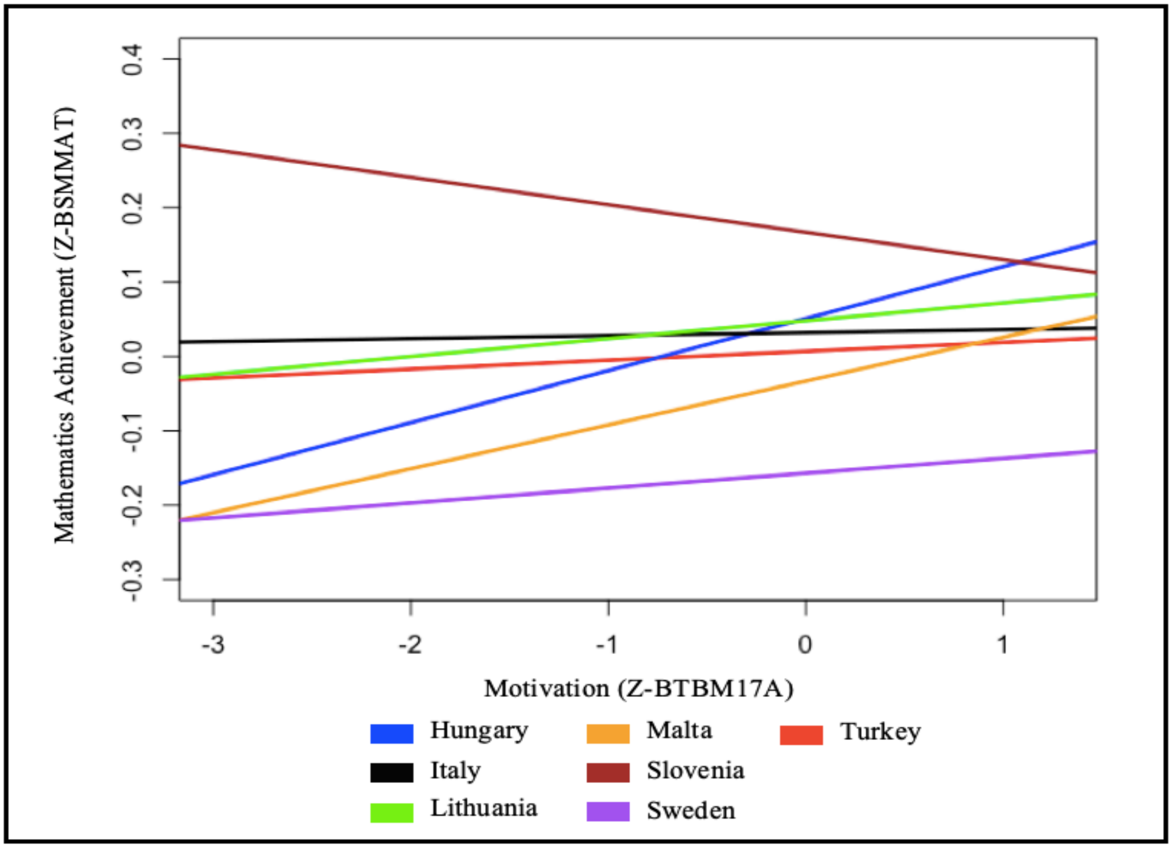

Figure 4.3. The Relationship between the Observed Variables of Motivation and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries

According to Figure 4.3, there are three distinctive relationships: high positive, slightly positive, and moderately negative between the teachers' characteristic of motivation and students' mathematics achievement. In Hungary and Malta, while teacher characteristic of motivation increased, students' mathematics achievement highly increased when comparing with the other countries, indicating a highly positive relationship respectively. In Italy, Lithuania, Turkey, and Sweden, this relationship is still positive, however the difference between the students' mathematics achievement scores whose teachers have higher characteristic of motivating students to learn mathematics and the ones who display lower motivation is slightly small, which results in a relatively slight positive relationship.

Slovenia is the only country where the relationship between the teachers' motivation and students' mathematics achievement is negative. In addition, the difference between the students whose teachers have higher motivation characteristic and the ones having lower is greater than the countries in the slightly positive relationship category. Therefore, Slovenia is reported as the country having a moderately negative relation between teachers' characteristic of motivation and students' mathematics achievement.

Interaction Model 4 – Teaching Complexity (Making mathematics relevant). On the other hand, when the relationship between the teachers' characteristic of making mathematics relevant, which is called the complexity of teaching by Stronge (2007), and students' mathematics achievement is moderated by the country membership (interaction term: 'teaching complexity: country membership' was added), variance explained by the interaction model (R^2_{wi} =.4698) was less than the one by the random intercept model (R^2_{wo}= .4699). Therefore, according to the formula provided by Tabachnick and Fidell (2013) ($[(R^2_{wi} - R^2_{wo})/m]/[(1 - (R^2_{wi})/\mathrm{df}_{\mathrm{res}}]$), F-incremental was negative; thus, there was no need to estimate the F-ratio test. In other words, interaction model for the teaching complexity did not fit well than the random intercept model with the data; thus, the interaction effect was not significant. As a result, it is not interpreted the results of the estimations of the intercept model for the teacher characteristic of teaching complexity.

Interaction Model 5 – Enhancing student engagement. When the relationship between teachers' characteristic of enhancing student engagement and students' mathematics achievement (interaction term 'student engagement: country membership' was added), F-ratio test results indicated that the interaction model for the enhancing student engagement fitted significantly better than the random intercept model (F_{inc} = 5.72, F_{critical} =2.09, *df*=6; 25,981, α=.05). Therefore, the results from the interaction model is provided below.

As a result of the analysis of the interaction model, the effect size was estimated as (f^2 = 0.009), which is small but typical (Aguinis et al., 2005). It was also observed that the interaction coefficient for Turkey (reference) is now significantly different than zero (γ_{21} = -.072, *t*(1,687) = -9.78, *p* = <.001), indicating that the relationship between the teachers' characteristic of enhancing student engagement and students' mathematics achievement is estimated to be significant in Turkey when controlling for the associated covariates, but negatively (Table 4.8). In addition, when estimating the coefficients for the other countries by referencing Turkey, it was found that while the coefficients for Lithuania (γ_{321} = .032, *t*(1,687) = 15.49, *p* = <.001), Italy (γ_{221} = -.091, *t*(1,687) = -2.57, *p* = .010), Slovenia (γ_{521} = -.041, *t*(1,687) = 4.79, *p* = <.001), and Sweden (γ_{621} = -.003, *t*(1,687) = 13.17, *p* = <.001) are estimated to be significantly different than the coefficient for Turkey in terms of the relationship between teachers' characteristic of enhancing student engagement and students' mathematics achievement, the ones for Hungary (γ_{121} = -.065, *t*(1,687) = 1.00, *p* =.317), and Malta (γ_{421} = -.071, *t*(1,687) = 0.17, *p* =.865) do not show significant difference when controlling for the associated covariates (Table 4.8).

Table 4.7. *Hierarchical Linear Modeling Results from the Interaction Model between Enhancing Student Engagement and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries.*

	Estimate	*S.E.*	*t*
Fixed Effects			
γ_{00} = Intercept (Reference – Turkey)	0.008	0.011	0.68
Country membership			
γ_{10} = Hungary	0.046	0.018	2.09*
γ_{20} = Italy	0.039	0.018	1.69
γ_{30} = Lithuania	0.035	0.017	1.56
γ_{40} = Malta	-0.030	0.011	-3.63**
γ_{50} = Slovenia	0.150	0.025	5.74**
γ_{60} = Sweden	-0.175	0.020	-8.95**
γ_{21} = Student engagement (Reference Turkey)	-0.072	0.007	-9.78**
γ_{121} = Student engagement:Hungary	-0.065	0.007	1.00
γ_{221} = Student engagement:Italy	-0.091	0.008	-2.57*
γ_{321} = Student engagement:Lithuania	0.032	0.007	15.49**
γ_{421} = Student engagement:Malta	-0.071	0.007	0.17
γ_{521} = Student engagement:Slovenia	-0.041	0.007	4.79**
γ_{621} = Student engagement:Sweden	-0.003	0.005	13.17**
Random Effects	*Variance Component*		
Level-two variance: τ_0^2 = var(U_{0j})	0.157		
Level-one variance: σ^2 = var(R_{ij})	0.580		
R^2:	0.4706		
Effect size (f^2):	0.009		
F-incremental:	5.72		

Note: This table only shows the main and interaction effects of the enhancing student engagement and country membership on students' mathematics achievement when controlling for the associated covariates. Since all other predictors in the model were standardized, prediction equations refer to having all other predictors at the mean, which is zero, when graphing these relationships. Therefore, since they don't appear in the interaction prediction equations, they also are not included in this table. In addition, coefficients for main and interaction effects for other countries were estimated by the reference of Turkey by default during the analysis.
* $p<0.05$, ** $p<0.001$

When taking both main and interaction effects into account to plot the relationships across the countries, following Figure (Figure 4.5) illustrates the relationship between teachers' characteristic of enhancing student engagement and students' mathematics achievement moderated by the focal EU countries.

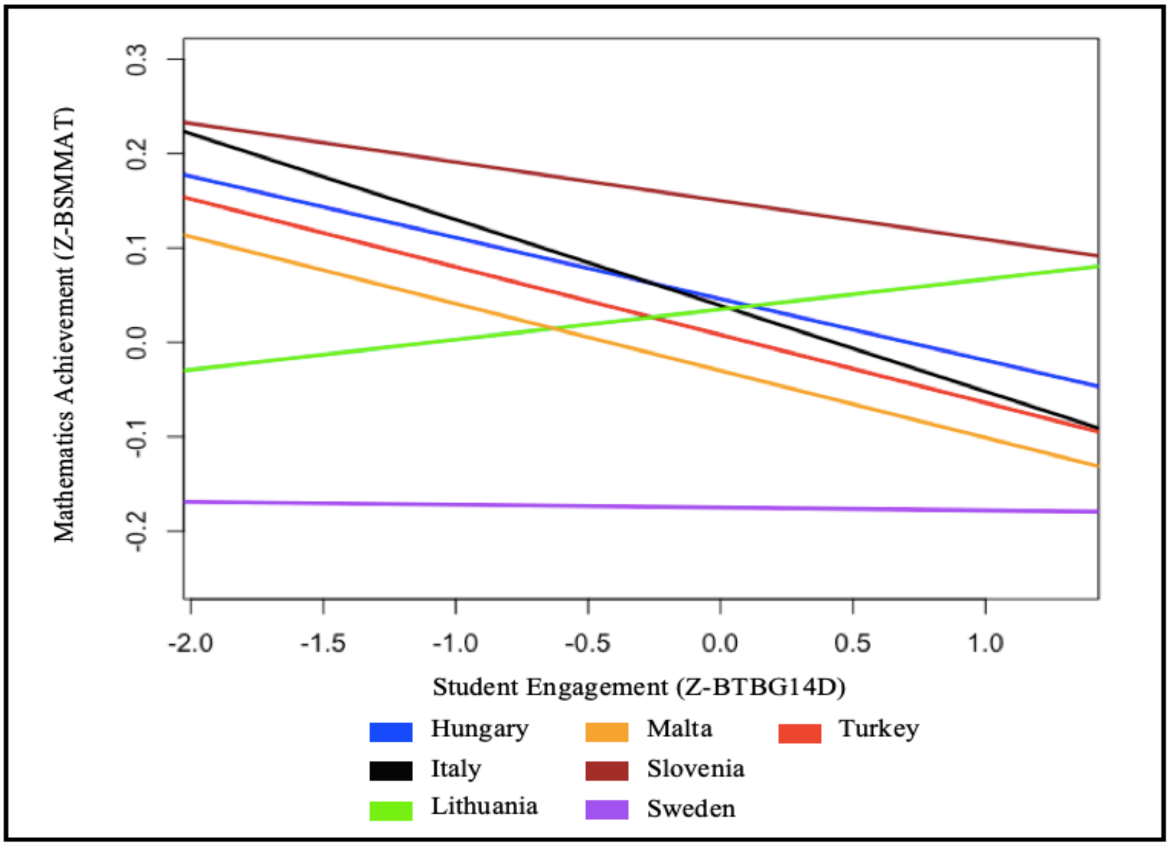

Figure 4.4. The Relationship between the Observed Variables of Enhancing Student Engagement and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries

According to Figure 4.5, the plots of the Hungary, Italy, Malta, Slovenia, and Turkey show a similar pattern, which indicates a moderate negative relationship between the teachers' characteristic of enhancing student engagement and students' mathematics achievement, while Italy deviates slightly from the other countries by skewing from moderate to highly negative. However, Lithuania holds a moderately positive relationship while Sweden illustrates a neutral relationship between these two variables.

Interaction Model 6 – Use of homework. Lastly, when the relationship between the teachers' characteristic of use of homework and students' mathematics achievement is moderated by country membership (interaction term 'homework: country membership' was added), F-ratio test results indicated that the interaction model for use of homework fitted significantly better than the random intercept model (F_{inc} = 9.00, F_{critical} =2.09, *df*=6; 25,981, α=.05). Therefore, the results from the interaction model is provided below.

As a result of the interaction model analysis, the effect size of the interaction is found as (f^2 = 0.010), a typical and small effect size (Aguinis et al., 2005). It was also observed that interaction coefficient for Turkey (reference) is significantly different than zero (γ_{22} = -.030, *t*(1,687) = -4.79, *p* = <.001), indicating that the relationship between the teachers' characteristic of use of homework and students' mathematics achievement is estimated to be significant in Turkey when controlling for the associated covariates, but negatively (Table 4.9). In addition, when estimating the coefficients for the other countries by referencing Turkey, it was found that while the coefficients for Italy (γ_{222} = -.081, *t*(1,687) = -8.24, *p* = <.001), Lithuania (γ_{322} = .050, *t*(1,687) = 15.30, *p* = <.001), Malta (γ_{422} = .015, *t*(1,687) = 5.69, *p* = <.001), Slovenia (γ_{522} = .029, *t*(1,687) = 4.58, *p* = <.001), and Sweden (γ_{622} = .007, *t*(1,687) = 5.42, *p* = <.001) are estimated to be significantly different than the coefficient for Turkey, Hungary (γ_{122} = -.038, *t*(1,687) = 1.02, *p* = .675) does not show significant difference when controlling for the associated covariates (Table 4.9).

