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RE-ANALYSIS of PISA 2003 DATA about STUDENTS' MATHEMATICS ANXIETY, SELF-EFFICACY, and MOTIVATION

ÖĞRENCİLERİN MATEMATİK KAYGISI, ÖZYETERLİK VE MOTİVASYONLARI ÜZERİNE PISA 2003 VERİLERİNİN TEKRAR ANALİZİ

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Öz
PISA 2003 verilerine dayanarak bu çalışmada, öğrencilerin matematik hakkındaki kaygıları, motivasyonları, özyeterlikleri ve öz-kavramaları incelenmiştir. Yaşları 15-16 arasında ve 41 farklı ülkede yaşayan 272138 öğrencinin oluşturduğu veri seti üzerinde analizler yapılmıştır. Örneklem seçimi iki aşamalı tabakalı yöntem ile yapılmıştır. Sonuçlar; (a) erkekler kızlara nazaran (istatistiki) anlamlı olarak daha yüksek özyeterlik, özkavrama, motivasyon, ve daha düşük matematik kaygısına sahiptirler, (b) yüksek sosyoekonomik durumda olanlar daha yüksek özyeterlik, motivasyon, ve daha düşük matematik kaygısına sahiptirler, ve (c) coğrafik bölgeler nazara alındığında özyeterlik, özkavrama, motivasyon ve kaygıda anlamlı olarak bir farklılaşma olduğunu göstermiştir.

Anahtar Kelimeler: PISA 2003, Matematik Eğitimi, Kaygı, Özyeterlik, Özkavrama, Motivasyon

Abstract
Relying on PISA 2003 data, the study investigated students' anxiety, motivation, self-efficacy, and self-concept on learning mathematics. The analysis was carried out over large amount of data, collected from 272138 students who were 15-16 years of age, coming from 41 countries. Two-stage stratified sampling strategy provided the sample for the analysis. Findings showed that (a) boys have significantly higher mathematical self-efficacy, self-concept, motivation and lower mathematics anxiety than girls, (b) students with higher socioeconomic status have higher self-efficacy, self-concept and motivation whereas students with the highest mathematics anxiety are in medium socioeconomic level, and (c) self-efficacy, self-concept, motivation and anxiety differ significantly with respect to geographical regions.

Keywords: PISA 2003, Mathematics Education, Anxiety, Self-Concept, Self-Efficacy, Motivation

Introduction

Affective constructs and their role in learning and teaching have been an important topic of educational research in the past several decades; specifically so in the case of mathematics

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education, since students' difficulties related with mathematical tasks have largely been reported. International studies of big scale create good opportunities to see whether affective constructs and their effects on academic achievement differ with respect to country, gender or socioeconomic status of the participants. One such study is the Programme for International Student Assessment (PISA), conducted by the Organization for Economic Co-operation and Development (OECD). PISA tests gather information about 15-year old students' progress as a result of their formal education. Four domains were assessed in PISA 2003 study; mathematics as major domain, reading, science, and problem solving as minor domains (OECD, 2005). Apart from cognitive tests for each domain, students also fill in questionnaires regarding their attitudes toward learning, family background and socioeconomic status (OECD, 2003).

To date, there have been numerous reports and papers published on the analysis of the PISA 2003 data such as, the OECD technical report (OECD, 2005), the PISA 2003 assessment framework (OECD, 2003). However, studies on affective dimensions spanning over all PISA 2003 data, meaning all countries in all continents, seem to be lacking, to our best knowledge. As PISA 2003 focuses on mathematics, this study investigates how students' various affective dimensions such as anxiety, self-concept, self-efficacy, interest, and motivation to learn mathematics differ with respect to their gender, socioeconomic status, and geographic location.

Literature Review

There is an extensive amount of research in mathematics education, considering affective constructs such as motivation, interest, attitudes and academic engagement that are related with learning and mathematics achievement (For example, see Baloglu & Kocak, 2006; Chiu & Klassen, 2010; Cleary & Chen, 2009; Lee, 2009; Ma & Kishor, 1997a, 1997b; Singh et al., 2002). These constructs are considered as school related variables, which can be altered by educational interventions. The following sections explore more about mathematics anxiety, motivation, mathematical self-concept and self-efficacy, as well as the connection between these constructs and mathematical achievement. It is also examined whether there are any cultural or gender differences regarding these constructs.

