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# Factors Predicting Turkish and Korean Students' Science and Mathematics Achievement in TIMSS 2011

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This study makes an important contribution to an expanding body of international comparative studies by exploring factors predicting differences in science and mathematics achievement by students in Turkey and the Republic of Korea on the 2011 TIMSS assessment. While these countries are similar with regards to population size, cultural beliefs about education, and public expenditure on education, students in each country have different levels of achievement in science and mathematics. The current research investigated how aptitude, instruction, and environment related factors predict Turkish and Korean students' achievement in science and mathematics. In both countries, some factors, such as student aptitude (e.g., science self-efficacy) and environmental (e.g., parental educational level) factors significantly predicted students' science and mathematics achievement. However, we found some differences between the two countries regarding certain classroom environmental variables, such as bullying and student sense of belonging at school. We discuss educational implications for these findings.

*Keywords*: student aptitude variables; instructional variables; environmental variables; mathematics achievement; science achievement; TIMSS 2011

## INTRODUCTION

*Trends in International Mathematics and Science Study* [TIMSS], a project of the *International Association for the Evaluation of Educational Achievement* [IEA], provides an international assessment of student achievement in science and mathematics at the fourth and eighth grades. Repeated every four years, TIMSS aims to provide participating countries "with an unprecedented opportunity to measure

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progress in educational achievement in mathematics and science together with empirical information about the contexts for schooling" (Mullis, Martin, Ruddock, O'Sullivan, & Preuschoff, 2009, p. 7). In addition to achievement data, TIMSS collects contextual information about the participating students, teachers, and schools. The gathered contextual information helps researchers understand what factors predict students' academic success.

Higher achievement in science and mathematics is important for students to prepare them for university, workplace after graduation, and life in our changing world (Mullis et al., 2012). The impetus for increasing students' success in the two subjects requires educators to understand what factors predict achievement. TIMSS provides individual countries with contextual information to analyze student achievement in comparison with other countries. International comparative research studies have reported various factors, such as school resources, family characteristics, and students' attitudes, can all contribute to variations in student achievement (Hong, 2012; Kaya & Rice, 2010; Paik, 2004).

***State of the literature***

- There are findings in the current literature reporting factors predicting students' science and mathematics achievement in Turkey and the Republic of Korea separately.
- There are different methods for analyzing large-scale data, which are mostly linear multiple regression analyses or hierarchical linear models.
- Research studies mostly used Walberg's Model of Educational Productivity for examining the predictors of science and mathematics achievement.

***Contribution of this paper to the literature***

- We first compared factors predicting science and mathematics achievement of Turkey and the Republic of Korea in TIMSS 2011. These countries have similar population, culture, and public expenditure on education, but they have different success levels in science and mathematics.
- The software called The IEA International Database Analyzer (2013) was used to analyze large-scale assessments, such as TIMSS.
- With regards to factors predicting students' science and mathematics achievement, the current study found similarities and differences between Turkey and Korea, which are new findings for the current literature.

In the most recent TIMSS 2011, the average science and mathematics scores of 8th grade students in Turkey were 483 and 452, respectively (TIMSS scale center point is 500). The percentages of these 8th grade students reaching the TIMSS international benchmarks in science were as follows: 79%-low, 54%-intermediate, 26%-high, and 8%-advanced. Similarly, the percentages of the 8th grade students reaching the TIMSS international benchmarks in mathematics were as follows: 67%-low, 40%-intermediate, 20%-high, and 7%-advanced. These numbers indicate that most Turkish students did not perform at higher levels in science and mathematics. In addition, there were too many students (21% for science and 33% for mathematics) who could not even reach the low benchmark. Turkish educators have been seeking ways to improve students' low achievement levels. For instance, the mathematics curriculum has been revised and renewed three times in the last decade. Similarly, the grade level that students start taking science courses was decreased from 4 to 3 in 2013 in order to engage students in scientific inquiry at earlier ages.

Investigating what factors are associated with students' success in science and mathematics may help educators understand the reasons of low achievement and guide new initiatives to increase students' achievement levels. Examining the factors that potentially affect student achievement in different countries might shed light on the determinants of cross-national variations in student achievement. To this end, in this study, we aimed to understand what factors predict students' science and mathematics achievement by comparing Turkey and a high achieving country that is similar to, in terms of population, culture, and public expenditure on education.

In TIMSS 2011, Korea was among the top three high performing countries at the 8th grade level with an average score of 560 in science and 613 in mathematics. Among the top performing countries on the TIMSS assessment, Korea has the closest population to Turkey (49 million for Korea, 75 million for Turkey). Both Korea and Turkey share some common features of eastern culture. For instance, both countries have strong family structure, high educational pressure, and a centralized education system (Paik, 2004; Tansel, 2013). In both countries, public expenditure on education is 4% of the gross domestic product (Mullis et al., 2012). Yet, there is a big achievement difference between the two countries. Understanding the factors predicting achievement in both countries will contribute to international knowledge base about comparative studies and help accelerate educational improvements by guiding policy decisions. In the sections that follow we compare the education systems of both countries and then we compare similarities and differences on the TIMSS 2011 to raise questions about factors that may impact student achievement in math and science.

## The education system in Turkey

Turkey has a central education system where the state governs teacher training, recruitment, curriculum, and instructional pace (Mullis et al., 2012). Students start 12-year compulsory and free education at the age of six. The school system in Turkey is organized around 4 year periods: 4 years for primary school, 4 years for middle school, and 4 years for high school (Ministry of National Education [MONE], 2013). Middle school teachers are trained in four-year faculties of education. Middle school students take 180 instructional hours (40 minutes) of mathematics per year. The middle school mathematics standards are organized around the following domains: number and operations, algebra, geometry and measurement, data analysis, and probability. The number of instructional hours spent on science in middle school is 144 per year. The middle school science standards are organized around the following domains: life sciences, matter and change, physical sciences, and earth and space. Students in the 8$^{th}$ grade take national examinations and are placed in a high school based on their scores. The high school system in Turkey has been criticized to cause significant achievement gaps between different types of high schools (Gumus & Atalmis, 2012; Topçu, 2014). At the end of high school, students take university entrance examinations to advance into tertiary education. Getting placed in a prestigious university is very competitive.

Completing a bachelor's degree is highly valued in Turkish society and increases the chance of getting a job (Tansel, 2013). High stakes tests in the Turkish education system cause competition among students and prompt parents to provide private tutoring (e.g., private instructor at home, cram school) to their children to help them improve their achievement scores. Research has found that family socioeconomic level is positively associated with students' science and mathematics achievement in Turkey (Alacacı & Erbaş, 2010; Berberoğlu, Çelebi, Özdemir, Uysal, & Yayan, 2003). For instance, parental education level (Berberoğlu et al., 2003), family income (Engin-Demir, 2009), and home educational resources (Topçu, Arikan, & Erbilgin, 2015) are predictors of achievement. Students' self-efficacy, perception of treatment by teachers, instructional quality and quantity, and safe school environment were also found to positively correlate with student achievement in Turkey (Akyüz, 2014; Alacacı & Erbaş, 2010; Engin-Demir, 2009).

## The education system in Korea

The Korean education system is highly centralized and uniformly standardized with state governing the teacher training, recruitment, curriculum and instructional pace (Park, Byun, & Kim, 2011). Students start compulsory education at the age of six. The schooling system is divided into preschool, elementary school (grades 1-6), middle school (grades 7-9), and high school (grades 10-12) with elementary and middle schools being free and compulsory (Mullis et al., 2012). Middle school teachers are trained for four years in a teacher education program. Middle school students take 136 instructional hours (45 minutes) of mathematics per year. The middle school mathematics standards are organized around the following five domains: numbers and operations, variables and expressions, patterns and functions, probability and statistics, and geometry. The number of instructional hours spent on science is 102 in grade 7 and 136 in grades 8-9 per year. The middle school science standards are organized around the following domains: energy, material, life, and the earth. After middle school, students can attend academic high schools or they can choose to attend vocational high schools. Based on the high school equalization policy, student assignment to academic high schools is based on where students live in a school district (Park et al., 2011). The state administers student scholastic achievement tests at the 9$^{th}$ and 11$^{th}$ grades to monitor the quality of education and provide information on student achievement to schools and parents. At the end of high school, students take the college entrance examinations to advance into tertiary education. Entering the prestigious institutions is highly competitive. The most salient features of Korean education system are national examinations and high standards (Paik, 2004). Korea has also received international attention for providing a high level of equality in education (So & Kang, 2014).