Table 4.8. *Hierarchical Linear Modeling Results from the Interaction Model between Use of Homework and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries.*

	Estimate	*S.E.*	*t*
Fixed Effects			
γ_{00} = Intercept (Reference - Turkey)	0.010	0.011	0.92
Country membership			
γ_{10} = Hungary	0.046	0.013	2.72^{*}
γ_{20} = Italy	0.050	0.020	2.06^{*}
γ_{30} = Lithuania	0.027	0.017	1.02
γ_{40} = Malta	-0.047	0.012	-4.81^{**}
γ_{50} = Slovenia	0.137	0.024	5.28^{**}
γ_{60} = Sweden	-0.130	0.022	-6.40^{**}
γ_{22} = Homework (Reference Turkey)	-0.030	0.006	-4.79^{**}
γ_{122} = Homework:Hungary	-0.038	0.019	-0.42
γ_{222} = Homework:Italy	-0.081	0.006	-8.24^{**}
γ_{322} = Homework:Lithuania	0.050	0.005	15.30^{**}
γ_{422} = Homework:Malta	0.015	0.008	5.69^{**}
γ_{522} = Homework:Slovenia	0.029	0.013	4.58^{**}
γ_{622} = Homework:Sweden	0.007	0.007	5.42^{**}
Random Effects	*Variance Component*		
Level-two variance: τ_0^2 = var(U_{0j})	0.157		
Level-one variance: σ^2 = var(R_{ij})	0.580		
R^2:	0.471		
Effect size (f^2):	0.010		
F-incremental:	9.00		

Note: This table only shows the main and interaction effects of the use of homework and country membership on students' mathematics achievement when controlling for the associated covariates. Since all other predictors in the model were standardized, prediction equations refer to having all other predictors at the mean, which is zero, when graphing these relationships. Therefore, since they don't appear in the interaction prediction equations, they also are not included in this table. In addition, coefficients for main and interaction effects for other countries were estimated by the reference of Turkey by default during the analysis.
* $p<0.05$, ** $p<0.001$

When considering both main and interaction effects corresponding to each individual country, following Figure (Figure 4.6) illustrates the plotted relationship between teachers' characteristic of use of homework and students' mathematics achievement moderated by the focal EU countries.

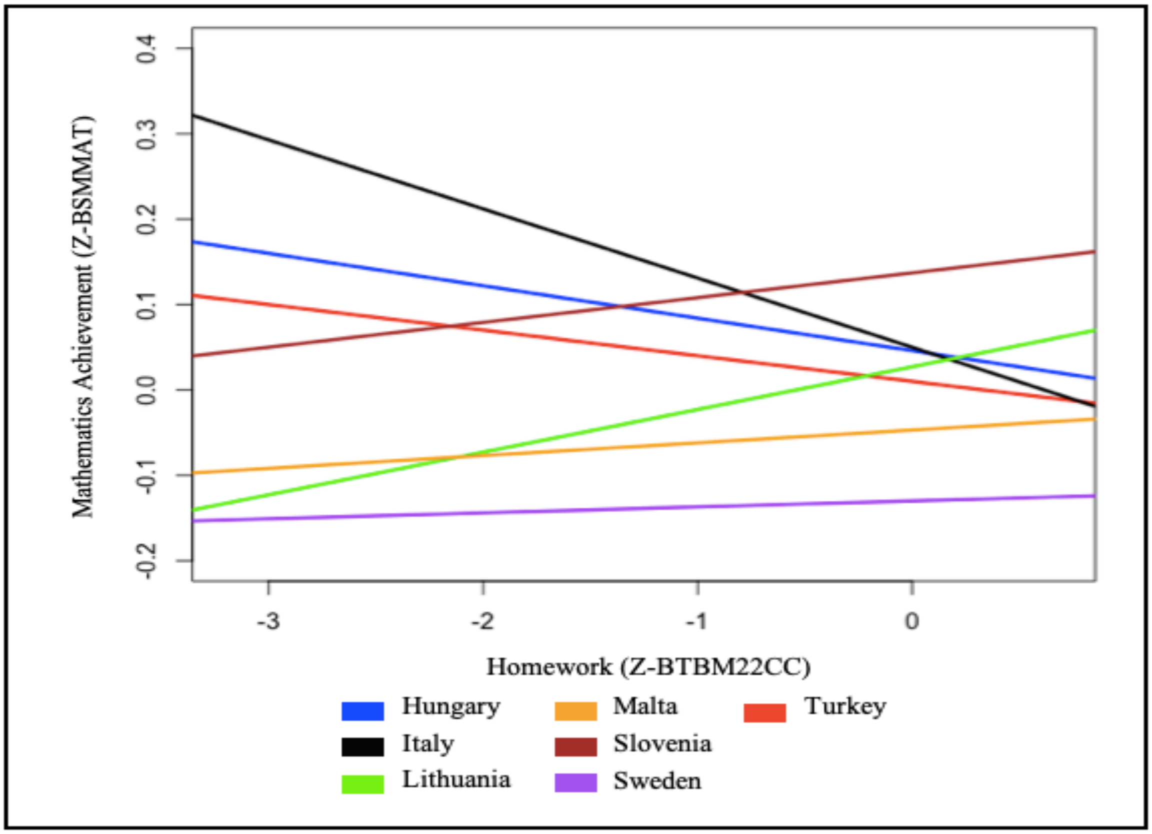

Figure 4.5. The Relationship between the Observed Variables of Use of Homework and Students' Mathematics Achievement Moderated by Country Membership in the Focal EU Countries

According to Figure 4.6, the patterns of the plots are highly negative, slightly negative, slightly positive, and moderately positive. While the relationship between the observed variables of teachers' characteristic of use of homework and students' mathematics achievement is highly negative in Italy, it is slightly negative in Hungary and Turkey, moderately positive in Lithuania and Slovenia, and slightly positive in Malta and Sweden.

Summary

In summary, one of the results of this study found that teachers' characteristic of disciplining students, caring, achievement expectations, high expectations, instructional strategies, experience, planning for instruction, classroom management, questioning, and attitude toward teaching were all estimated to be significantly and positively related to students' mathematics achievement at the eighth-grade level in the pooled sample of seven focal EU countries, from the strongest to weakest. On the other hand, the characteristics of focus on instruction, student engagement, using assessment, reflective practice, homework, and content and pedagogical knowledge were found to be significantly but negatively related to the students' mathematics achievement in these countries, from the strongest to weakest. At the same time, fairness and respect, enthusiasm, motivation, organization, adapting instruction, teaching complexity (making mathematics relevant), and feedback are the teacher characteristics that were not found to be significantly related to the students' mathematics achievement, after controlling for the associated covariates. Interpretation of these findings is discussed in the next chapter (Chapter 5).

In addition to the relationship between the teacher characteristics and students' mathematics achievement in the overall focal EU countries, this study also aimed to reveal the differences among these countries in terms of six of the teacher characteristics tested over these countries. It was found that teachers' content and pedagogy knowledge had a significantly positive relationship with students' mathematics achievement in the focal EU countries except Turkey and Italy. In addition, in Hungary, Italy, Lithuania, and Malta, classroom management had a positive relationship with students' mathematics achievement while this relationship is slightly negative in Slovenia and Sweden. The teachers' characteristic of motivation had a positive relationship with achievement in all countries except Slovenia while enhancing student engagement was negatively related to the achievement in Lithuania, Hungary, Sweden, and Turkey, neutrally in Sweden, and positively in Lithuania. Finally, the characteristic of use of homework had a positive relationship with students' mathematics achievement in Lithuania, Slovenia, Malta, and Sweden, and a negative in Italy, Hungary, and Turkey. On the other hand, the interaction model for the teacher characteristic of teaching complexity (making mathematics relevant) was not found to significantly increase the variance explained in the outcome variable. In other words, the relationship between the characteristic of teaching complexity (making mathematics relevant) and students' mathematics achievement was not significantly differ among the seven focal EU countries.

In this chapter, the results for the relationship between the teacher characteristics (Stronge, 2007) and students' mathematics achievement in the pooled sample of EU countries were provided. The results that were achieved were suggested by the previous researchers to be related, as well as the differences among these countries in terms of six of these teacher characteristics indicated to be implemented differently by European Commission (2011a). Therefore, in the following chapter, how these relationships were consistent with previous researchers' findings in the overall EU countries, and the possible linkages between the implementation of six of these characteristics in the curriculum and/or steering documents in these countries and the different relationships estimated individually for these countries in terms of those six variables are discussed.

Chapter 5: Discussions and Conclusion

While many factors have received attention from researchers in terms of their effect on student achievement, one of the most important ones was teacher characteristics (e.g., Aaronson et al., 2007; Clotfelter et al., 2007; Clotfelter et al., 2010; Kane & Staiger, 2008; Kane et al., 2008; Nye et al., 2004; Yoon et al., 2007). The European Union (EU) also emphasized the importance of effective teachers (European Commission, 2011a; European Council, 2009; European Council, 2014); however, since the Union respects national diversities, there are no clear specifications of the characteristics of effective teachers across the EU countries. In addition, implementation of the mathematics teaching practices varies between the EU countries (European Commission, 2011a). Therefore, by employing a conceptual framework created by Stronge (2007), in which he identified the teacher characteristics that are potentially related to students' mathematics achievement, this study attempted to reveal the teacher characteristics that are possibly linked to students' mathematics achievement across EU countries, as well as revealing the differences in these relationships between the countries, especially in light of the report published by the Eurydice (European Commission, 2011a). As a result, the main research questions of this study were: a) To what extent do teacher characteristics suggested as effective in previous studies consistently predict students' mathematics achievement in the overall focal EU countries, as documented by the Trends in International Mathematics and Sciences Study (TIMSS) 2015, after controlling for student and teacher background characteristics as well as the country membership? b) what are the differences among the focal EU countries in terms of the relationship between students' mathematics achievement and their teachers' characteristics as these are demonstrated differently in the national strategies and initiatives across these countries?

In order to provide possible answers for these questions, there were eight hierarchical linear models with two levels of students and teachers created for this study: an unconditional model that explained the necessity of having multilevel hierarchical linear models for the data set used in this study, a conditional model (random intercept model) that reveals the extent to which teacher characteristics suggested as effective in previous studies to predict students' mathematics achievement in the overall focal EU countries, and six additional conditional models (interaction models) that reveal the differences among the focal EU countries in terms of the six teacher characteristics indicated by Eurydice to predict students' mathematics achievement. Results of the estimation of these models were given in detail in the Chapter 4, except the interaction model for the teacher characteristic of teaching complexity because it did not significantly increase the variance explained by the explanatory variables in the outcome variable.

This chapter consisted of five sections. It begins with a discussion around how the results provided in Chapter 4 are able to answer the research questions of the study. This discussion is shaped around the previous researchers' findings provided in the literature review section, and the report by the Eurydice (European Commission, 2011a). In the second section, the limitations of the study are discussed while the third section indicates the implications of this study. Afterwards, the possible directions for the future research following the footsteps of this study are given. The chapter ends with the final conclusions based on the outcomes discussed in the previous sections.

Discussions Related to the Research Questions

Research Question – 1. The first research question of this study aimed to reveal the extent to which the teacher characteristics suggested as effective in previous studies predict students' mathematics achievement in the focal EU countries. As indicated in Chapter 4, most of the observed variables of teacher characteristics, except fairness and respect, enthusiasm, motivation, organization, adapting instruction, teaching complexity (making mathematics relevant), and feedback, were found to be significantly related, either positively or negatively, to students' mathematics achievement across the overall seven focal EU countries, according to the first conditional model (random intercept model). The significantly related teacher characteristics are discussed in this section; however, it is worth to mention the ones found to be not significantly related to students' mathematics achievement, first. Even though some researchers indicated these characteristics are effective teacher characteristics, the findings of this study illustrated the exact opposite results within the focal EU countries for those.

Teacher Characteristics not found to be Significantly Related to Student Achievement. The first teacher characteristic that was not found to be significantly related to students' mathematics achievement is fairness and respect. In terms of fairness and respect, Agne (1992) indicated in his comparative study between 88 'expert' teachers and 92 other teachers that the 'expert' teachers were the ones embracing a more democratic classroom environment that fostered a warm relationship between teacher and student, indicating strong fairness and respect in the classroom. In this study, fairness and respect variable is measured by an item in TIMSS that asks teachers the extent to which they agree if their students are respectful of them. As a result, *teachers' perception of their students' respect to themselves* was not found to be significantly related to their students' mathematics achievement in the focal EU countries, after controlling for the associated covariates. It could also be more useful if there was an item in the teacher questionnaire asking them how they are respectful of their students, actually. Therefore, the non-significant relationship in this manner actually illustrates only teachers' perception of their students.

Secondly, in terms of the enthusiasm, Rowan et al. (1997) indicated that enthusiasm is an essential characteristic of an effective teacher for both teaching and learning, while Jepsen (2005) found that teacher's enthusiasm is negatively related to their effectiveness in teaching mathematics by .05 standard deviation difference. Jepsen (2005) indicated that more enthusiastic teachers, in his study, were matched with more difficult classrooms, which could have affected the results. In response, Rowan et al. (1997) suggested researchers who are interested in the relationship between teachers' enthusiasm and student achievement needed to work in specific classrooms. In this study, the target classrooms were the ones in the overall EU countries that participated in TIMSS 2015. And teachers' enthusiasm is measured by a TIMSS item that asks teachers if they feel enthusiastic about their jobs. Therefore, *teachers' feeling of enthusiasm about their job* was found also not to be significantly related to students' mathematics achievements, which supports the conclusions of both Jepsen (2005) and Rowan et al (1997). Whether or not teachers feel more enthusiastic about their job, there was no significant difference in their students' mathematics achievement in the focal EU countries. Or in an opposite causality, there is no significant difference between the teachers of the high- or low-achieved students in mathematics in terms of their feeling of enthusiasm about their job.

The third characteristic found by previous researchers to be an effective teacher characteristic was motivation. Stronge (2007) indicated that effective teachers are the ones who are able to motivate their students to learn mathematics to reach their potentials. Covino and Iwanicki (1996) indicated that effective teacher use variety of methods to enhance students' intrinsic and extrinsic motivations to learn while Rowan et al. (1997) found out that teachers' motivation of students to learn mathematics had large effects on enhancing students' mathematics achievement. However, there is no significant relationship between the students' mathematics achievement and *teachers' confidence to inspire students to learn mathematics*, according to the random intercept model results. Or, it is also possible that there is no significant difference in teachers' confident to inspire students to learn mathematics whether their students are high- or low-achieved in mathematics.