Mathematics Anxiety

Mathematics anxiety is one of the most commonly investigated affective constructs related with mathematics learning. A general definition of mathematics anxiety can be given as "a discomfort state created when students are required to perform mathematical tasks" (Ma & Xu, 2004). The discomfort states can be “dislike,” “worry,” or “fear.” Typical signs include tension, frustration, distress, helplessness, and mental disorganization. Sources of mathematics anxiety can be situational, dispositional or environmental. Situational causes are “immediate factors that surround the stimulus” (Baloglu & Kocak, 2006), dispositional causes are personality related factors such as self-esteem, attitude toward mathematics, learning style in mathematics, confidence in mathematics (Baloglu & Kocak, 2006; Ma & Kishor, 1997a; Ma & Xu, 2004). Environmental factors are experiences in mathematics classes, and characteristics of teachers (Baloglu & Kocak, 2006).

There are different categorizations of mathematics anxiety. Ho et al. (2000) point out that two dimensions of general test anxiety, which are affective and cognitive, have also been found relevant for mathematics anxiety. Affective dimension refers to the emotional factors such as fear, nervousness, tension, dread, and unpleasant psychological reactions toward testing situations while cognitive dimension refers to the factors concerning worry, such as negative expectations, preoccupation with an anxiety causing situation and self-deprecatory thoughts about that situation. According to another classification, mathematics anxiety has three dimensions: mathematics test anxiety, numerical anxiety and abstraction anxiety. Mathematics test anxiety refers to anticipating, taking and receiving mathematics tests, numerical anxiety refers to worries about number manipulation and abstraction anxiety refers to worries about abstract mathematical content (Ma & Xu, 2004). According to Ashcraft and Moore (2009), mathematics anxiety can range from “minor frustration to overwhelming emotional (and psychological) disruption” (pp.197).

Motivation

Motivation can be defined as “an internal state that arouses, directs and maintains behavior” (Woolfolk, 2004). Causes of motivation can be internal, such as personal values or interests (intrinsic motivation) or they can be external, like rewards or punishments (extrinsic motivation). Attribution theory of motivation suggests that, students’ explanations for causes of academic success or failure can be categorized by the following dimensions: locus, referring to whether the causes come from the individual or from other people; stability, referring to whether the causes change over time; and controllability, whether the individual is able to control the cause (Weiner, as cited in Kloosterman, 1988). Students’ reasons for the cause of success or failure affect their motivation to attempt academic tasks. Students’ goal orientations also affect their motivation. Students having task-focused goals (i.e. learning goals) show personal interest in the task and believe that the task itself is rewarding, whereas students with performance goals either try to be best performer or be more successful than others (performance approach), or try not to be the least competent or be the poorest performer (performance avoidance) (Skaalvik & Skaalvik, 2004).

Self-Concept and Self-Efficacy

Self-concept is “the composite of ideas, feelings and attitudes people have about themselves” (Woolfolk, 2004). Self-concept is divided into sub-categories of general, academic, social, emotional and physical self-concepts (Shavelson et al., 1976). Academic self-concept can be subject or course specific, but they are not item or task specific. Mathematical self-concept can be defined as “positive or negative orientation toward one's ability, performance, and success in the learning of mathematics” (Ma & Kishor, 1997b). Self-efficacy, on the other hand, is a judgment of one’s ability to perform a specific task (Pajares & Miller, 1994).

Relationships between Mathematics Anxiety, Mathematical Self-Concept, Self-Efficacy, Motivation and Mathematics Achievement

Mathematics anxiety has negative effect on mathematics achievement and subsequently people with high mathematics anxiety tend to avoid taking mathematics classes and choose career paths that do not involve mathematics (Ashcraft & Moore, 2009). There are three models regarding the casual relationships between mathematics anxiety and achievement: (a) interference model, which proposes that high anxiety interferes with students’ prior learning, hence causes low achievement; (b) deficit model, which proposes that poor study skills and test taking skills resulting with low achievement leads to high anxiety; (c) reciprocal model, where mathematics anxiety and achievement have a reciprocal relationship (Ho et al., 2000; Ma & Xu, 2004).