In Korean society, education is viewed as a means of social mobility. Korean parents highly value education, have high academic expectations of their children and support their achievement through supplying educational resources at home such as books and computers and by providing private tutoring (Paik, 2004; Park et al., 2011). Studies have reported that parental guidance, support and expectations, students' self-efficacy, motivation, problem solving abilities, and learning time might account for Korean students' academic success (Bae & Wickrama, 2014; House & Telese, 2013; Paik, 2004). Despite Korean students' high performance in international tests, they lack interest in learning (So & Kang, 2014). For instance, according to TIMSS 2007 and 2011 reports, Korean students' scores in attitudes towards mathematics were below the international average (Mullis, Martin, & Foy, 2008; Mullis et al., 2012). As a result, Korea has been taking steps to reduce the stress on students. For instance, So and Kang (2014) reported that the student scholastic achievement test at the 6$^{th}$ grade was abolished in 2013. In addition, a recent reform initiative was introduced to provide middle school students with one semester of school in which no examinations are administered so that students and teachers will have more time to provide opportunities for students to participate in hands-on activities and time to participate in creative activities outside of school (So & Kang, 2014).

Even though Korean and Turkish education systems are similar in some respects such as being centralized and having high stakes tests, students in Korea showed higher levels of science and mathematics achievement in TIMSS 2011 compared to students in Turkey. The current study was conducted to closely examine the determinants of student achievement in both countries using the same dataset. It seems to be a first research effort to examine the predictors of mathematics and science achievement in Korea and Turkey, and aims to contribute to international comparative educational studies by elaborating which factors are related to student achievement in both countries.

## THEORETICAL FRAMEWORK

There has been a substantial body of research that has investigated possible predictors of science and mathematics achievement (e.g., Chen, Lin, Wang, Lin, & Kao, 2012; Hong, 2012; House, 2008; Kaya & Rice, 2010; Shen & Tam, 2008; Wilkins, Zembylas, & Travers, 2002). Researchers have found that achievement in science and mathematics is related to student, family, and school characteristics. Some research focused on specific predictors of achievement (e.g., motivation, school resources, bullying), while others examined a more comprehensive set of factors that influence achievement, including family, school and student variables. Within the latter group of research, Walberg's (1981, 1984, & 2004) model of educational productivity guided hundreds of studies (Young, Reynolds, & Walberg, 1996). These studies showed that the model was effective for examining the predictors of science and mathematics achievement (Reynolds & Walberg, 1992; Walberg, 1984; Young et al., 1996). The model takes into account the complexity of student learning, yet it is parsimonious by consisting of only nine factors that have been shown to predict students' affective, behavioral, and cognitive learning. Being an effective, parsimonious, generalizable, and comprehensive framework, Walberg's educational productivity model served as the framework for examining predictors of science and mathematics achievement in the current study.

Walberg's theory of educational productivity includes nine factors that require optimization to increase students' academic achievement (Walberg, 1981, 1984, & 2004). These nine factors fall into three general groups: A) Student aptitude variables consisting of ability/prior achievement, motivation/self-concept, and age/developmental level; B) instructional variables including quantity/time and quality of instruction, and; C) environmental variables involving home, classroom, peers, and exposure to mass media. The first set of factors is related to students' personal characteristics and background information. The second set indicates instructional aspects that affect learning. The last set of factors is related to social-psychological climate of home, classroom, and peer group. Research findings from literature related to each variable of Walberg's model will be presented in the following paragraphs.

Within the model's student aptitude variables, prior achievement is typically measured by standardized tests, motivation/self-concept by surveys, and developmental level by age (Paik, 2004; Reynolds & Walberg, 1992). Student motivation/self-concept refers to student's willingness to persevere with learning tasks and is more alterable by educators among the student aptitude variables of Walberg's model. It has been studied extensively. For instance, with the availability of student questionnaire data in TIMSS, relationships between students' science and mathematics achievement scores and their motivation, self-efficacy, and attitudes towards these subjects have been examined nationally or cross-nationally (House, 2008; Shen & Tam, 2008). Wilkins et al.'s (2002) study involved TIMMS 1995 data from 16 countries and revealed that students' self-efficacy in science and mathematics was a consistent predictor of student achievement in both subjects regardless of country differences. Shen and Tam (2008) used three waves of TIMSS data (1995, 1999, & 2003) and analyzed relationships between 8$^{th}$ grade students' self-concepts on mathematics and science and their achievement in these subjects. They reported a positive relationship between self-concept and achievement for within-country data. However, when the self-concept data is aggregated at the country level, they found a negative relationship between students' self-concept and achievement. This discrepancy may exist because the conception of self may differ from culture to culture. With the availability of comprehensive data collected by international comparative studies, investigating students' conceptions of "self" in individual countries will contribute to the existing literature about motivation or self-concept.

Instructional variables in Walberg's educational productivity model include quantity and quality of instruction. The quantity of instruction refers to the amount of time that students are involved in learning (Walberg, 2004). Quality of instruction refers to both method and content of instruction. Learning time in school has been found to positively associate with student achievement in science and mathematics

(Alacacı & Erbaş, 2010; Sousa, Park, & Armor, 2012). Regarding the quality of instruction, the study of Ma and Wang (2001) revealed that it influenced both student achievement and student career aspiration. When students are given opportunities to actively engage in the learning process, to develop problem-solving skills, and to make connections within and between different subject domains, their academic achievement increases (House, 2005; House & Telese, 2013).

Environmental variables in Walberg's model consist of home, classroom, peers, and exposure to mass media. Home environment or curriculum of the home (i.e., monitoring homework completion, educational resources at home) can enhance the effectiveness of learning time out of school (Walberg, 2004). Classroom environment or morale is related to social climate of the classroom and is most commonly measured by class size, behavior problems, and/or safe learning environment (Ma & Wang, 2001; Paik, 2004). Peer group outside school is related to how students' peers perceive schooling and being successful in academics. Exposure to media, particularly television viewing can displace learning activities outside school such as doing homework.

Walberg (2004) commented that among the environmental variables, home environment required attention since it shaped most of the out-of-school time and, as such, could be influenced by outreach programs. Research studies have shown that student achievement in science and mathematics is closely linked to home environment (Berberoğlu et al., 2003; Chen et al., 2012; Kaya & Rice, 2010). For instance, Berberoğlu et al. (2003) analyzed TIMSS 1995 data for Turkey and found that family socioeconomic status (SES), as measured by parents' education level and the number of books at home, was an important predictor of student achievement in science and mathematics. Family cultural and educational resources have been found to positively correlate with student achievement (Kaya & Rice, 2010; Topçu et al., 2015). Another home environment variable that has been related to student achievement is parental involvement in students' education. Studies examining parental involvement have reported mixed results. Some indicated that parent's expectations about the child's academic performance (Benner & Mistry, 2007), parent's discussions about school experiences with the child (Sui-Chu & Willms, 1996), and parental involvement in learning at home (Mcwayne, Hampton, Fantuzzo, Cohen, & Sekino, 2004) positively affected student achievement. On the other hand, other studies suggested that excessive parental control such as closely monitoring homework completion or strict behavioral control might negatively affect student achievement (Kramer, 2012; Shumow & Miller, 2001).

The current study used Walberg's educational productivity model to interpret the factors predicting achievement in Turkey and Korea. The following research question guided this study: How do aptitude, instruction, and environment related factors predict Turkish and Korean students' achievement in science and mathematics in TIMSS 2011?

## METHOD

### Sample

Data analyzed in this study were obtained from the TIMSS 2011 study in which the target population included students at the fourth and eighth grades in each participating country. The sampling procedure for TIMSS 2011 was decided by TIMSS & PIRLS International Study Center in cooperation with Statistics Canada and the IEA Data Processing and Research Center (for more information about the sampling method, see Joncas & Foy, 2012). Each participating country's National Research Coordinator and the TIMSS sampling experts were responsible for selecting the sample by using the planned procedure. In the TIMSS sampling procedure, a two-stage cluster sample design was used. In the first stage, a sample of schools was selected proportional to their size. In the second stage, classes were selected among selected schools randomly. The tests and questionnaires were administered to all students in each sampled class. This procedure was useful to reach classroom-based conclusions like students' curricular and instructional experiences (Joncas & Foy, 2012).

The sample for the present study comprised all data reported for grade eight Turkish and Korean students who took the 2011 TIMSS assessment. The sample consisted of 6928 students (3414 females and 3514 males) for Turkey and 5166 students (2663 females and 2503 males) for Korea.

## Measures

In TIMSS 2011 study, science and mathematics related achievement tests and student questionnaires were administered. In the current study, these achievement test scores and questionnaire items were used as measures. TIMSS assigned five plausible science and mathematics scores for each participating student as an achievement indicator. TIMSS 2011 student questionnaire had 53 items in science and 52 items in mathematics that were used to identify students' characteristics that influence their science and mathematics achievement respectively. The student questionnaire consisted of items related to things a student might possess at home, parental education level, future educational expectation of students, use of computer, parental involvement, feelings related to school, students' relation with other students, enjoyment of science/mathematics, feelings about one's science/mathematics teacher, whether a student thinks he or she can achieve science/mathematics, why a student gives importance to science/mathematics, and time spent on science/mathematics. All of these items were used in the study as these items generally represent dimensions of Walberg's model, namely, aptitude, instruction, and environment related factors. The student questionnaire items were used to identify aptitude, instruction, and environment related factors that are important in predicting achievement of Turkish and Korean students.