In addition, organization is another teacher characteristic indicated by previous researchers. Stronge et al. (2008) and Stronge et al. (2011) included this characteristic in their studies where they compared effective vs. ineffective and top- vs. bottom-quartile teachers, respectively. While Stronge et al. (2008) found a difference between the teacher groups favoring the effective teachers, Stronge et al. (2011)'s finding supported this and even indicated a significant difference favoring the top-quartile teachers. However, neither of the studies found a significant relationship between the characteristic of organization, on the part of the teacher, and students' mathematics achievement. Based on the definition provided by Stronge (2007) and the availability of an item in TIMSS 2015, teachers' organization characteristic is measured by an item that asked teachers if they agree that they have too much material to cover in the class. Therefore, *teachers' organization of the materials to cover the class* was found not to be significantly related to students' mathematics achievement in the focal EU countries.

Fifth teacher characteristic indicated by previous researchers is the adapting instruction. Covino and Iwanicki (1996) and Stronge (2007) indicated that the differentiation in instruction based on students' needs and abilities is a characteristic of an effective teacher. However, the findings of this study did not support this claim. It was not found a significant relationship between *teachers' confidence to adapt their teaching to engage students' interest* and their students' mathematics achievement in the focal EU countries, after controlling for the associated covariates.

Another characteristic is the teaching complexity (making mathematics relevant). Stronge (2007) described teaching as a complex action that includes the complexity of the subject itself as well as the complexity of learners coming from different backgrounds. Therefore, he indicated that it is important for teachers to recognize these individual differences among the students causing by their in- and out-of-class experiences and to make mathematics relevant for all these different backgrounded students. Stronge et al. (2008) and Stronge et al. (2011) included this variable in their analysis where they compare effective vs. ineffective and top- and bottom-quartile teachers, respectively, and indicated that effective and top-quartile teachers have higher teaching complexity skills even though the results are not statistically significant. However, by working with the data of the teachers from a very large sample of EU countries, this dissertation study found out that *teachers' confidence to make mathematics relevant to students* is not a teacher characteristic that is significantly related to students' mathematics achievement, after controlling for the associated covariates. There was no possible way to assess the extent to which teachers make mathematics relevant to students, especially with a large-scale international dataset. However, their confidence may give hints about their actual ability.

Finally, the last characteristic in the non-significant category is the teacher characteristic of feedback. Stronge (2007) stated that providing a timely manner feedback by teachers is essential for the student achievement as Cotton (2000) also indicated. In addition, Stronge et al. (2008) and Stronge et al. (2011) found that effective or top-quartile teachers have higher mean scores in terms of providing feedback to their students. However, according to the results from the random intercept model, it was found in this study that the *frequency of teachers' correcting assignments and giving feedback to students* is not significantly related to students' mathematics achievement in the focal EU countries.

Additionally, despite the fact that *student gender* was included in the multilevel models of this study as previous researchers suggested (Aaronson et al., 2007; Boyd et al., 2005; Clotfelter et al., 2010; Goldhaber & Anthony, 2007; Hill et al., 2005; Jacob & Lefgren, 2002; Rowan et al., 1997; Stronge et al., 2011), in order to study its effect on students' mathematics achievement as a control variable, it was also not found to be significantly related to mathematics achievement. Even though it was not the goal of this study to examine the relationship between gender and student achievement, it is worth mentioning that there is no significant difference in students' mathematics achievement, across the focal EU countries, based on student gender, after controlling for the associated covariates.

Teacher Characteristics found to be Significantly Related to Student Achievement. As a result of the conditional model (random intercept model), the teacher characteristics of 'disciplining students, caring, achievement expectations, high expectations, instructional strategies, experience, planning for instruction, classroom management, questioning, and attitude toward teaching' had a positively significant relationship with students' mathematics achievement, from the strongest to the weakest (Figure 5.1). On the other hand, the characteristics of 'content and pedagogy knowledge, use of homework, reflective practice, using assessment, enhancing student engagement, and focus on instruction' indicated a negatively significant relationship with students' mathematics achievement across the seven countries, in order from the weakest to strongest. The variables used in the conditional model (random intercept model) were all standardized; therefore, Figure 5.1 illustrates the change in students' mathematics achievement by standard deviation units when each individual variable increased by 1 standard deviation, after controlling for the associated covariates. As a result, it was possible to compare the change in each individual variable to each other in terms of the relative change in students' mathematics achievement since all changes are given in standard deviation units (Lorah & Wong, 2018).

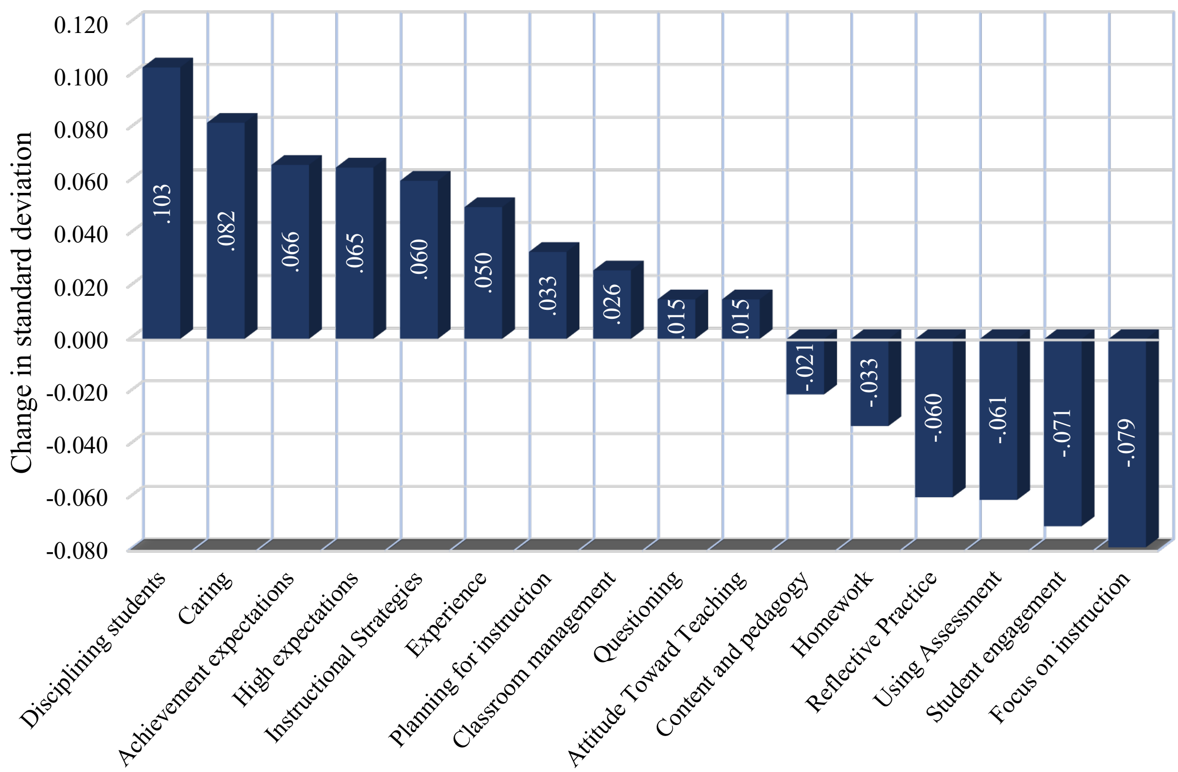

Figure 5.1. Expected Changes in Students' Mathematics Achievement Scores Corresponding to Change in Each Teacher Characteristic across the Pooled Sample of focal EU countries.

Note: Only the teacher characteristics that have a significant relationship with students' mathematics achievement are included in the figure. The changes in the teacher characteristics and the change in students' mathematics achievement are given in standard deviation units.

As illustrated in Figure 5.1, the teacher characteristic of disciplining students was found to be the most significantly and positively related to students' mathematics achievement across the EU countries. Based on the item used in this study to measure this characteristic, it can be concluded that 1 standard deviation increase in *teachers' perception of the limitation of their teaching by the disruptive students* is related to .103 standard deviation increase in their students' mathematics achievement. Therefore, it is consistent with Stronge (2007)'s statements that disciplining certain students over others is essential for student achievement. Covino and

Iwanicki (1996) also indicated that preventing students' misbehavior was an effective teacher characteristic that helped to maintain the students' focus on the lesson.

At the same time, the teacher characteristics of caring (Collinson et al., 1999; Peart & Campbell, 1999; Stronge et al., 2008; Stronge et al., 2011) was measured by the frequency of *teachers' encouragement of their students in the classroom to express their ideas*. Therefore, 1 standard deviation increase in teachers' encouragement of their students to express their ideas is related to .082 standard deviation increase in their students' mathematics achievement. In addition, 1 standard deviation increase in *teachers' overall perception of their expectations for student achievement in their school* is related to .066 standard deviation increase in students' mathematics achievement. Stronge et al. (2008) found out that effective teachers in their study had lower scores, as opposed to the findings of this study, in terms of their expectations of their students to achieve. On the other hand, Rowan et al. (1997) indicated that teachers' expectations of their students' achievement had a significant impact. Peart and Campbell (1999) also stated that teachers should not only have expectations for their students, but also should clearly communicate with them to remind their responsibilities through these expectations. As a result, a positive and significant relationship between the teachers' perception of their expectations and students' mathematics achievement is promising, at the same time, communicating with students in terms of these perceptions may increase their achievement, based on Peart and Campbell's (1999) suggestion.

Teachers' expectation of their students to achieve is essential; however, another important teacher characteristic indicated by Stronge (2007) was teachers' higher expectations. The main difference between these two characteristics is that high expectation is to encourage students to work on more challenging activities during the lesson, according to his descriptions.

As a result, 1 standard deviation increase in the *frequency of teachers' assignment of more challenging exercises to their students* is related to .065 standard deviation increase in their students' mathematics achievement. Mason et al. (1992) also found out in their study that students' mathematics achievement scores increased more when students in their study were placed in a more advanced mathematics classroom. Thus, having higher expectations of their students by assigning some challenging exercises may be useful to teachers.

In addition, the characteristic of instructional strategies is also indicated by the previous researchers as an effective teacher characteristic. Implementing the instruction through different strategies is essential to accommodate diverse students (Peart & Campbell, 1999), and enabling students to reach maximum understanding of the concept (Stronge, 2007). In addition, Stronge et al. (2008) and Stronge et al. (2011) also found out that effective and top-quartile teachers had higher scores in including different strategies in the instruction. In parallel to previous researchers' findings, it was found in this study that 1 standard deviation increase in *teachers' confidence of showing variety of problem-solving strategies to their students* is found to be related to .060 standard deviation increase in their students' mathematics achievement scores. Actually, the item used to measure this variable ask teachers about their confidence in showing different problem-solving strategies in their mathematics classroom, instead of different strategies to teach. However, it was the closest item to select for this purpose to have an idea of how teachers differentiated the instructional strategies by looking at their differentiation of problem-solving strategies. Thus, there was no information regarding the teachers' inclusion of different instructional strategies in the classroom; however, at least a differentiation in their problem-solving strategies seems to help teachers to work more effectively with their students.

Another teacher characteristic indicated by the previous researchers is teachers' teaching experiences (Aaronson et al., 2007; Boyd et al., 2005; Bruce et al., 2010; Clotfelter et al., 2007; Clotfelter et al., 2010; Goldhaber & Anthony, 2007; Hill et al., 2005; Jacob & Lefgren, 2002; Jepsen, 2005; Monk, 1994; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011). This actually was the most popular teacher characteristic within the literature review for this study. Even though Boyd et al. (2005) and Rivkin et al. (2005) indicated that teachers' teaching experience in years is an important factor in students' mathematics achievement gain, but in the first three years mostly while Clotfelter et al. (2010) indicated that it is an essential factor in teachers' first one or two years. In this study, teachers' teaching experience in years is measured by a continuous item ranging from one to 57 years. As a result, it was found that 1 standard deviation increase in *teachers' teaching experience in years* found to be related to .050 standard deviation increase in students' mathematics achievement. This was opposed to what Boyd et al. (2005), Rivkin et al. (2005), and Clotfelter et al. (2010) indicated, which stated that teachers' teaching experience in years becomes less effective in student achievement after the first two or three years.

These teacher characteristics were remarkably different than the other characteristics, as illustrated in Figure 5.1, with 1 standard deviation increase in each of these characteristics being related to more than .050 standard deviation unit increase in students' mathematics achievement. '.050' standard deviation unit does not indicate a cut score. However, in Figure 5.1 the characteristics with higher than .050 increase have no realistic statistical significance, but are worth noting anyways, given the fact that they seem, at first glance, to be remarkably different than the other results. As indicated in the parentheses, these characteristics were indicated as the effective teacher characteristics by the previous researchers and proven to be possibly related to students' mathematics achievement through this study.

In addition, the teacher characteristics of planning for instruction (Stronge et al., 2008; Stronge et al., 2011), classroom management (Stronge et al., 2008; Stronge et al., 2011; Wang et al., 1993), questioning (Covino & Iwanicki, 1996; Stronge et al., 2008; Stronge et al., 2011), and attitude toward teaching (Mitchell, 1998; Stronge et al., 2008; Stronge et al., 2011) also have been found to have a significantly positive relationship with students' mathematics achievement after controlling for the associated covariates. This study found out that 1 standard deviation increase in *the amount of time teachers need to prepare the lesson* is related to .033 standard deviation increase in their students' mathematics achievement. The time they need to prepare the lesson may not show how better they plan for the instruction. However, Stronge (2007) indicated that novice teachers especially struggle to prepare the lesson in advance. As a result, the amount they spent on the preparation can be related to the extent to which they are novice, and more novice they are more their student achieve. However, teacher' teaching experiences in years indicated above that more experienced teachers' students achieved .050 standard deviation higher. Therefore, the time they need to prepare the lesson may not only be related to how novice they are, but also to the better preparation of the lesson that may be related to an increase in students' performances in mathematics.