In their study, aiming to determine the casual direction between mathematics anxiety and achievement, Ma and Xu (2004) found that low prior mathematics achievement caused high mathematics anxiety across entire junior and senior high school grade levels, whereas high prior mathematics anxiety hardly caused low achievement across entire junior and senior high school grade levels. Gender differences were observed in the causal ordering. Low prior mathematics achievement caused high mathematics anxiety across entire junior and senior high school grade levels for boys, whereas high prior mathematics anxiety caused low achievement in critical transition points through grade levels. In addition, level of mathematics achievement was found to be more reliably stable than level of mathematics anxiety, and mathematics anxiety was found to be more reliably stable among girls than among boys.

In contrast, Ho et al. (2000) tested the interference model (high anxiety causes low achievement) and it fitted their data well. They considered two dimensions of mathematics anxiety; affective and cognitive. The affective factor has found to be consistently related (strong, negative relation) across three national samples (China, Taiwan and United States) but cognitive factor showed inconsistency across samples. Girls showed higher average levels in both affective and cognitive factors of mathematics anxiety in Taiwanese sample, while US girls showed high average levels only in cognitive factor and no significant mean differences occurred in either factors between Chinese boys and girls.

Ashcraft and Moore (2009) suggest that complex mathematics tasks result in heavy load in working memory. In addition, mathematics anxiety brings extra burden in working memory, which causes the performance to deteriorate. On the other hand, low skill or ability in mathematics and inadequate motivation or insufficient working memory are among the “risk factors” for mathematics anxiety.

Meece et al. (1990) found that students’ current performance expectancies in mathematics and perceived importance of mathematics have the strongest effect on mathematics anxiety, meaning that efficacy-related judgments of the students significantly predict their mathematics anxiety. They have also reported that students assigning more importance on achievement had less mathematics anxiety.

In their meta-analysis of the relationship of attitudes towards self and achievement in mathematics, Ma and Kishor (1997b) considered self-concept, gender role and family support to be the main indicators of attitude. They reached the following conclusions:

(a) The self-concept-achievement, the family support-achievement, and the male domain-achievement relationships were all statistically reliable;

(b) The three relationships did not show evident gender differences;

(c)The three relationships consistently decreased from the junior high grades to the senior high grades;

(d) The self-concept-achievement relationship varied as a function of ethnicity, whereas the family support achievement relationship was consistent across ethnic backgrounds;

(e) The three relationships were not consistent across sample selection;

(f) The self-concept-achievement relationship varied with sample size, whereas the family support-achievement and the male domain-achievement relationships were sample-size invariant;

(g) The self-concept-achievement relationship varied over time, whereas the family support-achievement and the male domain-achievement relationships remained almost unchanged over time; and

(h) There were no statistically significant interaction effects on any of the three relationships.

Kloosterman (1988) measured attribution style, effort as a mediator of mathematical ability, and failure as an acceptable phase in learning mathematics in order to explain self-confidence of 7^{th} grade students. He concluded that attribution style was the strongest predictor of confidence, followed by effort as a mediator of mathematical ability. The results also showed that students were making attributions for failure more often than success.

As an attempt to investigate predictive relations between self-efficacy and subsequent attainment in a mathematics task, Norwich (1987) assessed self-efficacy of primary school students (9-10 year-olds) over four trials. Between trials, students attempted mathematics tasks. Self-efficacy made no independent contribution to predicting task performance. However, prior self-efficacy and mathematics performance, independently predicted relations with self-efficacy when students were not familiar with the task but self-concept did not. When the students were familiar with the task, only prior self-efficacy had predictive relation with subsequent self-efficacy. In addition, mathematics self-concept and prior mathematics performance made significant contributions to predicting subsequent task performance.