## The procedure for data analysis

The present study separately analyzed relationships between science achievement and science related student factors and relationships between mathematics achievement and mathematics related student factors for eighth grade Turkish and Korean students. In this study, exploratory factor analysis was conducted by using all of the student questionnaire items that were expected to be related to science and mathematics achievement. All the factors obtained as a result of the exploratory factor analysis were named and classified according to student aptitude variables, environmental variables or instructional variables of Walberg's model. As these factors are prospective predictors of achievement, we aimed to identify which of them were significant in predicting achievement of students in educational context of Turkey and Korea. In order to identify significant factors for each country, by using factor scores as independent variables and by using TIMSS plausible science and mathematics values as dependent variables, multiple regression analyses were conducted.

In this study, first, exploratory factor analysis was conducted using 53 student questionnaire items for science and 52 student questionnaire items for mathematics. The main purpose of exploratory factor analysis was to reduce a large number of observable variables to unobservable explainable constructs or factors (George & Mallery, 2003). Therefore, it was possible to identify which variables were more correlated with each other. These correlated variables with one another but relatively uncorrelated with other variables were combined to form factors.

These factors were considered to reflect common underlying processes that result in high correlation among these variables (Tabachnick & Fidell, 2013).

Our next step in the research process was to evaluate, name and classify newly produced factors according to Walberg's model. This evaluation consisted of interpreting and naming common underlying factors responsible for high correlation among these set of observed variables and low correlation with other variables or factors (Tabachnick & Fidell, 2013). The factors were linear combinations of observed variables, where each separate linear combination produced a factor score for a subject. Therefore, each student had as many factor scores as newly produced factors. As the number of factors were far fewer than the number of observed variables, using factor scores was important for parsimony. Besides that, factor scores are often more reliable than individual observed variables (Tabachnick & Fidell, 2013).

Finally, using factor scores obtained from science questionnaire as independent variables and science plausible values as the dependent variable, a multiple regression analysis was conducted for Turkish and Korean data. The same procedure was repeated by using the mathematics related variables for Turkish and Korean students. Therefore, significant factors predicting science and mathematics achievement of Turkish and Korean students were identified. Specifically, multiple regression results were used to identify which independent variables were more important to predict variation in a dependent variable. In order to achieve multiple regression analysis, software called The IEA International Database Analyzer (2013) [IDB Analyzer] was used. IDB Analyzer was developed by the IEA Data Processing and Research Center in Hamburg, Germany in order to analyze IEA's large-scale assessments, such as TIMSS. The software produces an SPSS syntax that take into account sampling design, sampling weights and plausible values reported in TIMSS. IDB Analyzer can conduct multiple regression analysis and estimate regression coefficients for independent variables, which predict a dependent variable even if the dependent variable consists of several plausible values like in TIMSS. Conducting analysis with a program that does not take into account special structure of TIMSS would produce biased results (IDB Analyzer, 2013). Therefore, using IDB Analyzer for this study was necessary to obtain reliable results.

### Limitation of the study

The results of the study are based on students' self-report to the questionnaires. Buckley (2009) claimed that students might give more socially desirable responses if they are from countries with low gross domestic product (GDP) or they have lower socio-economic background or they are less educated. This self-reported data collection of TIMSS is one of the limitations of the study. Besides this, the study is also limited to the science and mathematics items that were used to measure science and mathematics achievement in TIMSS. The researchers had no impact on development, administration, and scoring of these items.

## RESULTS

### Factor structure of the TIMSS science and mathematics questionnaire

As a preliminary analysis, the number and characteristics of factors representing Turkish and Korean students' responses to the TIMSS 2011 student science and mathematics questionnaire were identified through exploratory factor analysis. The factors obtained by exploratory factor analysis were used as independent variables to answer the research question. For science, KMO values were estimated as 0.921 for Turkish data and 0.936 for Korean data. These values implied that the data was marvelous to perform factor analysis (George & Mallery, 2003). Additionally, Bartlett's test of sphericity was significant for Turkish and Korean data respectively ($\chi 2$ (1378) = 71895.34, $p$ < .05; $\chi 2$ (1378) = 44896.50, $p$ < .05). With orthogonal varimax rotation and an eigenvalue that was greater than one (as a cutoff point for factors); principal component analysis generated twelve factors that accounted for 56.82% of the variance for Turkish data and thirteen factors that accounted for 61.37% of the variance for Korean data. For Turkish data, since Cronbach's alpha reliability coefficient of the tenth and eleventh factors were very low and the twelfth factor included only one item, these factors could not be interpreted correctly, and were excluded from the analysis. As a result, we decided to name nine factors for Turkish data. For Korean data, since Cronbach's alpha reliability coefficient of the ninth, tenth and twelfth factors were very low and the eleventh and thirteenth factors included only one item, these factors could not be interpreted correctly, and were excluded from the analysis. As a result, we decided to name eight factors for Korean data (see Appendix A and B).

Factors were named in light of researchers' experiences and previous research related to TIMSS. The researchers have many publications in peer-reviewed journals and internationally recognized books about assessment and evaluation of international examinations such as The Programme for International Student Assessment [PISA] and TIMSS. They are also expert on factors predicting science and mathematics achievement, and measurement and evaluation of students' science and mathematics achievement. The researchers gave descriptive titles to each factor on the basis of high loadings of items. The common factors for Turkish and Korean science questionnaire data were anxiety towards science, perceived value of learning science, science self-efficacy, bullying, parental involvement, parental education level, and sense of belonging to school. In addition, the factors named enjoyment of science and computer use at home for Turkish data, and teacher effectiveness for Korean data were identified.

For mathematics, KMO values were estimated as 0.919 for Turkish data and 0.917 for Korean data, which implied that the data was sufficient for performing factor analysis (George & Mallery, 2003). Additionally, Bartlett's test of sphericity was significant for Turkish and Korean data respectively ($\chi 2$ (1326) = 65412.66, $p$ < .05; $\chi 2$ (1326) = 53765.15, $p$ < .05). Principal component analysis generated twelve factors that accounted for 56.08% of the variance for the Turkish data and twelve factors that accounted for 57.05% of the variance for Korean data. For the Turkish data, since Cronbach's alpha reliability coefficient of the eleventh factor was very low and tenth and twelfth factors included only one item, these factors could not be interpreted correctly, and were excluded from the analysis. As a result, we decided to name nine factors for the Turkish data. For the Korean data, since Cronbach's alpha reliability coefficients of ninth, tenth, eleventh and twelfth factors were very low, these factors could not be interpreted correctly, and therefore, were excluded from the analysis. As a result, we decided to name eight factors for the Korean data (see Appendix C and D).

The common factors for the Turkish and Korean mathematics questionnaire data were attitude towards mathematics, teacher effectiveness, perceived value of learning mathematics, bullying, parental involvement, parental education level, and sense of belonging to school. In addition, other factors for the Turkish data included computer use at home and home resources and for the Korean data, teacher expectations was identified as a factor. Factors obtained as a result of exploratory factor analysis in science and mathematics data were classified according to Walberg's model (See Table 1).

## The associations between the TIMSS questionnaire dimensions and science achievement

Multiple regression analysis was used to explain which factors were significant to predict Turkish and Korean students' science achievement. For both Turkish and Korean students, Student Aptitude variables anxiety towards science, perceived value learning of science, and science self-efficacy contributed significantly to the model. In addition, Environmental variables, including parental education level and sense of belonging to school contributed significantly to the model (See Tables 2 and 3).