In addition, 1 standard deviation increase in *teachers' perception of their students' orderly mannered behaviors* is related to .026 standard deviation increase in students' mathematics achievement. Students' orderly mannered behaviors could be counted as a student factor rather than a teacher characteristic; however, Stronge (2007) indicated that effective teachers are the ones preventing the disruptive behaviors in the classroom by creating a positive and engaging learning environment. Therefore, their perception of their students' behaviors may also give a hint for their preventative management of the disruptive students and having an environment where students behave in an orderly manner, which is related to higher achievement of students in mathematics. Furthermore, 1 standard deviation increase in the *frequency of teachers' questioning of their students to explain their answers* is related to .015 standard deviation increase in achievement, similarly to the 1 standard deviation increase in *teachers' satisfaction with their profession as a teacher*. Teachers' questioning techniques is highlighted by Covino and Iwanicki (1996) as an essential teacher characteristic to better interactions with the students. They further indicated that the quality of these interactions enhances teachers' ability to reach each individual in the classroom. In addition, while Stronge (2007) emphasized the essentiality of teachers' positive attitude toward teaching, Mitchell (1998) indicated the importance of their attitude toward life in addition to their teaching. Even though it is related to a small amount of change in student achievement, it is parallel to the findings of both Stronge et al. (2008) and Stronge et al. (2011) that teachers' satisfaction with their profession as a teacher is positively related to student achievement. Therefore, teachers' questioning of their students to have better interactions and to reach more to these individual students, as well as their satisfaction with their profession as a teacher are another two of the teacher characteristics that are significantly and positively related to students' mathematics achievement despite their small relatedness to .015 standard deviation change in student achievement.

On the other hand, the teacher characteristics of reflective practice (Covino & Iwanicki, 1996), using assessment (Rowan et al., 1997; Stronge et al., 2008; Stronge et al., 2011), enhancing student engagement (Cotton, 2000; Stronge et al., 2008; Stronge et al., 2011), and focus on instruction (Cotton, 2000; Stronge et al., 2008; Stronge et al., 2011) were found to be significantly related to students' mathematics achievement after controlling for the associated covariates, but negatively, as opposed to the researchers' findings (Figure 5.1). Among the significantly and negatively related teacher characteristics, these specific characteristics yielded higher than .050 standard deviation decrease in students' mathematics achievement relation to the 1 standard deviation increase in each characteristic, which is a remarkable difference from the other negatively related characteristics. Among the researchers indicated in the parentheses, Stronge et al. (2008) and Stronge et al. (2011) were the ones who worked empirically to indicate the difference between effective vs. ineffective (*n*=11) or top- or bottom-quartile teachers (*n*=32), respectively. Both studies found the characteristics indicated above as effective teacher characteristics as a result of the comparison between the two groups of those teachers. However, as they indicated, their sample sizes were very small, and studies involving larger sample sizes would yield more robust results. The results yielded from a larger sample, in this study, found that these characteristics are negatively related to students' mathematics achievement, which is in direct opposition to the results of the smaller sample sizes. As a result of this study, 1 standard deviation increase in the *frequency of teachers' interaction with other teachers related to their teaching experiences* is related to .060 standard deviation decrease in their students' mathematics achievement, interestingly. Stronge (2007) defined these interactions as the cautious self-criticism and introspective practices in terms of the improvement of their teaching practices. However, it was used the frequency of these interactions as a measure in this study, based on the availability of the data. If there was an available data regarding the quality of these interactions instead of their quantities, it would yield more meaningful results. Thus, it can be concluded that the quantity of the interactions between the teachers is not a positively related factor of students' mathematics achievement among the focal EU countries.

Another teacher characteristic found to be significantly and negatively related to students' mathematics achievement across the focal EU countries is using assessment. Based on the item used to measure this variable, it was found that 1 standard deviation increase in *teachers' emphasis on assessment of students' ongoing work to monitor their progress in mathematics* is related to .061 standard deviation decrease in students' mathematics achievement. Although Stronge's (2007) suggestion to teachers to use assessment to monitor students' progress and shape the further instruction, and Stronge et al.'s (2008) and Stronge et al.'s (2011) findings indicating that effective and top-quartile teachers had higher mean scores on using assessment in the classroom, there might be other factors related to how teachers emphasize the assessment that yields to a negative relation with achievement.

In addition, enhancing student engagement was also found to be significantly and negatively related to students' mathematics achievement in the focal EU countries. 1 standard deviation increase in the *frequency of teachers' encouragement of classroom discussion among students* is related to .071 standard deviation decrease in students' mathematics achievement. Stronge (2007) stated that there was no only one strategy to ensure classroom discussions. And, Cotton (2000) specified that "flexible in-class grouping" could be an effective contextual method to enhance student engagement with the instruction. Therefore, again, quantity of a teacher characteristic was found to have a negative relationship with student achievement. As a result, quantity of teachers' encouragement of student engagement was found to be negatively related to students' mathematics achievement in the focal EU countries; however, questions regarding the quality of these teachers' effort to ensure student engagement may yield more meaningful results in terms of this essential variable.

Among the teacher characteristics that found to be significantly and negatively related to students’ mathematics achievement, focus on instruction was the one holding the strongest negative relationship. As a result of this study, it was found that 1 standard deviation increase in *teachers’ confidence to help students to appreciate the value of mathematics* is related to .079 standard deviation decrease in students’ mathematics achievement. Stronge (2007) indicated that teachers’ effort to keep the focus on the mathematics learning not only helps teachers to manage the lesson, but also students to accomplish to meet the challenges of the lesson, as Cotton (2000) also emphasized the focus on learning in the classroom. However, it is measured the teachers’ confidence to help their students to appreciate learning mathematics. Keeping students’ focus on instruction may slightly be different than the focus on the idea of learning mathematics, but the concept of the focus on instruction is a little broad term. Therefore, based on the availability of the item in TIMSS, teachers’ confidence to focus on the idea of students’ learning mathematics is negatively related to mathematics achievement while literature suggested that the focus on instruction, in general, is a positively related teacher characteristic to student achievement. It was even the strongest negatively related teacher characteristic among the total of 24.

In addition to the negatively and strongly related characteristics, the characteristics of content and pedagogy (Aaronson et al., 2007; Betts et al., 2003; Boyd et al., 2005; Bruce et al., 2010; Clotfelter et al., 2007; Hill et al., 2005; Monk, 1994; Rowan et al., 1997; Stronge et al., 2011) and use of homework (Cotton, 2000; Jepsen, 2005; Stronge et.al, 2008; Stronge et al., 2011) were also found to be significantly and negatively related to students’ mathematics achievement after controlling for the associated covariates (Figure 5.1). However, these were the teacher characteristics with 1 standard deviation increase in each yields to .050 standard deviation decrease in students’ mathematics achievement. In terms of the content and pedagogy knowledge of the teachers, among the researchers that studied these characteristics, Betts et al. (2003) indicated that there is no statistical difference between the teachers with education or mathematics degree in terms of their effectiveness. Aaronson et al. (2007) also stated that having an education or mathematics degree is related to the teacher quality; however, it has a very small effect. In this study, content and pedagogy knowledge of teachers is measured by an item that asks them if they majored in mathematics or mathematics education. While the value 0 indicated no major in mathematics or mathematics education, 1 indicated majoring in mathematics, and 2 indicated majoring both in mathematics and mathematics education. Therefore, the findings of this study support the notion that content and pedagogy knowledge of the teachers measured by their college major is significantly however negatively related to students' mathematics achievement. One of the findings of the current study was that students of the teachers who did not obtain mathematics or mathematics education degree showed higher performance in mathematics in the overall focal EU countries.

In terms of the characteristic of use of homework, it was found in this study that 1 standard deviation increase in the *frequency of teachers' classroom discussions of the mathematics homework assignments* is related to .033 standard deviation decrease in their students' mathematics achievement. Jepsen (2005) stated that use of homework had a significant impact on student achievement only when students' prior achievement is controlled. On the other hand, Stronge et al. (2008) found ineffective teachers had higher scores on use of homework while Stronge et al. (2011) indicated top-quartile teachers had higher scores interestingly. However, Cotton (2000) indicated that homework is essential after the fourth-grade to let students know their progress. As a result, as opposed to Cotton (2000), this study found that the frequency of teachers' classroom discussions regarding the homework is negatively related to students' mathematics achievement while the frequency of their assignment of mathematics homework to their students may lead to different results, especially considering the opposite results in Stronge et al.'s (2008) and Stronge et al.'s (2011) studies.

Research Question – 2. The European Commission (2011a) indicated several differences between the EU countries in terms of the mathematics teaching implementations. However, the ones related to the teacher characteristics defined by Stronge (2007), which provides the conceptual framework for this study, are the interests of this study. As a reminder, second research question of this study was "What are the differences among the focal EU countries in terms of the relationship between students' mathematics achievement and their teachers' characteristics as these are demonstrated differently in the national strategies and initiatives across these countries? Therefore, the current study was focused on the variables of 'content and pedagogy knowledge, classroom management, motivation, teaching complexity (making mathematics relevant), enhancing student engagement, and use of homework' when discussing the differences across the focal EU countries in terms of the teacher characteristics and their relation to students' mathematics achievement. The following section features an interactive discussion of the results of the conditional models (interaction models) which were created individually for each of these variables and the differences actually indicated by the European Commission (2011a). However, since the interaction model for the teacher characteristic of teaching complexity (making mathematics relevant) was not found to significantly fit better than the random intercept model with the data, it was concluded that this teacher characteristic was not significantly differ across these countries in terms of its relationship with students' mathematics achievement; thus, it is not interpreted the results of that interaction model below.

Content and Pedagogy Knowledge. It was found that the relationship between the teachers' content and pedagogy knowledge and students' mathematics achievement is moderately positive in Slovenia and Sweden, slightly positive in Hungary, Lithuania, and Malta, slightly negative in Italy, and moderately negative in Turkey, when comparatively examining the plots of the interaction models (Figure 4.1) while it was found to be significantly but negatively related to student achievement for the pooled sample of focal EU countries as a result of the random intercept model (Figure 5.1). As indicated above, content and pedagogy knowledge of the teachers is measured if they major in mathematics or mathematics education (Appendix A). While the value 0 indicated no mathematics and mathematics education majors amongst the teachers, 1 indicated majoring in mathematics, and 2 indicated majoring both mathematics and mathematics education. Therefore, students' mathematics achievement is negatively related to whether their teachers have more background in the content of mathematics or both in the content and pedagogy of mathematics in Turkey and Italy, while the relationship is positive in the other countries. On the other hand, Betts et al. (2003) indicated that there is no significant difference between the teachers with the mathematics education or mathematics degree in terms of their effectiveness while Aaronson et al. (2007) stated that there is a difference between the teachers with mathematics education or mathematics degree; however, it is very small. Therefore, the results from the focal EU countries in this study revealed that there is a relationship between teachers' content and pedagogy knowledge and students' mathematics achievement, even though it is negative in Italy and Turkey, and positive in the rest of the countries, as opposed to the previous researchers' findings.

The European Commission (2011a) noted that that while there is no central regulation in Hungary, Slovenia, and Sweden, there is in Italy, Lithuania, Malta, and Turkey in terms of the percentage of the content and pedagogical courses in the teacher education programs. The total percentage of the mathematics subject and mathematics teaching courses in the overall course loadings in the general teacher education programs in these countries ranges from 4% to 10% (Table 1.2). On the other hand, the total percentage in the specialist teacher education programs are very high in Lithuania, Malta, and Turkey, the total ranging from 56% to 81%, while it is low in Italy (20%). However, both the European Commission (2011a) and the European Commission of 2015 indicated that it is suggested across the EU countries that teachers be educated in both the content and pedagogical aspects of mathematics. However, in Italy, the course loads for teachers who go through either the general or the specialist teacher education programs is low. On the other hand, in Lithuania, Malta, and Turkey, specialist teacher education programs offer a higher percentage of both mathematics and mathematics education courses.

As a result, in Lithuania and Malta, the relationship between the teachers' content and pedagogical knowledge and students' mathematics achievement is positive while teacher education with a high percentage of mathematics and mathematics education courses are provided. This means that when teachers used the opportunities provided to them and achieved higher content and pedagogical learning, it is more likely to their students achieved better on mathematics. Or, considering the reverse causality, high-achieved students in mathematics could be matched with the teachers who have higher content and pedagogical backgrounds in these countries. However, in Italy and Turkey, the relationship between the teachers' content and pedagogical knowledge and students' mathematics achievement was shown to be negative. In Italy, even in the specialist teacher education programs, the percentage of the mathematics and mathematics education courses is 20% in the total course loadings. Therefore, teachers actually did not have a higher opportunity to achieve content and pedagogical learning when comparing with other countries. These percentages actually represent the minimum requirements by these countries; however, they at least provide the general situation for the comparison purposes. It still does not explain the negative relationship between teachers' content and pedagogy knowledge and students' mathematics achievement; however, it might be possible that the course loadings of these two main aspects was very low to conduce toward negative relationship with students' mathematical understanding. On the other hand, in Turkey, the total percentage of these mathematics and mathematics education courses is 80% in the specialist teacher education programs. Therefore, Turkey's case is very different than the other countries. While there is an opportunity for teachers to go through specialist teacher education programs in order to gain further content and pedagogical experiences, students' mathematics achievement was still negatively related whether teachers used this opportunity or not to have higher content and pedagogical background in mathematics. As a result, it might be possible in Turkey that the course loadings of the mathematics and mathematics education courses may be higher than it should be for the Turkish mathematics teachers during their teacher education programs (80%), considering the fact that students of the teachers who did not major in neither mathematics nor mathematics education have higher scores than the ones did. Or, these teachers who did not major in these two programs might gained their content and pedagogical experiences in the field rather than in a teacher education program. Therefore, it is essential to examine the additional characteristics of these teachers in Turkey to reveal the reasons behind their students' higher mathematics achievement. In addition, a study that seeks for how mathematics and mathematics education courses in Turkey help teachers to gain their content and pedagogy knowledge would also yield more meaningful results. Even though these results reflected the situation after controlling the relationship between the other characteristics and student achievement, there might be additional factors that this study did not cover. In addition, since the findings of this study do not reflect causal relationships, it is essential to think in the opposite way. It means there is a possibility in Turkey that high-achieved students in mathematics could be matched with the teachers who did not major in these two programs.

Classroom Management. Based on the item used to measure the teacher characteristic of classroom management in TIMSS, it was observed that the relationship between teachers' perception of their students' orderly mannered behaviors and students' mathematics achievement is highly positive in Hungary, Italy, Lithuania, and Malta, slightly positive in Turkey, and slightly negative in Slovenia and Sweden, as a result of comparative examination of the plots of the interaction models (Figure 4.2) while it is found to be significantly and positively related to student achievement for the pooled sample of focal EU countries (Figure 5.1). Therefore, the mathematics achievement of the students whose teachers perceived them to behave more in an orderly manner seem higher in Hungary, Italy, Lithuania, and Malta while it is slightly higher in Turkey. Interestingly, mathematics achievement of the students whose teachers perceived them to behave in an orderly manner seems slightly lower in Slovenia and Sweden, as opposed to what Stronge (2007) and Wang et al. (1993) indicated that effective teachers manages the classroom better by preventing misbehaved student behaviors.