Another study about the effects of self-efficacy and self-concept on mathematics success was conducted by Pajares and Miller (1994) on undergraduate students. They concluded that, self-efficacy has stronger direct effects on performance than mathematics self-concept, perceived usefulness of mathematics, prior experience with mathematics or gender. Mathematics self-concept and high school level had modest direct effects. Self-efficacy was also reported to mediate the effect of gender and prior experience on mathematics self-concept, perceived usefulness of mathematics and mathematics performance.

A more recent study on high school students (Pietsch et al., 2003) showed that competency component of self-concept was differentiated with affective component but overlapped with self-efficacy when they were measured at the same level of generality. Social comparison (students comparing themselves with other students) had equal effect on both self-concept and self-efficacy. Self-efficacy beliefs were more strongly related with mathematics performance.

Investigating the role of self-efficacy in a structural model for mathematics achievement, Randhawa et al. (1993) concluded that self-efficacy was a mediator variable between attitudes towards mathematics and mathematics achievement.

Gender Differences

Gender differences are commonly measured in affected constructs such as motivation, mathematics anxiety, self-concept and self-efficacy. Considering the gender differences in three dimensions of the Revised Mathematics Anxiety Scale (RMARS) , namely mathematics test anxiety, numerical text anxiety and mathematics course anxiety, Baloğlu and Kolçak (2006) found that female students showed significantly higher mathematics test anxiety, males showed significantly higher numerical test anxiety, and there were no significant differences between mathematics course anxiety of males and females. When looked at the total scale of RMARS, females scored higher than males.

Stipek and Gralinski (1991) measured achievement related beliefs of 3rd grade (8-9 year-olds) and high school (13-14 year-olds) students before and after a regular mathematics exam. Girls reported lower ability and expectation of success. They were less likely to attribute success to high ability and failure to luck; instead, they were more likely to attribute failure to low-ability than boys.

Gender differences were also found in the study of Githua & Mwangi (2003), in favor of boys, in students' perception of likelihood of success and satisfaction in learning mathematics. They also concluded that girls in co-educational secondary schools in Kenya have the least self-concept and motivation to learn mathematics.

Comparing mathematics and verbal self-concept of boys and girls in Norwegian high schools, Skaalvik & Skaalvik (2004) also encountered gender differences: Boys had higher self-concept, performance expectations, intrinsic motivation and self-enhancing ego orientation than girls in mathematics; while girls had higher intrinsic motivation to learn language than boys. Verbal self-concept of older students was higher than their mathematical self-concept, regardless of their gender.

Greene et al. (1999) used a modified version of expectancy –value model (Ecless et al., as cited in Greene et al., 1999) which shows the relationships of values, beliefs and goals with effort and achievement, with respect to gender. Results show that task achievement goals predicted effort stronger than the other constructs. Prediction of achievement and effort differed according to gender and mathematics class type.

International Studies

Wilkins (2004) conducted a study based on TIMSS (Trends in Mathematics and Science Study) data ("TIMSS 1999"), regarding mathematics and science self-concept. Results showed that when self-concept was regarded as a student-level variable, internationally, students with higher self-concept had greater achievement and students with low self-concept had lower achievement scores. But when self-concept was regarded as a country level variable, it turned out that, on average, countries with higher achievement scores had lower self-concept scores and vice versa. In addition, Asian and Eastern European countries had lower self-concept than countries in other parts of the world.

In another study on TIMSS, Berberoğlu and Yayan (2004) analyzed the data for the Turkish students to look for factors influencing mathematics achievement. They found that perception of failure in mathematics was the most important latent variable predicting achievement. Home and family background characteristics and mathematics achievement were also found to be strongly related. Negative relationships were found between student-centered activities and achievement, and between classroom climate and activities and achievement. Researchers argue that the reason behind these results may be because the teachers and students in Turkey are more oriented to classical classroom methodologies and are not accustomed to student-centered learning environments.