**Table 1.** Factors classified according to Walberg's model

| Walberg's Model | TIMSS Factors |
|---|---|
| Student Aptitude V. | Anxiety towards science |
| Student Aptitude V. | Value learning science |
| Student Aptitude V. | Value learning mathematics |
| Student Aptitude V. | Science self-efficacy |
| Student Aptitude V. | Enjoyment of science |
| Student Aptitude V. | Attitudes towards mathematics |
| Environmental V. | Computer use at home |
| Environmental V. | Home resources |
| Environmental V. | Belonging to school |
| Environmental V. | Parental education level |
| Environmental V. | Parental involvement |
| Environmental V. | Bullying |
| Instructional V. | teacher effectiveness |
| Instructional V. | teacher expectation |

**Table 2.** The associations between the TIMSS questionnaire factors and Turkish students' science achievement

| TIMSS Factors | Unstandardized β weight | Standardized β weight | *t* |
|---|---|---|---|
| **Student Aptitude Variables** | | | |
| Enjoyment of science (f1) | 6.20 | .06 | 3.23* |
| Anxiety towards science (f2) | 22.95 | .24 | 13.84* |
| Value learning science (f3) | 5.09 | .05 | 3.63* |
| Science self-efficacy (f4) | 25.22 | .26 | 13.29* |
| **Environmental Variables** | | | |
| Computer use at home (f5) | 11.77 | .12 | 6.80* |
| Bullying (f6) | -9.92 | -.10 | -6.28* |
| Parental involvement (f7) | .05 | .00 | .03 |
| Parental Education Level (f8) | 32.53 | .35 | 11.37* |
| Belonging to school (f9) | -4.15 | -.04 | -2.52* |

** Statistically significant t values at p < .05 level.*

**Table 3.** The associations between the TIMSS questionnaire factors and Korean students' science achievement

| TIMSS Factors | Unstandardized β weight | Standardized β weight | *t* |
|---|---|---|---|
| **Student Aptitude Variables** | | | |
| Anxiety towards science (f1) | 26.09 | .35 | 14.21* |
| Value learning science (f2) | 17.06 | .23 | 9.66* |
| Science self-efficacy (f4) | 22.04 | .30 | 15.70* |
| **Environmental Variables** | | | |
| Bullying (f5) | 3.39 | .05 | 1.82 |
| Belonging to school (f8) | 8.39 | .11 | 5.32* |
| Parental involvement (f6) | 2.83 | .04 | 1.77 |
| Parental Education Level (f7) | 20.87 | .28 | 10.97* |
| **Instructional Variables** | | | |
| Teacher effectiveness (f3) | 5.78 | .08 | 4.33* |

** Statistically significant t values at p < .05 level.*

In the Turkish data, enjoyment of science, computer use at home and bullying also had predictive effect on science scores and these variables were not significant in predicting science achievement of Korean students. In the Korean data, teacher effectiveness also had a predictive effect on science scores and this variable was not significant in predicting science achievement of Turkish students. Altogether these variables explained 29% of the variability in the Turkish students' science achievement scores (adjusted $R^2 = 0.29$, $F(9, 3833) = 172.17$, $p < .05$) and 36% of the variability in the Korean students' science achievement scores (adjusted $R^2 = 0.36$, $F(8, 1981) = 140.48$, $p < .05$).

The standardized β weights for science achievement of Turkish and Korean students showed that anxiety toward science (.24 and .35), science self-efficacy (.26 and .30) and parental education level (.35 and .28) all had had strong predictive effects. Therefore, students with lower anxiety level (anxiety items were reversed), higher self-efficacy and highly educated family were found to score higher in science in both countries. In the Turkish educational context, computer use at home (.12) and bullying (-.10) were important factors. This implies that Turkish students who reported using a computer at home and who reported less exposure to school bullying were also more successful in science. In the Korean educational context, we found that students perceived value of learning science (.23) and student sense of belonging to school (.11) were strong predictors of success. This implies that Korean students who think science is important and who have positive feelings towards school have more success in science. Enjoyment of science (.06), perceived value of learning science (.05), and sense of belonging to school (-.04) had significant, but relatively small predictive power for science achievement among Turkish students. In a similar manner, teacher effectiveness (.08) had a significant, but relatively small predictive power of science achievement among Korean students.

## The associations between the TIMSS Questionnaire Dimensions and Mathematics Achievement

Multiple regression analysis showed that for both Turkish and Korean students, Student Aptitude variables attitude towards mathematics and perceived value of learning mathematics contributed significantly to the model. In addition, Environmental variables parental education level and student sense of belonging to school contributed significantly to the model (See Table 4 and 5).

In the Turkish data, teacher effectiveness, computer use at home, bullying and home resources all had predictive effects on mathematics scores and these variables were not significant in predicting mathematics achievement of Korean students. In

**Table 4.** The associations between the TIMSS questionnaire factors and Turkish students' mathematics achievement

| TIMSS Factors | Unstandardized β weight | Standardized β weight | *t* |
|---|---|---|---|
| **Student Aptitude Variables** | | | |
| Attitude towards mathematics (f1) | 45.38 | .41 | 27.44* |
| Value learning mathematics (f3) | 6.58 | .06 | 3.77* |
| **Environmental Variables** | | | |
| Computer use at home (f4) | 16.42 | .15 | 11.07* |
| Bullying (f5) | -12.18 | -.11 | -6.24* |
| Parental involvement (f6) | .69 | .01 | .37 |
| Parental education level (f7) | 40.68 | .39 | 18.21* |
| Belonging to school (f8) | -5.28 | -.05 | -2.88* |
| Home resources (f9) | 15.90 | .14 | 6.93* |
| **Instructional Variables** | | | |
| Teacher effectiveness (f2) | 18.44 | .17 | 10.00* |

* Statistically significant *t* values at $p < .05$ level.

the Korean data, teacher expectation and parental involvement had predictive effects on mathematics scores and these variables were not significant in predicting mathematics achievement of Turkish students. Altogether these variables explained 43% of the variability in the Turkish students' mathematics achievement scores (adjusted $R^2 = 0.43$, $F(9, 3684) = 308.56$, $p < .05$) and 45% of the variability in the Korean students' mathematics achievement scores (adjusted $R^2 = 0.45$, $F(8, 2832) = 295.50$, $p < .05$).

The standardized β weights for mathematics achievement of Turkish and Korean students showed that attitude toward mathematics (.41 and .47) and parental education level (.39 and .33) both had strong predictive effects. Therefore, students with more positive attitudes towards mathematics and who reported they came from highly educated families were more successful in mathematics in both countries. Factors of importance in the Turkish educational context included teacher effectiveness (.17), computer use at home (.15), home resources (.14), and bullying (-.11). This implies that Turkish students who have effective teachers, who report having resources and using computers at home, and who report they are less often exposed to bullying are more successful in mathematics. Factors important in the Korean educational context were teacher expectation (.27), perceived value of learning mathematics (.21), and sense of belonging to school (.10). This implies that Korean students who report having teachers with high expectations, who think that learning mathematics is important, and who report positive feelings towards school, are more likely to be successful in mathematics. Perceived value of learning mathematics (.06) and sense of belonging to school (-.05) had a significant, but relatively small predictive power of mathematics achievement among Turkish students. In similar manner, parental involvement (.04) had a significant but relatively small predictive power of mathematics achievement among Korean students.

For both subjects in both countries, there were some common student aptitude and environmental variables that were significant in predicting student achievement, and as such, these variables could be considered important for general student success. Specifically, students who reported having more positive attitudes, a greater sense of self-efficacy, less anxiety towards these subject areas, who reported they valued learning these subject areas, and who had highly educated parents were all more likely to be successful. In Turkey, environmental factors, such as computer usage at home and not being bullied were more effective in predicting mathematics and science achievement than in Korea. However, instructional variables such as teacher effectiveness and teacher expectations were more effective in predicting mathematics and science achievement in Korean than in Turkey.

**Table 5.** The associations between the TIMSS questionnaire factors and Korean students' mathematics achievement

| TIMSS Factors | Unstandardized β weight | Standardized β weight | *t* |
|---|---|---|---|
| **Student Aptitude Variables** | | | |
| Attitude towards mathematics (f1) | 39.71 | .47 | 30.60* |
| Value learning mathematics (f2) | 17.19 | .21 | 9.30* |
| **Environmental Variables** | | | |
| Bullying (f4) | .64 | .01 | 0.39 |
| Parental involvement (f5) | 3.29 | .04 | 2.03* |
| Parental Education Level (f6) | 27.56 | .33 | 17.34* |
| Belonging to school (f7) | 8.51 | .10 | 6.32* |
| **Instructional Variables** | | | |
| Teacher effectiveness (f3) | 1.70 | .02 | 1.56 |
| Teacher expectation (f8) | 22.46 | .27 | 12.22* |

** Statistically significant t values at p < .05 level.*

## DISCUSSION AND IMPLICATIONS

This study makes an important contribution to a growing body of cross-country comparative research studies by comparing factors predicting science and mathematics achievement for two countries, Turkey and the Republic of Korea. Even though the Korean and Turkish education systems are similar in some respects, such as being centralized, having high stakes tests, and having similar public expenditure on education, the two countries have reported different science and mathematics scores on the 2011 TIMSS assessment. For example, Korean students generally score in the top three of all countries while Turkey's students score lower than the international average. This research sought to answer the following question: How do aptitude, instruction, and environment related factors predict Turkish and Korean students' achievement in science and mathematics?

### Factors predicting science and mathematics achievement

Based on the multiple regression analyses results and Walberg's model, the factors significantly predicting Turkish and Korean students' science and mathematics achievement are compared and discussed in the following sections.