The European Commission (2011a) report indicated that there are no central guidelines in Hungary, Italy, and Sweden while it was recommended for teachers to group students in their classrooms in Lithuania, Malta, Slovenia, and Turkey for classroom management's sake (Figure 1.1). Therefore, it was seen that students' mathematics achievement is positively related to teachers' perception of their students' orderly mannered behaviors in the countries where it was recommended that there should be types of grouping for the better classroom management

(Lithuania, Malta, and Turkey), except Slovenia. This relationship is also slightly negative in Sweden, where there is no central guideline for grouping students for the better classroom management. On the other hand, in Hungary and Italy, even though there is no central guideline for grouping students in the classrooms, the relationship between teachers' perception of their students' orderly mannered behaviors and students' mathematics achievement is highly positive. It can be inferred that teachers already had strategies in Hungary and Italy even though they are not encouraged by the central initiatives. However, in Slovenia, teachers were encouraged to have classroom management strategies, such as grouping students, and mathematics achievement of the students whose teachers perceived them to behave in an orderly manner seems lower. Therefore, the case of Slovenia is different than the other countries. It is essential to examine how teachers follow the central suggestions to manage the classroom, how they perceive whether their students behaved in an orderly manner or not, or the reasons behind the negative relatedness of this perception to students' mathematics achievement in Slovenia. It might be possible that teachers tried to manage the classroom by preventing the misbehaviors of the students more than the expected. In other words, the extent to which teachers prevent students' misbehaviors may exceed its optimum level and lead to obstruct students' engagement with the instruction.

In addition, even though there was no central guideline, the relationship is also negative in Sweden. Thus, it may also be helpful to examine how teachers perceive if their students behaved in an orderly manner, or the actions they take to ensure about that in Sweden. However, again, it is also worth to mention that this study did not look neither capable for the causal relationships. Therefore, there is always the opposite direction of students' mathematics achievement and its impact on teachers' perception of their students' orderly mannered behaviors in the classroom. It is also possible that when students achieved higher in mathematics, their teachers perceive them to behave more in an orderly manner.

Motivation. As a result of the comparative examination of the plots of the interaction models, it was found that the relationship between the teachers' confidence to inspire students to learn mathematics and students' mathematics achievement is highly positive in Hungary and Malta, slightly positive in Italy, Lithuania, Sweden, and Turkey, and moderately negative in Slovenia (Figure 4.3) while it was found to be significantly and positively related to student achievement for the pooled sample of focal EU countries as a result of the random intercept model (Figure 5.1). Thus, mathematics achievement of the students whose teachers felt more confident to motivate or inspire them to learn mathematics seems higher in all focal EU countries, except Slovenia. While Covino and Iwanicki (1996) indicated that effective teachers are the ones using variety of strategies to increase students' intrinsic and extrinsic motivations, Rowan et al. (1997) found as a result of their study that teachers' motivation had a very large effect on increasing students' mathematics achievement. Therefore, only the result for the Slovenia showed inconsistency with the previous researchers' findings in terms of teachers' confidence to inspire students to learn mathematics and its relationship with students' mathematics achievement.

The European Commission (2011a) indicated that there is no national strategy or initiatives for teachers to motivate their students in Hungary, Lithuania, Slovenia, and Turkey while there are national strategies or centrally coordinated initiatives in Italy, Malta, and Sweden (Figure 1.2). As a result, students' mathematics achievement found to be related to teachers' confidence to inspire students to learn mathematics in the countries where there are some national strategies or initiatives to encourage teachers to do so. However, it was also found to be related to students' mathematics achievement in the countries where there is no national strategy or initiative, except Slovenia. Slovenia is the only country across the focal EU countries where the relationship between teachers' confidence to inspire students to learn mathematics and students' mathematics achievement is negative, as opposed to previous researchers' findings, and there is no national strategy or initiative to encourage teachers to motivate their students. It is observed in the cases of Hungary, Lithuania and Turkey that this relationship can be positive even though there was no central guideline. Therefore, it is important to examine how teachers in Slovenia feel confident to inspire students to learn mathematics. It is possible that their perception of the confidence to inspire their students may be different than their colleagues in the other countries. Or, the way they feel confident about inspiring their students and the actual inspiration students acquired could be different in Slovenia.

Teaching Complexity (Making Mathematics Relevant). Since the interaction model for the teaching complexity (making mathematics relevant) did not fit significantly better with the data than the random intercept model, which is identical to this interaction model except the interaction term, it was concluded that the relationship between teachers' confidence to make mathematics relevant to their students and students' mathematics achievement moderated by the country membership was not significant. In other words, there was no significant difference between the focal EU countries in terms of the relationship between teachers' confidence to make mathematics relevant and students' mathematics achievement although countries have different national strategies or centrally coordinated initiatives in terms of the teacher characteristic of making mathematics relevant to their students, according to the report by the European Commission (2011a). As a result, it was not interpreted the results of the estimations of the interaction model for the teaching complexity (making mathematics relevant).

Enhancing Student Engagement. The teacher characteristic of enhancing student engagement showed a similar result to motivation in terms of the dividedness among the countries. Comparative examination of the plots of the interaction models revealed that the relationship between the frequency of teachers' encouragement of classroom discussion among students and students' mathematics achievement is moderately positive in Lithuania, neutral in Sweden, moderately negative in Hungary, Malta, Slovenia, and Turkey, and highly negative in Italy (Figure 4.5), while it is found to be significantly but negatively related to student achievement for the pooled sample of focal EU countries as a result of the random intercept model (Figure 5.1). Therefore, mathematics achievement of the students whose teachers encourage more of classroom discussions among them unexpectedly lower in all the focal countries but two: Sweden (neutral) and Lithuania (moderately higher). Stronge et al. (2008) and Stronge et al. (2011) indicated as a result of their empirical studies that the characteristic of enhancing student engagement was one of the effective teacher characteristics. However, Stronge (2007) also indicated that there was not only one way for the teacher to ensure student engagement in the classroom.

The European Commission (2011a) indicated that student engagement in the mathematics classroom is not centrally promoted in Sweden and Turkey in relation to both teaching methods and extracurricular activities. However, in Hungary and Italy, extracurricular activities are well promoted. Furthermore, in Lithuania, Malta, and Slovenia, extracurricular activities were highly promoted, and teaching methods were encouraged as additions (Figure 1.4). As a result, Lithuania again illustrated a positive relationship between the frequency of teachers encouragement of the classroom discussions among the students and students' mathematics achievement when student engagement was centrally promoted through teaching methods and extracurricular activities. In addition, the relationship is negative in Malta and Slovenia even though both of these methods were centrally promoted. In Hungary and Italy, only extracurricular activities are centrally promoted, but the relationship is still negative. In Sweden and Turkey, neither of these methods were centrally promoted, but the relationship seemed neutral in Sweden and negative in Turkey. Therefore, on the one hand, Lithuania is the only country holding a positive relationship, as previous researchers indicated, and having centrally promoted strategies for the teachers in terms of enhancing student engagement, for the sake of student achievement. On the other hand, Hungary, Italy, Malta, and Slovenia also have centrally promoted strategies for the teachers to enhance student engagement; however, the relationship between the frequency of teachers' encouragement of student engagement and mathematics achievement is negative in these countries. Thus, it is essential to remind what Stronge (2007) indicated, there is not only one way to ensure student engagement in the classroom. And, also European Commission (2011a) indicated that it was mostly used ICT (information and communication technologies) to enhance student engagement in the EU countries. As a result, it can be concluded that EU countries should examine into the strategies they encourage teachers to do for enhancing student engagement. It may worth EU countries to show attention to Cotton's (2000) recommendation of promoting "flexible in-class grouping" strategy to the teachers. In addition, Sweden is the country where there is no central initiatives and the relationship between the frequency of teachers' encouragement of classroom discussions and students' mathematics achievement is almost neutral.

Use of Homework. Comparative examination of the plots for the interaction models for the focal countries indicated that the relationship between the frequency of teachers' classroom discussions of the mathematics homework assignments and their students' mathematics achievement is moderately positive in Lithuania and Slovenia, while slightly positive in Malta and Sweden. On the other hand, the relationship is slightly negative in Hungary and Turkey, and moderately negative in Italy (Figure 4.6) while it was found to be significantly but negatively related to student achievement for the pooled sample of focal EU countries as a result of the random intercept model (Figure 5.1). Therefore, mathematics achievement of the students whose teachers discuss the homework assignments more in the classroom seems higher in Lithuania, Malta, Slovenia, and Sweden while lower in the rest of the focal EU countries. Or, in an opposite causality, higher-achieved students in mathematics in these countries could be matched with the teachers who discuss the homework assignments more in the classroom. This supports Cotton's (2000) claim that homework is essential after the fourth-grade to let students know their progress in the classroom, in the countries where there is a positive relationship. On the other hand, as indicated earlier in the study, while Stronge et al. (2008) interestingly found that ineffective teachers have higher scores, Stronge et al. (2011) found out that top-quartile teachers have higher scores in using homework.

The European Commission (2011a) report stated that there is no central guideline for teachers to assign homework in Hungary, Italy, Malta, Slovenia, and Sweden while there is a general guideline for all the subjects including mathematics in Lithuania, and specific guidelines for mathematics in Turkey (Figure 1.5). Again, Lithuania is completely different from the other countries. It is the country where there is a guideline (at least general) for assigning homework for the teachers and the relationship between frequency of teachers' discussions of the homework in the classroom and students' mathematics achievement is positive. Where there is a specific guideline for teachers in Turkey, the relationship is slightly negative. It can be suggested as a result of this study that countries should pay attention to not only promote their teachers to assign homework, but also to discuss it in the classroom so that their students know their progress. Lithuania case proved that students' mathematics achievement is positively related to the time teachers spend in the classroom to discuss the homework assignment and there is at least a general guideline for teachers to use homework. The results for Slovenia, Malta, and Sweden also showed that teachers' discussion of the homework in the classroom is positively related to students' mathematics achievement even though there is no central guideline for teachers to do so. The result for Turkey, however, unexpectedly showed that even though there is a guideline for teachers, even specifically designed for mathematics, mathematics achievement of the students whose teachers spend more time in the classroom to discuss the homework assignments seems lower than the ones do not spend. There is no information regarding the way how teachers discuss the homework in the classroom in Turkey, neither it was assumed that teachers only discussed the answers for the homework in the classroom. However, it might be useful to examine into how homework assignments are discussed with the students in the classroom in Turkey and encourage teachers to find more effective ways to take advantage of the homework assignments. It was not assumed that teachers only discuss the answers of the homework assignment in the classroom in Turkey; however, it may be more useful if teachers discuss the homework in the classroom in a way that leads to let students know more of their progress. Otherwise, spending the partial amount of the class time on homework discussions may also yield to a lack of time their teachers spend on the topic of the day.

Limitations of the study

This study employed a cross-sectional multi-country level data that represents the seven focal EU countries that participated in TIMSS 2015. Due to the nature of the data itself, it was not possible to make powerful causal inferences. Since the data acquired was only from one school year, it was not possible to examine the trends in teacher characteristics and students' mathematics achievement over time. TIMSS collects data in a four-year cycle; however, the sample of each assessment is different than the previous ones. Therefore, it would be a suggestion to the TIMSS developers to find a way to collect the data in multiple years with the same sample so that researchers can conduct longitudinal studies. Examining the trend in time instead of on a single year-based will help researchers to make more causal inferences in terms of the student achievement and the factors related. In this study, the relationship between the teacher characteristics and students' mathematics achievement was only based on the most recent TIMSS assessment in 2015. Therefore, estimated relationships within and between the focal EU countries only indicated the most likely possibilities that need to be examined further in depth. As a result, the possibilities revealed in this study may help researchers, including myself, in conducting future in-depth analysis so that more causal inferences can be made. However, the contributions of this study in terms of providing the broad picture of the teacher characteristics-students' mathematics achievement construct across the focal EU countries cannot be ignored.

The second limitation of this study was the lack of the control over the items used to measure the variables. An item for each teacher characteristic was picked from the TIMSS 2015 teacher questionnaire that was answered by the mathematics teachers, according to how Stronge (2007) (the conceptual framework of this study) defined each characteristic. Close attention was paid to the questionnaire, in order to choose the best suitable item for each teacher characteristic. However, this method was not as effective as creating new items according to the definitions by Stronge (2007) and giving them to teachers directly. However, it was almost impossible to collect information directly from the teachers from those seven different countries. Moreover, the reliability and validity would become a major concern in that case. Therefore, using only one item for each variable is another limitation of the study. However, items were picked based on how Stronge (2007) defined each characteristic, and there were no multiple available items for these characteristics in TIMSS data set to compute a composite score for each characteristic.

Lastly, while there was no control over the wording of the items used to measure the variables of this study, there was also no control over the differences in the response patterns of students and teachers on TIMSS items among the different EU countries. The term for this is measurement invariance. Steenkamp and Baumgartner (1998) indicated that the differences of the responses from the individuals of different countries on a scale might be caused either by the 'true difference' between these individuals, which the scale of the item intended to measure, or the 'systematic biases' in the cultural response patterns of these individuals to the certain items. Therefore, while this is the last limitation of the study, it is certainly not the least. However, working on the measurement invariance between these countries can be a subject of an entire study and it is out of the scope of this dissertation study. However, it could be a topic of further research.

Implications of the study

In this study, the results for the relationship between the teacher characteristics and students' mathematics achievement for the first research question of this study reflect the estimations of the conditional model (random intercept model), which is estimated through the pooled sample of overall focal EU countries (*n*-students = 26,021, *n*-teachers = 1,399). Besides the significantly and positively related teacher characteristics to student achievement, it is discussed the ones having no significant or significant but negative relationship with students' mathematics achievement in this section to provide insight implications to the controversial findings this study provided to the previous researchers' findings. As a result of this study, teachers' perception of students' respect to themselves, feeling of enthusiasm about their job, confidence to inspire students to learn mathematics, confidence to adapt teaching to engage students' interests, confidence to make mathematics relevant to students, organization of the materials to cover in the class, and the frequency of correcting assignments and giving feedback to students, which were found to be effective teacher characteristics in previous studies, were found not to be significantly related to students' mathematics achievement across the overall EU countries. As indicated earlier, this study is not looking nor capable for the causal relationships. Therefore, these relationships reflect both directions. In other words, while it is possible that there is no significant difference between students' mathematics achievement whether or not their teachers have higher scores on the characteristics given above, it is also possible that there is no significant difference in teachers' given characteristics whether their students achieved higher in mathematics or not. Thus, the results should be read by both possibilities. On the other hand, based on the items used in this study, these characteristics were measured mostly by teachers' perceptions, feelings, and confidence; therefore, they reflected teachers' self-reported perspectives regarding these characteristics. Therefore, it also raises a concern that how teachers feel about these characteristics and their actual implications in the classroom might be different. However, considering the difficulty of measuring these implications, especially in a large-scale assessment data, their perceptions, feelings, or confidence can still give hints regarding the actual implications in the classrooms from the teachers' perspective. Otherwise, it would be very difficult to measure their actual implementations in the classrooms, which will most likely raise some other major concerns.