Berberoğlu and Güzel (2005) used PISA 2000 data to investigate reading and mathematical literacy skills across different cultural settings. They used data from Brazil, Japan and Norway. Structural models for the three countries were formed. The path from reading literacy to mathematical literacy indicated large effect sizes for all countries. Strongest effect on reading literacy was use of technology in Brazil, communication with parents in Japan and attitudes toward reading in Norway. A reciprocal relationship between attitudes towards mathematics and mathematical literacy was found in Brazil and Norway, where paths from mathematical literacy to attitudes towards mathematics having larger effect size. Another finding is that communication with parents contributes to high performance in mathematics and reading literacy in all the three countries.

Methodology

Participants

Two-stage stratified sampling strategy was used in most of the countries where first stage sampling unit consisted of individual schools. The schools were chosen systematically from a complete list of eligible schools with probabilities that were proportional to a measure of size. Second stage sampling unit consisted of students, who are at the age of 15-year old. 35 students were selected from each school with equal probability. For those of schools having less than 35 students, all the students were assigned to the analysis (Raymond, 2005). In the Appendix, Table 6 shows the number of students participated in each country.

Instruments

The student questionnaire (OECD, 2005, p.251) was designed to collect information about student characteristics, educational and family background of student, student reports related to the school, students' learning of mathematics, and students' lessons in mathematics. Development of the questionnaire was guided by the priorities of PISA Governing Board, and it was carried out in co-operation with OECD, international experts and national centers. An initial piloting of the material was done in a few participating countries. Then, two versions of the questionnaire were administered in a field trial in all participating countries. Final selection of the material was made on the basis of the analyses of the field trial data (Raymond, 2005).

Participant responses to the items from ST30Q01 to ST32Q10 in this questionnaire were used in this study. These items were developed to measure student interest, motivation, self-concept, self-efficacy in mathematics and mathematics anxiety (OECD, 2005, p.384). All items have four-point scales with response categories coded as "strongly agree" (= 1) to "strongly disagree" (= 4).

Item ST03Q01 is used to label the gender of the student, where codes were female (=1), male (=2).

For socioeconomic status, ESCS (Economic, Social and Cultural Status) index was used. This index is derived using the following variables: highest level of parental education (PARED), highest parental occupation (HISEI) and number of home possessions (HOMEPOS).

Parental education is classified using six categories, called the ISCED levels, from "no education" (=0) to "tertiary and post graduate" (=6). PARED index score shows the ISCED level of either parent, recorded into estimated years of schooling (Raymond, 2005, p.316).

HISEI index is obtained as follows: Occupational data, obtained by open-ended questions, were first coded into four-digit International Standard Classification of Occupations (ISCO) codes (Raymond, 2005, p.316). These codes were then mapped to the international socio-economic index of occupational status (ISEI) values (Raymond, 2005, p.316). Finally, HISEI, the Highest Occupational Status of Parents index, refers to the higher ISEI score of the either parent.

HOMEPOS is a scale index, derived from the student reports on availability of 13 household items at home (Raymond, 2005, p.283). Scale indices are estimates of latent traits obtained using Item Response Theory (IRT) scaling methodology. International item parameters were obtained from calibration samples consisting of randomly selected sub-samples within each OECD country sample. Then weighted likelihood estimation was used to obtain individual student scores. These scores were transformed to an international metric with an OECD mean zero and standard deviation one (Raymond, 2005, p.278).

Finally, in order to calculate ESCS index, OECD standardized variables HISEI, HOMEPOS and PARED were used for a principal component analysis. Each OECD country was given a weight of 1000. ESCS scores were obtained as factor scores of the first principal component, where OECD student average was 0 and standard deviation was 1. For partner countries, the following formula was used to obtain ESCS scores:

$$ESCS = \frac{\beta_1 HISEI' + \beta_2 PARED' + \beta_3 HOMEPOS'}{\varepsilon_f}$$

Here, β_1, β_2 and β_3 represent the OECD factor loadings, HISEI', PARED' and HOMEPOS are OECD standardized variables, and ε_f is the eigenvalue of the first principal component (Raymond, 2005, p.316).