### Student aptitude variables

Anxiety towards science was found as a significant predictor of both Turkish and Korean students' science achievement. This factor seems to be the most important factor that might influence Korean students' science achievement. Similarly, for Turkey, it seems to be the second most important factor that might affect Turkish students' science achievement. Research indicates that students in both countries experience a great deal of pressure from their families and schools to study (Paik, 2004; Park et al., 2011; Topçu et al., 2015), and as a result, their anxiety levels could negatively influence their achievement in science. This result suggests that starting from early years of education, serious precautions should be taken to decrease students' anxiety towards science. Hassan (2008) claimed that, "students who are less anxious toward science are more likely to be motivated to pursue their studies and a career in science" (p. 132). Therefore, we need to find new teaching strategies and methods to decrease students' anxiety towards science. For example, educational video games including 3D Multi-User Virtual Environments might be used for eliminating students' anxiety. Educational games situated in science learning environments have increased students' interest in learning science (Annetta, Cheng, & Holmes, 2010; Barab, Sadler, Heiselt, Hickey, & Zuiker, 2007), and also supported their self-efficacy and content learning (Sadler, Romine, Stuart, & Merle-Johnson, 2013). Therefore, using these educational games in science learning environments can decrease their anxiety and increase their science interest, self-efficacy, and content learning.

Science self-efficacy was one of the most effective factors predicting Turkish and Korean students' science achievement in TIMSS 2011. This factor seems to be the most important factor that might influence Turkish students' science achievement among the other factors. Similarly, for Korea, it seems to be the second most important factor that might affect Korean students' science achievement. Wilkins et al., (2002) studied 16 countries' TIMSS data sets from 1995 and reported that students' science self-efficacy was a consistent predictor of science achievement regardless of country differences. The present study supports this claim that regardless of country characteristics, science self-efficacy, as a universal factor, might influence students' science achievement. Ceylan and Berberoğlu (2007) studied the 1999 TIMSS-Repeat (TIMMS-R) data set and reported that one of the most effective factors in predicting Turkish students' science achievement was students' perceptions of success, which was directly related to their science self-efficacy. Similarly, studies have reported that students' self-efficacy and motivation might account for Korean students' academic success (Bae & Wickrama, 2014; House & Telese, 2013; Paik, 2004). In light of the previous research (e.g., Akyüz, 2014; Ceylan & Berberoğlu, 2007; Topçu et al., 2015; Wilkins et al., 2002) and the present study, it can be suggested that regardless of country differences, students' science self-efficacy is an important educational variable that should be increased to improve students' science achievement. Self-efficacy has a potential that influences students' feelings, thinking, motivation, and behaviors (Arikan, 2014). If students' self-efficacy is strong enough, they are expected to achieve more challenging goals. Bandura (1993) claims that when two students have the same knowledge and skills, their achievement changes depending on their self-efficacy levels. When students' self-efficacy increases, especially low achieving students' self-efficacy, it is expected that their science achievement also increases.

Students who value learning science are more likely to perform well in science. The findings of the present study corroborate previous research (Singh, Chang, & Dika, 2005; 2006) that valuing science correlates with high science achievement. Similarly, value learning mathematics was found to have a significant positive relationship with Korean and Turkish students' mathematics achievement. Students' valuing science or mathematics has been related to parental variables such as family socioeconomic status (Singh et al., 2005; 2006). For instance, when students lack a role model that works in a science or mathematics related field, they may be less likely to get interested in a science or mathematics-related job or may not understand the utility of learning science and mathematics. An implication of the present study is that when teachers and parents help students to value science and mathematics, students' science and mathematics achievement could be improved. Teachers might show the usefulness of scientific and mathematical knowledge by making real life connections in science and mathematics lessons. Schools may introduce science and mathematics-related jobs to students and emphasize how learning science and mathematics can open many career opportunities.

Attitude towards mathematics was the most effective factor predicting both Turkish and Korean students' mathematics achievement in TIMSS 2011. If students' attitudes towards mathematics increase, their mathematics achievement also increases, and vice versa. At this point we can claim that regardless of country characteristics, attitude towards mathematics seems a very important factor that predict significantly and largely students' mathematics achievement. Therefore, if we want to increase students' mathematics achievement, it would be a good start to promote students' attitudes towards mathematics. However, the previous literature presents inconsistent findings about this relationship. Ma and Kishor (1997) conducted a meta-analysis about the relationship between attitudes towards mathematics and mathematics achievement and concluded that there was not any consensus on the existence of this relationship. While a significant number of research have reported quite low correlations between attitudes towards mathematics and mathematics achievement and concluded that this relationship was not considered to be of practical significance (e.g., Wolf & Blixt, 1981), many other researchers have demonstrated strong relationships (e.g., Kloosterman, 1991). Although the inconsistent findings about this relationship between attitudes towards mathematics and mathematics achievement, we claim that attitudes towards mathematics has a large potential to explain mathematics achievement variation for both countries. As an implication of this result, necessary precautions should be taken by mathematics teachers and parents to improve students' attitudes towards mathematics positively. As the National Council of Teachers of Mathematics (2000) encouraged mathematics teachers to incorporate affective factors with cognitive factors in teaching mathematics, we should not ignore the affective part of mathematics teaching and learning in classrooms. In order to increase students' positive attitudes towards mathematics, students should be actively engaged in worthwhile mathematical tasks designed to arouse students' curiosity and to deepen their conceptual understanding.

## Environmental variables

Parental education level was one of the most effective factors in predicting science and mathematics achievement for both Turkey and Korea. Consistent with the current literature (Berberoğlu et al., 2003; Chevalier & Lanot, 2002; Fuchs *& Wößmann,* 2007), the present study revealed that parental education level was significantly correlated with student achievement. Berberoğlu et al. (2003) found that parental education level, a component of family SES, was an important factor, predicting Turkish students' science and mathematics achievement based on TIMSS 1995 data. Similarly, Fuchs and Wößmann (2007) revealed that student performance increased in mathematics and science due to the increase of parental education level based on PISA 2000 data set. Consistent with the previous research, we can claim that regardless of country characteristics, parental education level could be another universal factor that predicts students' both science and mathematics achievement. Different from previous factors, parental education levels significantly predicted both a students' science and mathematics achievement levels. Therefore, we suggest that every country might place emphasis on their citizens' education. For example, governments in Turkey and Korea might organize some educational programs such as summer institutions or evening classes for parents in order to increase parental education level. Particularly, schools might provide additional educational support for parents having low education levels. Schools might develop specific family support programs in order to increase educational knowledge and awareness of parents.

Belonging to school was related to both Turkish and Korean students' science and mathematics achievement, but direction of this relationship was different for each country. Korean students who reported that they liked school, felt safe, and felt they belonged to school were more successful in science and mathematics. On the contrary, when Turkish students' belonging to school increased, their science and mathematics achievement decreased. This relationship pattern for Turkish students is an unexpected result when we compare this result with the findings about Korean students and previous research. Ma (2003) found that disciplinary environment in school was important in increasing sense of belonging to school. However, if students perceived school rules as unfair, sense of belonging to school was damaged. One of the reasons of this unexpected relationship for Turkish students might stem from students' negative perception about schools. The studies conducted in Turkey showed that some students perceived teachers as judges and guardians (Çuhadar & Sarı, 2007), and they saw themselves as slaves and prisoners (Saban, 2009). These findings show that some Turkish students perceive schools as a kind of pressure area (Ozdemir, 2012). Willms (2003) suggested that school administrators design their school environment in a positive and attractive way to motivate students for attending their school more eagerly. Producing and maintaining positive environment for learning and organizing educational, extracurricular, and sportive activities at school would enhance students' sense of belonging.

So far, we discussed the common factors that predicted Turkish and Korean students' achievement in science and mathematics. In the following part, we will discuss the factors that predicted Korean and Turkish students' achievement separately. The factor named bullying was significantly associated with Turkish students' science and mathematics achievement, but this factor did not predict

Korean students' science and mathematics achievement. Lai, Ye, and Chang (2008) found significant correlations between existence of bullying in schools and academic achievement in some countries, however, they also found insignificant correlations between existence of bullying in schools and academic achievement in other countries. Our findings supported this conclusion that bullying was a significant factor for Turkey but not for Korea. The previous research (Akiba & Han, 2007) resonates with the finding of the present study, which found that bullying in Korean schools did not predict student achievement. A study conducted by Harel-Fisch et al. (2011), including cross-national analyses, showed the consistency of the relationship between negative school experience and involvement in bullying across 40 European and North American countries. There have been, also, research studies reporting that bullying is common in Turkish schools (Alikasifoglu, Erginoz, Ercan, Uysal, & Albayrak-Kaymak, 2007; Kepenekci & Çınkır, 2006). Thus, the existence of both negative school perception and bullying might affect Turkish students' science and mathematics achievement negatively. When students suffer from bullying and have negative school perception, these conditions might affect their emotional development negatively; consequently, their achievement in core courses such as science and mathematics could decrease (Sharp, 1995). Bullying may also cause psychological, social, or academic problems (Woods & Wolke, 2004). If we expect high achievement from Turkish students, we need to provide safe and stable environments for students who can focus and improve their academic achievement in science and mathematics. School administrators, teachers, counselors, and parents in Turkey should be proactive to plan strategies for preventing bullying and to change students' school perception positively. For example, school administrations and psychological counselors could organize educational programs for students and their parents in order to increase awareness about bullying. In these programs, the meaning of bullying, preventing from bullying, and consequences of bullying could be presented to students and their families.