In addition, there was also a controversy with the teacher characteristics that are found to be significantly related to students' mathematics achievement by the previous researchers. The teacher characteristics of “content and pedagogy knowledge (Aaronson et al., 2007; Betts et al., 2003), homework (Cotton, 2000; Jepsen, 2005; Stronge et al., 2008; Stronge et al., 2011), reflective practice (Covino & Iwanicki, 1996), using assessment (Rowan et al., 1997; Stronge et al., 2008; Stronge et al., 2011), student engagement (Stronge et al., 2008; Stronge et al., 2011), and focus on instruction (Cotton, 2000; Peart & Campbell, 1999; Stronge et al., 2008; Stronge et al., 2011)” were indicated by the relevant researchers stated in the parentheses, found to be significantly but negatively related to students’ mathematics achievement in the focal EU countries, as a result of this study. When considering the items used to measure these characteristics, again there are two possibilities. First of all, mathematics achievement of the students whose teachers have more content and pedagogical college experiences, discuss the homework assignments more in the classroom, interact more with other teachers for their teaching experiences, put more emphasis on assessments of students’ ongoing work to monitor their progress, encourage students to have classroom discussions more, and more confident to help students to appreciate the value of learning mathematics are lower than the ones do less. Or, teachers perform more of the mentioned characteristics could be matched with lower achieved students in mathematics, in the other perspective. Therefore, both possibilities are provided in the following implications that this study makes.

First of all, it is interesting that teachers’ content and pedagogical knowledge was negatively related to students’ mathematics achievement. While Betts et al. (2003) indicated that there was no difference between the teachers with mathematics or education degree, Aaronson et al.’s (2007) indicated both of them have a very small effect on teacher quality. As a result, it is possible that teachers’ content and pedagogical knowledge in the focal EU countries may have different impact on student achievement than in the other countries, which is a low possibility.

On the other hand, it is highly possible that high achieved students in these countries are placed in the classroom of the teachers who have less content and pedagogical background in their college experiences. Therefore, it is possible that these teachers having high achieved students in their classrooms might acquire their content and pedagogical knowledge through their in-class experiences rather than through their pre-service education. Nevertheless, it does not change the situation that it is essential to examine deeply how teacher education courses successfully work to provide the content and pedagogical knowledge experiences to the teachers in these focal EU countries, based on the negative relatedness to students' mathematics achievement.

In addition, the frequency of in-class homework discussions also found to be negatively related to students' mathematics achievement. While Stronge et al. (2011) found that top-quartile teachers assign more homework assignments, Stronge et al. (2008) indicated the opposite. Therefore, in addition to Stronge et al.'s (2008) finding on the frequency of assigning them, this study added that frequency of discussing the homework assignments is also negatively related to student achievement. This raises a concern regarding the use of homework to enhance student achievement. Should we really use homework assignments? If so, what would be a proper way to take advantage of students' effort to work on them and spending partial time of the instruction to discuss them in the classroom.

Further, while Covino and Iwanicki (1996) stated that effective teachers analyze and improve their teaching practices and share their experiences with other teachers, student achievement is found to be negatively related to the frequency of teachers' interaction with others to discuss their teaching practices, in the focal EU countries. The context of these discussions, therefore, might have a negative impact on teachers in terms of supporting their students to achieve. Or, teachers interact more with other teachers when they have low-achieved students, which is better likely possible. The frequency of these interactions, on the other hand, does not give an idea of the quality of these interactions. Understanding the possible negative contexts of these interactions that might yield to lower student achievement, or the opposite situation, which is the contextualization of these interactions arising by having low-achieved students, will make more sense why it is negatively related to student achievement.

Teachers' emphasis on assessment of students' ongoing work is another teacher characteristic found to be negatively related to students' mathematics achievement. While it is possible that the way teachers put emphasize on the assessments in the classroom may have a negative impact on student achievement, it is high likely possible the opposite direction that teachers emphasize the assessments more in the classrooms when their students achieve low in mathematics. The frequency of teachers' encouragement of the classroom discussions among the students also seems a negatively related teacher characteristic to student achievement. It is again possible that teachers' effort to ensure student engagement might yield to low student achievement, or they ask their students to engage more when their students achieve lower on mathematics. Besides the both possibilities, I would like to highlight another aspect. Frequency actually gives hint about the quantity of teachers' emphasis on assessment or encouragement of student engagement; however, again the quality of teachers' effort would yield more meaningful results. For instance, frequently reminding students to have discussions among each other may not be sufficient by itself; however, whether or not teachers take a participant role in these discussions or bringing students' perspectives from the discussion groups to the whole classroom level would most likely be more effective. Therefore, it is highly suggested assessment developers to have more of these items asking teachers about the details rather than the frequencies of the occurrences.

Last teacher characteristics was their confidence to help students to appreciate the value of learning mathematics. It would be a high likely possibility that teachers help students to appreciate the value of learning mathematics when they have low-achieved students if this item was measuring the frequency. However, it was asked teachers about their confidence to help students. Therefore, it is interesting in terms of both aspects that teachers felt more confident to help them to appreciate to learn mathematics when they have low-achieved students or students' mathematics achievement is lower when their teachers felt more confident to help them. It is essential to ask teachers how they perceive the confidence of helping students to appreciate the value of learning mathematics. For instance, when a teacher frequently says students "mathematics is important, guys!" and feels confident about his/her help the students to appreciate the value of learning mathematics, can we count this teacher as a confident or helpful? One of the most common explanations I had heard from my teachers was "mathematics is important because you need to learn it to have your degree and earn your own money". We should understand how this kind of statement can give a student stress to learn mathematics that may end up with low achievement. Therefore, again, there is a need of an in-depth analyses on these findings to see why teachers' confidence, for example, to help their students to appreciate mathematics is negatively related. Teacher educators can also play an important role by providing better strategies to teacher candidates for how they can help their students to appreciate mathematics. Rather than explaining the importance of mathematics in the placement tests, or school applications, providing the examples of the applications of mathematics in the applied sciences would be a better strategy, for instance.

Based on the findings, this study revealed that the relationship between teacher characteristics and students' mathematics achievements will change based on the population. In the literature review, it was indicated that the empirical studies focused on this matter mostly worked with the U.S. population (e.g., Aaronson et al., 2007; Clotfelter et al., 2007; Clotfelter et al., 2010; Hill et al., 2005; Kane & Staiger, 2008; Kane et al., 2008; Monk, 1994; Nye et al., 2004; Stronge et al., 2008; Stronge et al., 2011). Therefore, some of the characteristics they found to be related to student achievement were not estimated to be related in this study, or related but negatively for the pooled sample of focal EU countries. Therefore, it was estimated in this study that the relation of every teacher characteristic to the students' mathematics achievement may be different in different educational systems.

In addition, the disparity between the previous researchers' positive findings and the negative estimations in this study, does not mean that these characteristics have a negative impact on student achievement. This study does not look for causal relationships, neither it is capable of doing so, as discussed in the limitations section. However, these negative estimations might be related to the actual implications of these characteristics in the teaching and learning environments. For instance, reflective practice is indicated as an effective teacher characteristic by the previous researchers (Covino & Iwanicki, 1996). This is a situation that occurs in the classroom when a teacher reflects upon his/her own teaching and concludes that his/her teaching abilities would be enhanced by the feedback provided by other teachers, thereby enhancing students' mathematics achievement. In the TIMSS 2015 teacher questionnaire, teachers were asked about the frequency of their interactions with other teachers in order to share what they had learned about their teaching experiences, in order to measure their reflective practices. Thus, we only have the information regarding the frequency of these interactions, however, these interactions between the teachers should be examined in-depth to understand why reflective practices are estimated to be negatively related to student achievement in the overall focal EU countries. Or, it is also possible that teachers might increase the frequency of interactions with other teachers when they have low-achieved students more in their classrooms. Therefore, it may be reasonable to conduct, for example, professional development activities for teachers and observe how they interact with each other in terms of their teaching practices, and when they decide to interact with other teachers. As a result, it may be revealed the reasons behind the unexpected relationship found between teachers' reflective practice and students' mathematics achievement, as opposed to the other researchers. Therefore, the findings of this study not only provide the big picture of the relationships between the teacher characteristics and students' mathematics achievement, but also gives possible future directions for the future researchers, especially through its controversial findings.

Considering the scope of this study, it was aimed to reveal the relationships, including the controversial ones, with the previous researchers' findings. It did not attempt to conduct in-depth analyses in the seven EU countries on the controversial teacher characteristics in this study. That kind of study will require more time and effort, as well as a larger budget, and should be conducted by the joint organizations of these EU countries with the help of a research team. Therefore, it can be a suggestion for researchers to conduct an in-depth analysis, especially on the teacher characteristics estimated to be non-significantly or significantly but negatively related to students' mathematics achievement. Working on the possible issues related to these characteristics and enhancing their actual implications in teaching and learning environments may yield improvements in student achievement.

In addition to pointing out the overall situation across the overall focal EU countries and the controversies between the findings of this study and previous researchers' findings based on the different populations, this study also aimed to reveal the differences between the focal EU countries in terms of the six teacher characteristics identified by Stronge (2007) and indicated by the European Commission (2011a). As a result of the estimations of the second conditional model (interaction models), it was found that countries also differ in terms of the teacher characteristics that are implemented differently in their curriculum and/or steering documents and their relationship to students' mathematics achievement.

In terms of the teacher characteristic of content and pedagogy knowledge, it was implied in this study that Turkey should be examined carefully. Even though there is an opportunity for teachers to go through the specialist teacher education programs to acquire more content and pedagogy knowledge, students' mathematics achievement was significantly decreased when their teachers had used this opportunity. Slovenia attracted a lot of attention in relation to the characteristic of classroom management. Although it was recommended to use strategies to manage the classroom better, the relationship between the teachers' perception of their students' orderly mannered behaviors and students' mathematics achievement is negative in Slovenia. Slovenia also illustrated a difference in terms of the characteristic of motivation. Teachers' confidence to inspire students to learn mathematics was generally found to be related to students' mathematics achievement, whether countries have national strategies or initiatives or not. This was not the case in Slovenia. Again, Slovenia also illustrated a remarkable difference in the characteristic of 'enhancing student engagement' along with Malta. While both teaching methods and extracurricular activities are centrally promoted to enhance student engagement in Slovenia and Malta, the frequency of teachers' encouragement of classroom discussions among students is negatively related to students' mathematics achievement in these countries. In addition, interestingly, this relationship is almost neutral in Sweden. Lastly, in terms of the use of homework, Turkey is different than the rest of the countries because, it is the only country where there is a specific guideline for mathematics and the relationship between teachers' use of homework and students' mathematics is negative. Lithuania also had mixed results across the board. In Lithuania, there were national strategies or initiatives for all of the teacher characteristics, except motivation. The relationship between all of these characteristics and students' mathematics achievement found to be positive in Lithuania.

As a result of the interaction models, Slovenia, Lithuania, and Turkey seem different than the other countries. While Slovenia was found to be the country where there are national strategies or initiatives for the all teacher characteristics except content and pedagogy and use of homework, the relationship between these four characteristics and students' mathematics achievement were negative. On the other hand, there are national strategies and initiatives in all teacher characteristics except motivation in Lithuania, and the relationship between all of the six characteristics and students' mathematics achievement were found to be positive. However, in terms of the characteristics of 'content and pedagogy' and 'homework', Turkey illustrated different results. Even though there were opportunities for teacher to acquire further content and pedagogy knowledge, and specific guidelines for the use of homework in mathematics, either by the curriculum and/or steering documents; the relationship between these two characteristics and students' mathematics achievement was found to be negative in Turkey.

Therefore, in addition to the findings for the overall EU countries, the differences found between the countries will also be useful for future researches. The differences will be useful because they reflect the possible linkages between the actual implications of the teacher characteristics in the curriculum and/or steering documents and the relationships found between these characteristics and students' mathematics achievement in the focal EU countries. While the implications of the characteristics and the relationships estimated in this study seems mostly consistent in Lithuania, that is not the case in Slovenia. Turkey also revealed inconsistencies, especially in the characteristics of content and pedagogy knowledge and use of homework. Therefore, in addition to the in-depth analyses of the actual implications of these characteristics in the overall EU countries in the teaching and learning environments, as suggested earlier in this section, the inclusion of these teaching practice implications in the curriculum and/or steering documents should also be closely examined, especially in these three countries. Examining the suggestions made to the teachers by the central authorities through these documents and how teachers react to these suggestions could also be the main focus of a study. Again, this study did not go beyond its scope because it would require much more time and effort, as well as a larger than budget than the capabilities of this dissertation study. However, these will most likely be future research interests for myself during my future career.

Direction for the future research

This dissertation study aimed to reveal the possible relationships between the teacher characteristics and students' mathematics achievement across the focal EU countries through testing the teacher characteristics suggested as effective by the previous studies with the help of the conceptual framework of this study (Stronge, 2007). However, there are some discrepancies in terms of the consistency between the relationships indicated by previous researchers and the estimated relationships in this study. While some teacher characteristics are estimated to be significantly and positively related as previous research indicated, some are estimated to be significantly but negatively related, and some are estimated not to be significantly related to students' mathematics achievement. Since these estimations across the focal EU countries indicated interesting possibilities, future research should focus on the in-depth analysis of these relationships in the actual classroom environment, especially in the context of EU countries.

As indicated before, Eurydice already published a report to reveal the reasons behind the low student mathematics achievement in the EU countries, entitled "Mathematics Education in Europe" (European Commission, 2011a). However, the possible reasons indicated by that report were based on a descriptive analysis of the circumstances among the countries. It was already indicated in that report that there is a need for a study that further analyzes the circumstances that have a relationship with students' mathematics achievement. This dissertation study aimed to satisfy the need for a secondary level analysis on student achievement in mathematics, especially in terms of teacher characteristics, across the focal EU countries by employing hierarchical linear modeling approach. Not only did the study demonstrate the relationships across the focal EU countries, but also the differences among them through the interaction models. The teacher characteristics identified by Stronge (2007) and indicated by Eurydice (European Commission, 2011a) were tested across the countries to reveal these differences. As a result, this study, given its limitations, may not only help educational researchers, but also policy makers when considering the differences in implementations of the teacher characteristics and their relationship with student achievement. It may also help educators, especially in the EU countries, to consider the characteristics of the teachers and their relationships with their future students' mathematics achievement, so that the teacher's preparation becomes more sophisticated. In addition, the classroom environments in Slovenia, Lithuania, and Turkey should be carefully examined. It seemed in these countries that the implications of the teacher characteristics in relation to the curriculum and/or steering documents and their relationship with students' mathematics achievement illustrated opposite results.

Nevertheless, the main future direction is to look at the actual classroom environments in the focal EU countries to understand why some teacher characteristics are negatively or positively related to students' mathematics achievement differently than the previous researchers' findings, and why some countries showed differences in these relationships in terms of some of these characteristics. Specifically, the analyses of the observations of the actual classrooms, and/or interviews with students and teachers may be helpful to reveal the actual in-depth circumstances with the help of the possible findings of this study. Researchers from the European countries can collaboratively work on this question with the help of the EU Council and Commission, including myself.

Conclusion

As indicated by the previous researchers, the characteristics of teachers that predict students' mathematics achievement and how these may differ among diverse populations (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011) are actually the concerns in this dissertation study. Thus, the framework developed by Stronge (2007) was used as the basis for analysis. He categorized effective teacher characteristics under six main themes, "prerequisites for effective teachers, the teacher as a person, classroom management and organization, planning and organizing for instruction, implementing instruction, and monitoring student progress and potential" (Figure 2.1) and identified the elements of each category. Through this conceptual framework, the elements he identified were tested across the overall focal EU countries to determine the teacher characteristics that possibly predict students' mathematics achievement. In addition, according to the Eurydice report (European Commission, 2011a), there has been reported differences in implementations of the six characteristics Stronge (2007) identified in these focal EU countries. Therefore, the six characteristics defined by Stronge (2007) and indicated by Eurydice (European Commission, 2011a) were also tested between the focal EU countries, to reveal how teacher characteristics could predict students' mathematics achievement differently across the focal EU countries.

One result of this study was the finding that teachers' perception of the limitation of their teaching by the disruptive students, encouragement of their students in the classroom to express their ideas, overall perception of their expectations for student achievement, frequency of assignment of more challenging exercises to their students, confidence of showing variety of problem solving strategies, teaching experience in years, need of time to prepare the lesson, perception of their students' orderly mannered behaviors, frequency of questioning of their students to explain their answers, and satisfaction with their profession as a teacher had a significant and positive relationship with students' mathematics achievement across the overall focal EU countries, in an order from the strongest to weakest, in accordance with the previous researcher's findings. On the other hand, as opposed to the previous research, their content and pedagogy knowledge, frequency of classroom discussions of the mathematics homework assignments, frequency of interaction with other teachers related to their teaching experiences, emphasis on assessment of students' ongoing work to monitor their progress in mathematics, frequency of encouragement of classroom discussion among students, and confidence to help their students to appreciate the value of mathematics had significantly but negatively related to students' mathematics achievement across these countries. In addition, their perception of students' respect to themselves, feelings of enthusiasm about their job, confidence to inspire students to learn mathematics, organization of the materials to cover the class, confidence to adapt their teaching to engage students' interest, confidence to make mathematics relevant to students, and frequency of correcting assignments and giving feedback to students were found not to be significantly related to students' mathematics achievement, as opposed to the previous researchers' findings. Therefore, while teachers do matter in the classroom in terms of their effects on student achievement according to the previous researchers, the characteristics of the teachers may differ based on the educational system they are in, as previous researchers also indicated (Aaronson et al., 2007; Jepsen, 2005; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011). EU countries jointly agreed to focus on raising student achievement (e.g., European Commission, 2011a; European Council, 2003; European Council, 2009) so that, while the Union respects the national actions taken by each country for this purpose, and did not identify specific goals for each country, it still worked on motivating them toward common principles. Therefore, this study revealed the possible relationships between the teacher characteristics and students' mathematics achievement across the overall focal EU countries that jointly aimed to raise students' mathematics achievement and collaboratively indicated the importance of the teaching practices. The results of these relationships are reflected on the possibilities of two directions, how these teacher characteristics may influence students' mathematics achievement or how student achievement may have an impact on these teacher characteristics. Even though this study is neither looking nor capable for providing a causal direction between these two aspects, in-depth further analyses will most likely reveal the powerful causalities. Nevertheless, it cannot be ignored the contribution of this study to provide a very broad picture of these relationships that may help teacher, teacher educators, and educational policy makers.

At the same time, in terms of the characteristics identified by Stronge (2007) and indicated by the report of European Commission (2011a), there were also major differences revealed among these focal EU countries. Therefore, this study also contributed to the literature by providing results from a large population of EU countries in terms of the differences in the relationship between the teacher characteristic and student achievement across these countries, as well. While the EU provides motivation to the member countries in terms of having common principles, it also respects the diversity in the educational systems towards these principles (Arslan-Cansever, 2009; Caliskan-Maya, 2006; European Council, 2009; European Council, 2014). Therefore, with the help of the Eurydice report (European Commission, 2011a) and the conceptual framework of this study (Stronge, 2007), the differences among the focal EU countries was also revealed. The aim of this study was not to make connections between the different relationships between teacher characteristics and students' mathematics achievement and the different implications of the teacher characteristics in the curriculum and steering documents. However, both of these aspects were provided through the descriptive explanations. According to these descriptively given aspects, Slovenia, Lithuania, and Turkey seemed different than the other countries. Slovenia seems to be a country where there are usually some national initiatives or strategies for the six teacher characteristics (European Commission, 2011a; Stronge, 2007), but the relationship between these characteristics and students' mathematics achievement are negative. On the other hand, Lithuania usually has strategies and initiatives, but the relationships are positive based on the estimations of this study. Turkey showed larger differences in the characteristics of 'content and pedagogy' and 'use of homework' than the other countries. While there are strategies or initiatives in Turkey in terms of these characteristics, the relationships were found to be negative in Turkey. Especially for 'use of homework', Turkey was the only country where there are specific guidelines to assign mathematics homework while it is negatively related to students' mathematics achievement.

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Appendices

Appendix A. *Variables Used in the Study and Relevant Items in TIMSS 2015*

Category	Variable	Relevant item in TIMSS 2015	Responses
Student Background	Female*	Are you a girl or a boy?	1- Girl 0- Boy
	Home Educational Resources	Home educational resources (derived variable)	Continuous variable
Teacher Background	Female*	Are you female or male?	1- Female 0- Male
Effective Teacher Characteristics **(Prerequisites)**	Content knowledge*	During your <post-secondary> education, what was your major or main area(s) of study? • Mathematics	1- Yes 0- No
	Knowledge of teaching and learning*	During your <post-secondary> education, what was your major or main area(s) of study? • Education–Mathematics • Education-General	
	Teaching experience	By the end of this school year, how many years will you have been teaching altogether?	Continuous variable
Effective Teacher Characteristics **(Teacher as a person)**	Caring	How often do you do the following in teaching this class? • Encourage students to express their ideas in class	1- Never 2- Some lesson 3- About half the lesson 4- Every or almost every lesson
	Fairness and respect	Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. • The students are respectful of the teachers	1- Disagree a lot 2- Disagree a little 3- Agree a little 4- Agree a lot
	Enthusiasm	How often do you feel the following way about being a teacher? • I am enthusiastic about my job	1- Never or almost never 2- Sometimes 3- Often 4- Very often
	Motivation	In teaching mathematics to this class, how would you characterize your confidence in doing the following? • Inspiring students to learn mathematics	1- Low 2- Medium 3- High 4- Very high
	Attitude toward teaching	How often do you feel the following way about being a teacher? • I am content with my profession as a teacher	1- Never or almost never 2- Sometimes 3- Often 4- Very often
	Reflective practice	How often do you have the following types of interactions with other teachers? • Share what I have learned about my teaching experiences	

Effective Teacher Characteristics (Class management and organization)	Classroom management	Thinking about your current school, indicate the extent to which you agree or disagree with each of the following statements. • The students behave in an orderly manner	1- Disagree a lot 2- Disagree a little 3- Agree a little 4- Agree a lot
	Disciplining students	In your view, to what extent do the following limit how you teach this class? • Disruptive students	1- A lot 2- Some 3- Not at all
	Organization	Indicate the extent to which you agree or disagree with each of the following statements. • I have too much material to cover in class	1- Disagree a lot 2- Disagree a little 3- Agree a little 4- Agree a lot
Effective Teacher Characteristics (Planning and organizing for instruction)	Focus on instruction	In teaching mathematics to this class, how would you characterize your confidence in doing the following? • Helping students appreciate the value of learning mathematics	1- Low 2- Medium 3- High 4- Very high
	Achievement expectations	How would you characterize each of the following within your school? • Teachers' expectations for student achievement	1- Very low 2- Low 3- Medium 4- High 5- Very high
	Planning for instruction	Indicate the extent to which you agree or disagree with each of the following statements. • I need more time to prepare for class	1- Disagree a lot 2- Disagree a little 3- Agree a little 4- Agree a lot
Effective Teacher Characteristics (Implementing instruction)	Instructional strategies	In teaching mathematics to this class, how would you characterize your confidence in doing the following? • Showing students a variety of problem solving strategies	1- Low 2- Medium 3- High 4- Very high
	Adapting instruction	In teaching mathematics to this class, how would you characterize your confidence in doing the following? • Adapting my teaching to engage students' interest	1- Low 2- Medium 3- High 4- Very high
	Teaching complexity	In teaching mathematics to this class, how would you characterize your confidence in doing the following? • Making mathematics relevant to students	1- Low 2- Medium 3- High 4- Very high
	High expectations	How often do you do the following in teaching this class? • Ask students to complete challenging exercises that require them to go beyond the instruction	1- Never 2- Some lesson 3- About half the lesson 4- Every or almost every lesson
	Questioning	How often do you do the following in teaching this class? • Ask students to explain their answers	1- Never 2- Some lesson 3- About half the lesson 4- Every or almost every lesson
	Student engagement	How often do you do the following in teaching this class? • Encourage classroom discussions among students	1- Never 2- Some lesson 3- About half the lesson 4- Every or almost every lesson

Effective Teacher Characteristics (Monitoring student progress and potential)	Homework	How often do you do the following with the mathematics homework assignments for this class? • Discuss the homework in class	1- Never or almost never 2- Sometimes 3- Always or almost always
	Feedback	How often do you do the following with the mathematics homework assignments for this class? • Correct assignments and give feedback to students	
	Using assessment	How much emphasis do you place on the following sources to monitor students' progress in mathematics? • Assessment of students' ongoing work	1- Little or no emphasis 2- Some emphasis 3- Major emphasis

Note 1. Binary variables marked with asterisk (*) were recoded to 1 and 0, from 1 and 2.
Note 2. Rest of the original TIMSS items were recoded into the reverse direction so that high values on the variable scales indicate higher positive meanings. For example, for the item "In teaching mathematics to this class, how would you characterize your confidence in doing the following? Helping students appreciate the value of learning mathematics", the response options were 1- Very high to 4- Low, but now recoded to 1- Low to 4- Very high.

Appendix B. *Relevant Resources for the Effective Teacher Characteristics*

Categories	Variables within the countries	Relevant resources	Variables between the countries
Prerequisites	Content and pedagogy*	Aaronson et al., 2007; Betts et al., 2003; Boyd et al., 2005; Bruce et al., 2010; Clotfelter et al., 2007; Hill et al., 2005; Monk, 1994; Rowan et al., 1997; Stronge et al., 2011	Yes
	Experience	Aaronson et al., 2007; Boyd et al., 2005; Bruce et al., 2010; Clotfelter et al., 2007; Clotfelter et al., 2010; Goldhaber & Anthony, 2007; Hill et al., 2005; Jacob & Lefgren, 2002; Jepsen, 2005; Monk, 1994; Nye et al., 2004; Rivkin et al., 2005; Stronge et al., 2011	-
Teacher as a person	Caring	Collinson, Killeavy, & Stephenson, 1999; Peart & Campell, 1999; Stronge et.al, 2008; Stronge et.al, 2011	-
	Fairness & respect	Agne, 1992; Stronge et.al, 2008; Stronge et.al, 2011	-
	Enthusiasm	Hill et al., 2005; Jepsen, 2005; Rowan et al., 1997	-
	Motivation	Covino & Iwanicki, 1996; Rowan et al., 1997	Yes
	Attitude tow. Teaching	Mitchell, 1998; Stronge et.al, 2008; Stronge et.al, 2011	-
	Reflective practice	Covino & Iwanicki, 1996	-
Class management and organization	Classroom management	Stronge et.al, 2008; Stronge et.al, 2011; Wang et al., 1993	Yes
	Disciplining students	Covino & Iwanicki, 1996; Stronge et.al, 2008	-
	Organization	Stronge et al., 2008; Stronge et al., 2011	-
Planning and organizing for instruction	Focus on instruction	Cotton, 2000; Stronge et al., 2008; Stronge et al., 2011	-
	Achievement expectations	Peart & Campbell, 1999; Stronge et al., 2008; McKown & Weinstein, 2008	-
	Planning for instruction	Stronge et al., 2008; Stronge et al., 2011	-
Implementing instruction	Instructional strategies	Peart & Campbell, 1999; Stronge et.al, 2008; Stronge et.al, 2011	-
	Adapting instruction	Covino & Iwanicki, 1996; Stronge et.al, 2008; Stronge et.al, 2011	-
	Teaching complexity	Stronge et.al, 2008; Stronge et.al, 2011	Yes
	High expectations	Mason et al., 1992	-
	Questioning	Covino & Iwanicki, 1996; Stronge et.al, 2008; Stronge et.al, 2011	-
	Student engagement	Cotton, 2000; Stronge et.al, 2008; Stronge et.al, 2011	Yes
Monitoring student progress and potential	Homework	Cotton, 2000; Jepsen, 2005; Stronge et.al, 2008; Stronge et al., 2011	Yes
	Feedback	Cotton, 2000; Stronge et.al, 2008; Stronge et.al, 2011	-
	Using assessment	Rowan et al., 1997; Stronge et.al, 2008; Stronge et.al, 2011	-

* This item and variable is derived by combining two variables of "content knowledge" and "knowledge for teaching and learning".