Findings of the present study showed that another factor predicting Korean and Turkish students' achievement differently is parental involvement. While parental involvement was not significantly related to science achievement in both countries, it was only related to Korean students' mathematics achievement. This result aligns with the previous research (Bae & Wickrama, 2014; House & Telese, 2013; Paik, 2004) that parental guidance, support, and expectations might account for Korean students' academic success. Since Korean parents highly value education and have high academic expectations for their children (Paik, 2004; Park et al., 2011), parental involvement might positively influence Korean students' mathematics achievement. Students who have parents that talk about what he or she learned in school, and check homework were expected to be more successful. Therefore, Korean families who highly value and support their children show a good parental example for other countries. Similarly, previous research findings suggest that parental involvement have positive influences on student achievement (Mcwayne et al., 2004; Sui-Chu & Willms, 1996). However, the type of parental involvement makes a difference in influencing students' educational outcomes. For instance, excessive parental control, such as closely monitoring homework completion or strict behavioral control, might negatively affect student achievement (Kramer, 2012; Shumow & Miller, 2001). Our analysis suggests that existence or influence of parental involvement for Korean students could explain Korean students' high achievement in mathematics. If we expect high achievements in mathematics from students, we need to promote parental involvement. Accordingly, school administrators might develop strategies to increase awareness about effective ways of parental involvement and positive effects of such involvement on student achievement.

The present study also showed that home resources and computer use at home are other variables that predicted Turkish and Korean students' achievement differently. These variables significantly predicted science and mathematics achievement for Turkish students, but not for Korean students. In PISA 2006 and PISA 2009, Turkish students having higher number of computers and home educational resources scored significantly higher in science achievement than those who had fewer numbers of computers at home and home educational resources (Topçu et al., 2015). These findings corroborate previous studies reporting that home educational resources are significantly associated with achievement in science (Ma, 2003). These findings underline the importance of home educational resources for improving Turkish students' achievement (Topçu et al., 2015). These results also suggest some vision for educational policies regarding home-school cooperation. For example, schools might inform parents about making their investments in educational resources. Parents could be informed that they should make more investments in educational resources such as computer use for educational purposes.

### Instructional variables

As an instructional variable, teacher effectiveness was a significant predictor of Turkish students' mathematics achievement, but this factor was not associated with Korean students' mathematics achievement. Teacher effectiveness, in this study, represented the quality of instruction in Walberg's model and referred to teachers' clear communication of topics, expectations, and interesting materials in the mathematics classrooms as perceived by students. Such instructional practices were positively correlated with students' mathematics achievement based on international average in TIMSS 2011 (Mullis, Martin, Foy, & Arora, 2012). Aligned with our findings, previous studies, defining teacher effectiveness in similar manner, revealed that teacher effectiveness positively correlated with students' mathematics achievement in some countries and weakly correlated or negatively correlated with students' mathematics achievement in some other countries (Akyüz, 2014; Lamb & Fullarton, 2002; Ma & Wang, 2001). Akyüz (2014) reported that teacher effectiveness positively influenced students' mathematics achievement in Turkey. Stronge, Ward and Grant (2011) noted, "the common denominator in school improvement and student success is the teacher" (p. 351). Thus, investment in effective teaching practices seems a promising effort for improving mathematics education. This study found no relationship regarding teacher effectiveness in Korean context. Akiba, LeTendre and Scribner (2007) concluded that Korea had a high percentage of qualified mathematics teachers and equal access to qualified mathematics teachers by high and low SES students. Since Korean students have an equal access to qualified teachers regardless of their SES, teacher effectiveness might not create a variation in Korean students' achievement in mathematics. We can infer that other countries such as Turkey should provide equal access to qualified teachers, similar to Korea. However, this is not the case for many developing countries such as Turkey. Therefore, there exist big achievement gaps or variances at both individual and school levels in these countries (Topçu, 2014).

## CONCLUSION

The results of the present study are reliable in a sense that multiple regression analyses were conducted by IDB Analyzer, which took into account sampling design, sampling weights, plausible values reported in TIMSS, and gave predictions even the dependent variable consisted of several plausible values. With regard to factors predicting students' science and mathematics achievement, the current study found similarities and differences between Turkey and Korea. One of these similarities was that in both countries some student aptitude variables (e.g., attitude towards mathematics, anxiety towards science, science self-efficacy) significantly predicted students' science or mathematics achievement. Another similarity was that in both countries, some environmental variables (e.g., parental educational level, belonging to school) predicted both science and mathematics achievement. One of the differences occurred regarding some environmental variables, such as bullying. Instructional variables also predicted achievement differently in each country. To sum up, environmental and instructional variables had different predictive effects in each country.

The findings of this study can be generalized to other countries. Education policymakers from other countries may use our findings to improve their education systems. To be more specific, some factors (attitude towards mathematics, anxiety towards science, science self-efficacy, and parental education level) have a potential to be universal factors since the present study and previous studies showed that these factors influenced science or mathematics achievement consistently and largely regardless of country characteristics. Therefore, the findings of the present study and previous research shed light on potential factors that can influence and explain science and mathematics achievement globally. Our findings suggest future studies as well. For instance, the insignificant relationship between bullying and students' achievement in Korea might be further investigated. Similarly, the insignificant relationship between teacher effectiveness and mathematics achievement in Korea might be examined in future research.

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**Appendix A.**

Factor loadings from principal component analysis of Turkish student science questionnaire

| Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I like science | **.691** | .443 | | | | | | | | | | |
| I learn many interesting things in science | **.685** | | | | | | | | | | | |
| I enjoy learning science | **.674** | .375 | | | | | | | | | | |
| I am interested in what my teacher says | **.632** | | | | | | | | | | | |
| My teacher is easy to understand | **.593** | | | | | | | | | | | |
| It is important to do well in science | **.577** | | .343 | | | | | | | | | |
| I know what my teacher expects me to do | **.508** | | | .448 | | | | | | | | |
| I think learning science will help me in my daily life | **.499** | | .290 | | | | | | | | | |
| My teacher gives me interesting things to do | **.495** | | | .304 | | | | | | | | |
| I read about science in my spare time | **.464** | | | | | | | | | | | |
| Science is harder for me than any other subject | | **.757** | | | | | | | | | | |
| Science is not one of my strengths | | **.737** | | | | | | | | | | |
| Science makes me confused and nervous | | **.729** | | | | | | | | | | |
| Science is more difficult for me than for many of my classmates | | **.714** | | | | | | | | | | |
| Science is boring | .408 | **.690** | | | | | | | | | | |
| I wish I did not have to study science | .296 | **.662** | | | | | | | | | | |
| I think of things not related to the lesson | | **.577** | | | | | | | | | | |
| I need to do well in science to get the job I want | | | **.860** | | | | | | | | | |
| I need to do well in science to get into the <university> of my choice | | | **.830** | | | | | | | | | |
| I would like a job that involves using science | | | **.683** | | | | | | | | | |
| I need science to learn other school subjects | .371 | | **.600** | | | | | | | | | |
| My teacher thinks I can do well in science <programs/classes/ lessons> with difficult materials | .309 | | | **.709** | | | | | | | | |
| My teacher tells me I am good at science | .351 | | | **.694** | | | | | | | | |
| I am good at working out difficult science problems | | .321 | | **.596** | | | | | | | | |
| I usually do well in science | .422 | .385 | | **.492** | | | | | | | | |
| I learn things quickly in science | .412 | .384 | | **.469** | | | | | | | | |
| Computer usage frequency at home | | | | | **.891** | | | | | | | |
| Possession computer at home | | | | | **.889** | | | | | | | |
| Possession internet connection at home | | | | | **.856** | | | | | | | |
| I was hit or hurt by other student(s) (e.g., shoving, hitting, kicking) | | | | | | **.720** | | | | | | |
| Someone spread lies about me | | | | | | **.692** | | | | | | |
| I was made fun of or called names | | | | | | **.655** | | | | | | |
| I was made to do things I didn't want to do by other students | | | | | | **.583** | | | | | | |
| I was left out of games or activities by other students | | | | | | **.574** | | | | | | |
| Something was stolen from me | | | | | | **.525** | | | | | | |
| My parents ask me what I am learning in school | | | | | | | **.745** | | | | | |
| I talk about my schoolwork with my parents | | | | | | | **.693** | | | | | |
| My parents check if I do my homework | | | | | | | **.688** | | | | .289 | |
| My parents make sure that I set aside time for my homework | | | | | | | **.657** | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Highest education level-mother | | | | | | | | **.808** | | | | |
| Highest education level-father | | | | | | | | **.798** | | | | |
| Number of books at home | | | | | | | | **.576** | | | | |
| I feel like I belong at this school | | | | | | | | | **.785** | | | |
| I feel safe when I am at school | | | | | | | | | **.756** | | | |
| I like being in school | | | | | | | | | **.702** | | | |
| Possession study desk at home | | | | | | | | .323 | | **.572** | | |
| Possession books of your very own (do not count your school books) | | | | | | | | | | **.548** | | |
| Possession own room at home | | | | | | | | .339 | | **.548** | | |
| Computer usage frequency at school | | | | | | | | -.329 | | **.479** | | |
| Computer usage frequency at other places | | | | | | | | | | .270 | **.603** | |
| Frequency of giving homework of teachers | | | | | | | | | | | **.595** | |
| Future education level expectation | | | | | | | | .263 | | .338 | **-.355** | |
| Spending time on your homework | | | | | | | | | | | | **.925** |
| **Cronbach's Alpha Coefficients (α)** | .85 | .85 | .82 | .86 | .77 | .69 | .70 | .70 | .66 | .25 | -.08 | – |
| **Eigenvalues** | 9.81 | 4.23 | 2.73 | 2.49 | 1.92 | 1.62 | 1.46 | 1.33 | 1.22 | 1.19 | 1.10 | 1.00 |
| **% of variances** | 18.51 | 7.99 | 5.15 | 4.70 | 3.62 | 3.06 | 2.75 | 2.52 | 2.31 | 2.24 | 2.08 | 1.89 |