- No difference indicated by European Commission (2011a)

Appendix C. *Correlation Matrix*

	M1	M2	M3	M4	M5	HER	S1	T1	T2	T5	T6C	T7D	T7E	T9C	T10A	T10D
M1	1															
M2	.923**	1														
M3	.923**	.922**	1													
M4	.924**	.923**	.923**	1												
M5	.924**	.924**	.924**	.924**	1											
HER	.489**	.488**	.489**	.494**	.488**	1										
S1	-.021**	-.016**	-.015*	-.019**	-.022**	.030**	1									
T1	.125**	.127**	.129**	.134**	.130**	.169**	.015*	1								
T2	.060**	.062**	.064**	.066**	.061**	.089**	.029**	.175**	1							
T5	-.016**	-.020**	-.021**	-.019**	-.018**	-.030**	-.024**	-.153**	-.036**	1						
T6C	.169**	.169**	.169**	.171**	.172**	.185**	.021**	.065**	.010	.086**	1					
T7D	.209**	.210**	.213**	.213**	.216**	.214**	.041**	.079**	.032**	.050**	.354**	1				
T7E	.176**	.174**	.177**	.177**	.181**	.169**	.025**	.051**	.002	.079**	.318**	.739**	1			
T9C	-.007	-.005	-.006	-.009	-.003	.008	-.013*	-.042**	.042**	.048**	.104**	.063**	.087**	1		
T10A	.091**	.092**	.090**	.088**	.094**	.083**	.017**	-.017**	.053**	.073**	.223**	.330**	.323**	.172**	1	
T10D	.058**	.059**	.055**	.056**	.061**	.062**	.013*	-.010	.009	.029**	.241**	.271**	.296**	.220**	.650**	1
T11B	.034**	.035**	.039**	.036**	.031**	.044**	.034**	.055**	.123**	-.068**	-.016**	-.034**	-.052**	-.017**	-.108**	-.088**
T11D	.083**	.080**	.085**	.088**	.081**	.106**	.024**	.029**	.101**	-.004	.039**	.041**	-.005	-.022**	-.096**	-.050**
T14B	.035**	.037**	.036**	.038**	.041**	.021**	-.027**	-.013*	.021**	.054**	.062**	.069**	.063**	.105**	.062**	.103**
T14C	.124**	.124**	.126**	.127**	.128**	.114**	-.014*	.007	-.057**	.014*	.174**	.096**	.111**	.134**	.123**	.132**
T14D	.063**	.064**	.066**	.067**	.070**	.095**	-.004	.094**	-.020**	.019**	.160**	.146**	.123**	.129**	.160**	.168**
T14G	.014*	.016*	.016**	.014*	.020**	-.028**	.010	.012	.036**	.045**	.081**	.115**	.130**	.091**	.143**	.138**
T15D	.242**	.241**	.240**	.244**	.244**	.217**	.036**	.197**	.046**	.036**	.209**	.349**	.306**	.010	.145**	.118**
T17A	.092**	.088**	.090**	.089**	.092**	.062**	.006	.076**	.002	.077**	.242**	.156**	.157**	.176**	.278**	.302**
T17B	.140**	.136**	.142**	.140**	.143**	.123**	-.002	.082**	.017**	.110**	.198**	.160**	.161**	.177**	.214**	.231**
T17D	.062**	.057**	.056**	.057**	.061**	.038**	.005	.022**	-.036**	.028**	.240**	.137**	.124**	.184**	.257**	.301**
T17E	.052**	.048**	.048**	.050**	.052**	.038**	.008	.064**	.000	.046**	.246**	.147**	.129**	.193**	.253**	.319**
T17H	.040**	.036**	.037**	.038**	.042**	.020**	-.008	.059**	.042**	.141**	.229**	.130**	.140**	.154**	.239**	.292**
T22A	-.124**	-.124**	-.125**	-.124**	-.119**	-.156**	.005	-.089**	-.071**	-.015*	-.027**	-.015*	.029**	-.027**	.051**	.084**
T22C	.146**	.147**	.147**	.149**	.145**	.198**	.014*	.287**	.181**	-.063**	.140**	.144**	.099**	.012*	.091**	.063**
T23A	-.040**	-.043**	-.040**	-.044**	-.041**	-.062**	.006	.018**	.102**	.058**	.056**	.004	.028**	.104**	.092**	.094**

Appendix C. *Correlation Matrix (continued)*

	T11B	T11D	T14B	T14C	T14D	T14G	T15D	T17A	T17B	T17D	T17E	T17H	T22A	T22C	T23A
T11B	1														
T11D	.391**	1													
T14B	-.071**	.023**	1												
T14C	-.004	.067**	.225**	1											
T14D	-.037**	.047**	.274**	.373**	1										
T14G	-.067**	-.058**	.291**	.173**	.364**	1									
T15D	.005	.050**	.006	.141**	.168**	.015*	1								
T17A	-.019**	-.063**	.173**	.236**	.204**	.220**	.171**	1							
T17B	-.058**	-.022**	.253**	.208**	.181**	.236**	.132**	.557**	1						
T17D	-.008	-.072**	.151**	.201**	.211**	.226**	.115**	.574**	.459**	1					
T17E	-.029**	-.025**	.174**	.230**	.225**	.218**	.124**	.552**	.456**	.623**	1				
T17H	-.105**	-.090**	.208**	.152**	.186**	.260**	.049**	.551**	.481**	.570**	.604**	1			
T22A	-.082**	-.112**	.096**	.075**	.077**	.109**	-.130**	-.003	-.046**	.054**	.061**	.043**	1		
T22C	.172**	.115**	.023**	.145**	.170**	.076**	.207**	.129**	.093**	.107**	.117**	.036**	-.048**	1	
T23A	-.048**	-.092**	.202**	.065**	.130**	.208**	-.039**	.198**	.130**	.180**	.129**	.175**	.122**	.039**	1

M1: *BSMMAT01*, M2: *BSMMAT02*, M3: *BSMMAT03*, M4: *BSMMAT04*, M5: *BSMMAT05*, HER: *BSBGHER*, S1: *BSBG01*, T1: *BTBG01*, T2: *BTBG02*, T5: *BTBG05*, T6C: *BTBG06C*, T7D: *BTBG07D*, T7E: *BTBG07E*, T9C: *BTBG09C*, T10A: *BTBG10A*, T10D: *BTBG10D*, T11B: *BTBG11B*, T11D: *BTBG11D*, T14B: *BTBG14B*, T14C: *BTBG14C*, T14D: *BTBG14D*, T14G: *BTBG14G*, T15D: *BTBG15D*, T17A: *BTBM17A*, T17B: *BTBM17B*, T17D: *BTBM17D*, T17E: *BTBM17E*, T17H: *BTBM17H*, T22A: *BTBM22CA*, T22C: *BTBM22CC*, T23A: *BTBM23A*

* Correlation is significant at the .05 level (2-tailed)
** Correlation is significant at the .01 level (2-tailed)
Correlation matrix is created by SPSS (IBM Corporation, 2013).

MUSA SADAK

CURRICULUM VITAE

EDUCATION

2014 – 2019
Indiana University, Bloomington, IN, USA
Ph.D. (Doctor of Philosophy)
Major: Mathematics Education
Minor: Inquiry Methodology

2013 – 2014
University of Delaware, Newark, DE, USA
Student (Intensive English Language Program)
English Language Institute

2012 – 2013
Hacettepe University, Ankara, Turkey
Student (Academic English Program)
School of Foreign Languages

2006 – 2011
Ataturk University, Erzurum, Turkey
M.Sc. (Master of Science) &
B.Sc. (Bachelor of Science)
Major: Mathematics Education

PROFESSIONAL EXPERIENCES

2016 – 2018
Associate Instructor
Indiana University, Bloomington, IN, USA
(Aug 2016 – May 2018)
N103 – Geometry Content and Pedagogy in Elementary Education

2015
Research Assistant
Indiana University, Bloomington, IN, USA
(January – June 2015)
IDReAM (Investigating Differentiated Instruction and Relationships between Rational Number Knowledge and Algebraic Reasoning in Middle School)
Worked with Middle Grade Level students

2015
Research Assistant
Indiana University, Bloomington, IN, USA
(May 18-22, 2015)
InchWorm Academy – Kids' Camp, Hammond, IN
Worked with kindergarteners and 1st – 2nd graders on measurement through exploration

2015 — ***Teaching Assistant***
Indiana University, Bloomington, IN, USA
(January – May 2015)
N103 – Geometry Content and Pedagogy in Elementary Education
Grading homework, preparing questions, and partially lecturing

2011 – 2012 — ***Mathematics Teacher***
Ugur Private Educational Institute
(July 2011 – April 2012)
Taught mathematics to varied level of students, including the range between 4th grade through high school level (Certified to teach secondary education mathematics).

PUBLICATIONS & PRESENTATIONS

Publications

- **Sadak, M.** (in preparation). Turkish 8th graders' mathematics performance on TIMSS with the lens of national high school placement tests.
- **Sadak, M.** (2016, November). The performance of Turkish and US students on PISA 2012 mathematics items: A Differential Item Functioning analysis. In *Proceedings of the International Conference of Education, research and Innovation* (ICERI 2016) (pp. 3242-3248), Seville, Spain.
- **Sadak, M.** (2016, November). The proposal of technology-enhanced formative assessment to expand the usage area of the FATIH project in Turkey. In *Proceedings of the International Conference of Education, research and Innovation* (ICERI 2016) (pp. 3433-3440), Seville, Spain.
- **Sadak, M.** (2015, November). Turkish 8th graders' mathematics success on TIMSS in relation to national high school placement tests. In *Proceedings of the 37th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (PME – NA 37) (p. 124). East Lansing, MI: Michigan State University.

Presentations

- **Sadak, M.** (2017, March). The relationship between PSTs' mathematical content knowledge and their self-confidence: A Multiple Case Study. Paper presented as a work-in-progress study in the Indiana Mathematics Education Research Symposium (IMERS – 2017), Indiana University – Purdue University Indianapolis, Indianapolis, IN.
- Jacobson E., Liu J., Matyska R., **Sadak M.,** and Suksak S. (2017, March) Examining Different Kinds of Mathematical Work for Teaching the Same Mathematical Topic: How is Knowledge for Teaching Mathematics Structured? Paper presented in a panel discussion section in the Indiana Mathematics Education Research Symposium (IMERS – 2017), Indiana University – Purdue University Indianapolis, Indianapolis, IN.

- **Sadak, M.** (2016, February). Turkish 8th graders' mathematics performance on TIMSS with the lens of national high school placement tests. Paper presented as a brief research report at Curriculum and Instruction Research and Creative Activity Symposium (CIRCAS 2016), Indiana University, Bloomington, IN.
- **Sadak, M.,** Borowski, R. (2014, March). Dynamic geometry environments: Their impact on pre-service teachers' learning. Paper presented as a work-in-progress study in the Indiana Mathematics Education Research Symposium (IMERS – 2015), Indiana University – Purdue University Indianapolis, Indianapolis, IN.

SERVICE ACTIVITIES

- **Discussion Chair**
  - *American Educational Research Association (AERA) 2018 Annual Meeting*
- **Journal Referee**
  - *International Education Studies Journal*, Canadian Center of Science and Education.
- **Conference Manuscript Reviewer**
  - American Educational Research Association (AERA 2018)
  - Psychology of Mathematics Education – North America (PME-NA 2016)
  - Curriculum and Instruction Research and Creative Activity Symposium (CIRCAS 2016)
- **Conference Local Organization Committee Member**
  - Psychology of Mathematics Education – North America (PME-NA 2017)
  - Indiana Mathematics Education Research Symposium (IMERS 2016)
- **Steering Committee Nomination**
  - Psychology of Mathematics Education – North America (PME–NA 2016)
- **Treasurer**
  - Indiana University – Turkish Student Association, (2015–2016)

PROFESSIONAL AFFILIATIONS

- American Educational Research Association (AERA)
- Psychology of Mathematics Education – North America (PME–NA)
- National Council of Teachers of Mathematics (NCTM)
- Hoosier Association of Mathematics Teacher Educators (HAMTE)

AWARDS, HONORS & FELLOWSHIPS

- **Clyde-Bessie Lineback Fellowship – (Fall 2018)**
  Indiana University (nominated by the faculty)
- **Neatrour-McGlasson Fellowship – (Fall 2017 – Spring 2018)**
  Indiana University (nominated by the faculty)
- **Indiana University School of Education Fellowship – (Fall 2016 – Spring 2017)**
  Indiana University School of Education, Curriculum and Instruction Department

- **PhD Fellowship Abroad – (2012 – 2019)**
  Republic of Turkey - Ministry of National Education

  I was ranked as **92nd** in the ALES (acronym stands for Academic Graduate Education Exam) among **250.000 college graduated students in Turkey** to be selected in this fellowship. It covers the tuition and education fees, stipend, health insurance, conference, travel, and textbook expenses.
- **Mathematics Olympiads Team Member – (May 2005 – Antalya, Turkey)**
  10th Mediterranean University National Mathematics Olympiads
- **Mathematics Olympiads Team Member – (May 2005 & May 2004 – Kayseri, Turkey)**
  13th The Scientific and Technological Research Council of Turkey National Mathematics Olympiads

  12th The Scientific and Technological Research Council of Turkey National Mathematics Olympiads
- **Physics Olympiads Team Member – (May 2005 – Kayseri, Turkey)**
  13th The Scientific and Technological Research Council of Turkey National Physics Olympiads
- **Private Jury Award – (May 2005 – Adana, Turkey)**
  2nd Burc Science and Engineering Fair

  I competed with hundreds of projects from Turkey in this fair with my **own-invented** "smart kitchen exhaust".
- **Honorable Mention – (April 2004 – Istanbul, Turkey)**
  13th International Environmental Project Olympiads (INEPO)

  I competed with hundreds of projects from all around the WORLD in this fair with my **own-invented** "smart kitchen exhaust".

RESEARCH INTERESTS

- International Large-Scale Assessments
- Teacher Education
- Technology in Teaching and Learning Mathematics

LANGUAGES

- Turkish (Native)
- English (Fluent)
- Arabic (Elementary)

COMPUTER SKILLS

- Basic Computer Programs (Microsoft Office)

- Statistical Programs (SPSS, R Studio, NVivo, IRT-PRO, SIBTEST, DIMTEST, MPlus)
- Mathematics Educational Programs (GeoGebra, Geometric Sketch Pad, Java Bars)