*Note. Item loadings lower than .25 were suppressed*
*Factor1: Enjoyment of science*
*Factor2: Anxiety towards science*
*Factor3: Value learning science*
*Factor4: Science self-efficacy*
*Factor5: Computer use at home*
*Factor6: Bullying*
*Factor7: Parental involvement*
*Factor8: Parental education level*
*Factor9: Belonging to school*

**Appendix B.**
Factor loadings from principal component analysis of Korean student science questionnaire

| Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Science is harder for me than any other subject | **.801** | | | | | | | | | | | | |
| Science is not one of my strengths | **.751** | | | .345 | | | | | | | | | |
| Science makes me confused and nervous | **.749** | | | | | | | | | | | | |
| Science is more difficult for me than for many of my classmates | **.740** | | | .275 | | | | | | | | | |
| Science is boring | **.691** | | .387 | | | | | | | | | | |
| I wish I did not have to study science | **.633** | .276 | .309 | | | | | | | | | | |
| I like science | **.594** | .363 | .433 | | | | | | | | | | |
| My teacher thinks I can do well in science <programs/classes/ lessons> with difficult materials | **.577** | | | .525 | | | | | | | | | |
| I enjoy learning science | **.567** | .354 | .451 | | | | | | | | | | |
| I think of things not related to the lesson | **.481** | | .447 | | | | | | | | | | |
| I need to do well in science to get into the <university> of my choice | | **.830** | | | | | | | | | | | |
| I need to do well in science to get the job I want | | **.823** | | | | | | | | | | | |
| I need science to learn other school subjects | | **.739** | | | | | | | | | | | |
| It is important to do well in science | | **.722** | | | | | | | | | | | |
| I think learning science will help me in my daily life | | **.683** | | | | | | | | | | | |

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I would like a job that involves using science | .315 | **.570** | | | | | | | | | | | |
| I am interested in what my teacher says | .331 | .262 | **.738** | | | | | | | | | | |
| My teacher gives me interesting things to do | | | **.704** | .295 | | | | | | | | | |
| My teacher is easy to understand | .285 | | **.690** | | | | | | | | | | |
| I learn many interesting things in science | .415 | .368 | **.460** | | | | | | | | | | |
| I usually do well in science | .280 | | | **.752** | | | | | | | | | |
| My teacher tells me I am good at science | .351 | | | **.724** | | | | | | | | | |
| I am good at working out difficult science problems | .451 | | | **.637** | | | | | | | | | |
| I learn things quickly in science | .446 | | | **.522** | | | | | | | | | |
| I know what my teacher expects me to do | | | .439 | **.472** | | | | | | | | | |
| I read about science in my spare time | .273 | .264 | .256 | **.371** | | | | | | | | | |
| I was made fun of or called names | | | | | **.727** | | | | | | | | |
| I was hit or hurt by other student(s) (e.g., shoving, hitting, kicking) | | | | | **.703** | | | | | | | | |
| Someone spread lies about me | | | | | **.678** | | | | | | | | |
| I was left out of games or activities by other students | | | | | **.663** | | | | | | | | |
| I was made to do things I didn't want to do by other students | | | | | **.636** | | | | | | | | |
| Something was stolen from me | | | | | **.613** | | | | | | | | |
| My parents make sure that I set aside time for my homework | | | | | | **.799** | | | | | | | |
| My parents ask me what I am learning in school | | | | | | **.743** | | | | | | | |
| My parents check if I do my homework | | | | | | **.741** | | | | | | | |
| I talk about my schoolwork with my parents | | | | | | **.736** | | | | | | | |
| Highest education level-father | | | | | | | **.839** | | | | | | |
| Highest education level-mother | | | | | | | **.832** | | | | | | |
| Number of books at home | | | | | | | **.560** | | | | | | |
| Future education level expectation | | | | | | | **.351** | | | | -333 | | |
| I feel safe when I am at school | | | | | | | | **.778** | | | | | |
| I like being in school | | | | | | | | **.770** | | | | | |
| I feel like I belong at this school | | | | | | | | **.736** | | | | | |
| Possession computer at home | | | | | | | | | **.800** | | | | |
| Possession internet connection at home | | | | | | | | | **.748** | | | | |
| Computer usage frequency at home | | | | | | | | | **.654** | | | | |
| Possession study desk at home | | | | | | | | | | **.730** | | | |
| Possession own room at home | | | | | | | | | | **.620** | | | |
| Possession books of your very own (do not count your school books) | | | | | | | | | | **.498** | -325 | | |
| Computer usage frequency at other places | | | | | | | | | | | **.771** | | |
| Spending time on your homework | | | | | | | | | | | | **.753** | |
| Frequency of giving homework of teachers | | | | | | | | | | | .298 | **.652** | |
| Computer usage frequency at school | | | | | | | | | | | | | **.855** |
| **Cronbach's Alpha Coefficients (α)** | .92 | .88 | .85 | .86 | .75 | .78 | .68 | .73 | .27 | .29 | – | .22 | – |
| **Eigenvalues** | 12.50 | 3.11 | 2.89 | 2.09 | 1.77 | 1.66 | 1.53 | 1.30 | 1.28 | 1.18 | 1.14 | 1.07 | 1.00 |
| **% of variances** | 23.59 | 5.86 | 5.45 | 3.95 | 3.35 | 3.12 | 2.88 | 2.46 | 2.41 | 2.33 | 2.15 | 2.02 | 1.89 |

*Note. Item loadings lower than .25 were suppressed*
*Factor1: Anxiety towards science*
*Factor2: Value learning science*
*Factor3: Teacher effectiveness*
*Factor4: Science self-efficacy*
*Factor5: Bullying*
*Factor6: Parental involvement*
*Factor7: Parental education level*
*Factor8: Belonging to school*

**Appendix C.**

Factor loadings from principal component analysis Turkish student mathematics questionnaire

| Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mathematics is not one of my strengths | **.794** | | | | | | | | | | | |
| Mathematics is harder for me than any other subject | **.771** | | | | | | | | | | | |
| Mathematics is boring | **.748** | | | | | | | | | | | |
| I like mathematics | **.706** | | .271 | | | | | | | | | |
| Mathematics is more difficult for me than for many of my classmates | **.694** | | | | | | | | | | | |
| Mathematics makes me confused and nervous | **.679** | | | | | | | | | | | |
| I wish I did not have to study mathematics | **.675** | | | | | | | | | | | |
| I usually do well in mathematics | **.668** | .342 | | | | | | | | | | |
| I am good at working out difficult mathematics problems | **.651** | .283 | | | | | | | | | | |
| I learn things quickly in mathematics | **.644** | .325 | | | | | | | | | | |
| I enjoy learning mathematics | **.640** | .267 | .260 | | | | | | | | | |
| My teacher tells me I am good at mathematics | **.542** | .525 | | | | | | | | | | |
| I would like a job that involves using mathematics | **.531** | | .495 | | | | | | | | | |
| I think of things not related to the lesson | **.417** | | | | | | | | | .417 | | |
| My teacher thinks I can do well in mathematics <programs/classes/ lessons> with difficult materials | .282 | **.682** | | | | | | | | | | |
| I know what my teacher expects me to do | | **.674** | | | | | | | | | | |
| My teacher is easy to understand | | **.614** | | | | | | | | | | |
| My teacher gives me interesting things to do | | **.511** | | | | | | | | | | |
| I am interested in what my teacher says | .291 | **.501** | | | | | | | | -.327 | | |
| I learn many interesting things in mathematics | .330 | **.381** | .266 | | | | | | | | | |
| I think learning mathematics will help me in my daily life | | **.361** | .351 | | | | | | | | | |
| I need to do well in mathematics to get the job I want | | | **.811** | | | | | | | | | |
| I need to do well in mathematics to get into the <university> of my choice | | | **.806** | | | | | | | | | |
| I need mathematics to learn other school subjects | | .265 | **.515** | | | | | | | | | |
| It is important to do well in mathematics | | | **.414** | | | | | | | -.384 | | |
| Computer usage frequency at home | | | | **.898** | | | | | | | | |
| Possession computer at home | | | | **.892** | | | | | | | | |
| Possession internet connection at home | | | | **.855** | | | | | | | | |
| I was hit or hurt by other student(s) (e.g., shoving, hitting, kicking) | | | | | **.711** | | | | | | | |
| Someone spread lies about me | | | | | **.688** | | | | | | | |
| I was made fun of or called names | | | | | **.648** | | | | | | | |
| I was made to do things I didn't want to do by other students | | | | | **.585** | | | | | | | |
| I was left out of games or activities by other students | | | | | **.558** | | | | | | | |
| Something was stolen from me | | | | | **.553** | | | | | | | |
| My parents ask me what I am learning in school | | | | | | **.746** | | | | | | |
| I talk about my schoolwork with my parents | | | | | | **.698** | | | | | | |
| My parents check if I do my homework | | | | | | **.675** | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| My parents make sure that I set aside time for my homework | | | | | | **.644** | | | | | | |
| Highest education level-mother | | | | | | | **.768** | | | | | |
| Highest education level-father | | | | | | | **.756** | | | | | |
| Number of books at home | | | | | | | **.563** | | | | | |
| Computer usage frequency at school | | | | | | | **-.390** | | .332 | | | .271 |
| I feel like I belong at this school | | | | | | | | **.787** | | | | |
| I feel safe when I am at school | | | | | | | | **.746** | | | | |
| I like being in school | | | | | | | | **.682** | | | | |
| Possession study desk at home | | | | | | | .263 | | **.625** | | | |
| Possession own room at home | | | | | | | .279 | | **.605** | | | |
| Possession books of your very own (do not count your school books) | | | | | | | | | **.518** | | | |
| Computer usage frequency at other places | | | | | | | | | .362 | **-.532** | | |
| Frequency of giving homework of teachers | | | | | | | | | | | **.688** | |
| Future education level expectation | | | | | | | .290 | | | | **-.362** | .308 |
| Spending time on your homework | | | | | | | | | | | | **.840** |
| **Cronbach's Alpha Coefficients (α)** | .91 | .75 | .71 | .77 | .69 | .70 | .54 | .66 | .59 | - | -.15 | – |
| **Eigenvalues** | 9.43 | 4.01 | 2.77 | 2.53 | 1.71 | 1.50 | 1.43 | 1.34 | 1.19 | 1.10 | 1.05 | 1.03 |
| **% of variances** | 18.14 | 7.87 | 5.33 | 4.86 | 3.28 | 2.89 | 2.75 | 2.57 | 2.29 | 2.11 | 2.02 | 1.97 |

*Note. Item loadings lower than .25 were suppressed*
*Factor1:Attitude towards mathematics*
*Factor2:Teacher effectiveness*
*Factor3:Value learning mathematics*
*Factor4:Computer use at home*
*Factor5:Bullying*
*Factor6:Parental involvement*
*Factor7:Parental education level*
*Factor8:Belonging to school*
*Factor9:Home resources*

**Appendix D.**

Factor loadings from principal component analysis Korean student mathematics questionnaire

| Items | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Mathematics is harder for me than any other subject | **.816** | | | | | | | | | | | |
| Mathematics is not one of my strengths | **.810** | | | | | | | | | | | |
| I like mathematics | **.773** | | .299 | | | | | | | | | |
| I usually do well in mathematics | **.731** | | | | | | | .368 | | | | |
| I enjoy learning mathematics | **.715** | | .349 | | | | | | | | | |
| Mathematics is more difficult for me than for many of my classmates | **.696** | | | | | | | .268 | | | | |
| Mathematics is boring | **.688** | | .363 | | | | | | | | | |
| Mathematics makes me confused and nervous | **.669** | .346 | | | | | | | | | | |
| I am good at working out difficult mathematics problems | **.650** | | | | | | | .372 | | | | |
| I wish I did not have to study mathematics | **.637** | | .317 | | | | | -.260 | | | | |
| I learn many interesting things in mathematics | **.627** | | .374 | | | | | | | | | |
| I learn things quickly in mathematics | **.587** | | | | | | | .360 | | | | |
| I would like a job that involves using mathematics | **.498** | .380 | .273 | | | | | | | | | |
| I need to do well in mathematics to get the job I want | | **.801** | | | | | | | | | | |
| I need to do well in mathematics to get into the <university> of my choice | | **.797** | | | | | | | | | | |
| It is important to do well in mathematics | | **.685** | | | | | | | | | | |
| I need mathematics to learn other school subjects | .271 | **.634** | | | | | | | | | | |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| I think learning mathematics will help me in my daily life | | | | **.520** | .305 | | | | | | | |
| I am interested in what my teacher says | | | .302 | | **.737** | | | | | | | |
| My teacher gives me interesting things to do | | | | | **.703** | | | | | | | |
| My teacher is easy to understand | | | | | **.596** | | | | | | | |
| I think of things not related to the lesson | | | .273 | | **.482** | | | | | | | |
| Computer usage frequency at school | | | | | **-.223** | | | | | | | |
| I was made fun of or called names | | | | | | | **.706** | | | | | |
| I was hit or hurt by other student(s) (e.g., shoving, hitting, kicking) | | | | | | | **.703** | | | | | |
| Someone spread lies about me | | | | | | | **.668** | | | | | |
| I was left out of games or activities by other students | | | | | | | **.662** | | | | | |
| I was made to do things I didn't want to do by other students | | | | | | | **.638** | | | | | |
| Something was stolen from me | | | | | | | **.597** | | | | | |
| My parents make sure that I set aside time for my homework | | | | | | | | **.793** | | | | |
| My parents ask me what I am learning in school | | | | | | | | **.739** | | | | |
| My parents check if I do my homework | | | | | **.728** | | | | | | | |
| I talk about my schoolwork with my parents | | | | | **.725** | | | | | | | |
| Highest education level-father | | | | | | **.829** | | | | | | |
| Highest education level-mother | | | | | | **.827** | | | | | | |
| Number of books at home | | | | | | **.557** | | | | | | |
| Future education level expectation | | | | | | **.393** | | | | | | |
| I like being in school | | | | | | | **.755** | | | | | |
| I feel safe when I am at school | | | | | | | **.747** | | | | | |
| I feel like I belong at this school | | | | | | | **.739** | | | | | |
| My teacher thinks I can do well in mathematics <programs/classes/ lessons> with difficult materials | .381 | | | | | | | **.640** | | | | |
| My teacher tells me I am good at mathematics | .452 | | | | | | | **.614** | | | | |
| I know what my teacher expects me to do | | | .354 | | | | | **.538** | | | | |
| Possession computer at home | | | | | | | | | **.786** | | | |
| Possession internet connection at home | | | | | | | | | **.728** | | | |
| Computer usage frequency at home | | | | | | | | | **.628** | | | |
| Possession study desk at home | | | | | | | | | | **.686** | | |
| Possession own room at home | | | | | | | | | | **.656** | | |
| Computer usage frequency at other places | | | | | | | | | | | **-.709** | |
| Possession books of your very own (do not count your school books) | | | | | | | | | | .371 | **.442** | |
| Frequency of giving homework of teachers | | | | | | | | | | | | **.802** |
| Spending time on your homework | | | | | | | | | | | .300 | **.620** |
| **Cronbach's Alpha Coefficients (α)** | .93 | .80 | .62 | .75 | .78 | .68 | .73 | .73 | .27 | .25 | -.05 | .19 |
| **Eigenvalues** | 10.34 | 3.02 | 2.99 | 2.28 | 1.89 | 1.62 | 1.51 | 1.38 | 1.34 | 1.12 | 1.11 | 1.07 |
| **% of variances** | 19.89 | 5.81 | 5.75 | 4.38 | 3.63 | 3.12 | 2.90 | 2.66 | 2.58 | 2.16 | 2.13 | 2.05 |

*Note. Item loadings lower than .25 were suppressed*
*Factor1: Attitude towards mathematics*
*Factor2:Value learning mathematics*
*Factor3:Teacher effectiveness*
*Factor4:Bullying*
*Factor5:Parental involvement*
*Factor6:Parental education level*
*Factor7:Belonging to school*
*Factor8:Teacher expectation*