Data Analysis

In order to investigate geographic differences, countries were divided into seven regions. These regions were determined with respect to continents, with two exceptions: European countries were divided into two subgroups, European Union (EU) members and non EU members. In addition, Israel and Tunisia were categorized as South-East Mediterranean countries. Table 1 shows the regions and their codes.

Table 1.
Regional Codes

CODE	Region
1	Europe-EU countries
2	Europe-non EU countries
3	Asia
4	North America
5	South America
6	South-East Mediterranean
7	Oceania

Socioeconomic statuses (SES) of the students were categorized using ESCS indices. Indices were divided into 5 categories from “very low” to “very high”. Table 2 shows the boundary values for the indices and the codes given to the categories. Table 3 depicts the number of participants with respect to region, SES level and gender.

Table 2.
Categorization of ESCS indices

Min	Max	SES	Code
-4.614590	-3.099648	Very Low	1
-3.099647	-1.584706	Low	2
-1.584705	-0.069764	Medium	3
-0.069763	1.445178	High	4
1.445179	2.960120	Very High	5

Although index values calculated for the variables student interest, motivation, self-concept, self-efficacy and mathematics anxiety are available in the PISA database, the researchers preferred to obtain the subscales via factor analysis. Principal component factor analysis with varimax rotation was conducted for the student questionnaire items. Rotation method was done with Kaiser Normalization.

GLM analyses were carried out for each category to discern whether there were any significant mean differences in the constructs with respect to gender, socioeconomic status and geographical region. Turkey’s HSD post-hoc analyses were carried out to further investigate multiple comparisons of mean differences among categories of the predictors.

Table 3.
Distribution of participants with respect to region, SES, and gender.

CATEGORIZATION	CODE	N
REGION	1	111392
	2	29604
	3	37706
	4	31982
	5	39956
	6	4708
	7	16790
SES	1	1427
	2	28015
	3	113049
	4	114300
	5	15347
GENDER	1 (Female)	137457
	2 (Male)	134623
TOTAL (Includes 58 missing)		272138

Results

Factor analysis results gave four categories whereas the items used was reported to measure five constructs, namely motivation, interest, self-concept, self-efficacy and mathematics anxiety (OECD, 2005, p.384). All self-efficacy items were a distinct category (SE), while all interest and motivation items fell into the same category (IM). Mathematics anxiety (MA) and self-concept (SC) items were also in distinct categories, except the item “I am just not good at mathematics” fell into the self-concept category, rather than the mathematics anxiety category. Table 4 shows factor loadings of the items. Means, standard deviations and reliability coefficients of the categories, as well as the number of corresponding items are given in Table 5.

Remark. It is important to keep in mind that, since the response categories were coded as “strongly agree” (= 1) to “strongly disagree” (= 4), higher means indicate lower self-concept, self-efficacy, motivation and anxiety.

Self-efficacy (SE)

GLM analysis on SE showed significant mean differences with respect to gender, $F(3, 272134) = 366.32$, $p=.001<.05$; socioeconomic status $F(4, 272133) = 3229.24$, $p=.001<.05$; and geographic region, $F(6, 272131) = 1188.38$, $p=.001<.05$.

Table 4.
Factor loadings of the questionnaire items

Item No.	Factor Components			
	SE	IM	MA	SC
ST30Q01	0.200	0.692	0.081	0.327
ST30Q02	0.254	0.768	0.170	0.111
ST30Q03	0.218	0.720	0.077	0.339
ST30Q04	0.236	0.701	0.031	0.382
ST30Q05	0.300	0.767	0.201	0.106
ST30Q06	0.250	0.751	0.110	0.282
ST30Q07	0.258	0.775	0.161	0.122
ST30Q08	0.262	0.769	0.210	0.094
ST31Q01	0.739	0.214	0.169	0.141
ST31Q02	0.776	0.246	0.160	0.161
ST31Q03	0.781	0.245	0.117	0.198
ST31Q04	0.766	0.218	0.185	0.141
ST31Q05	0.757	0.231	0.149	0.206
ST31Q06	0.763	0.236	0.128	0.204
ST31Q07	0.725	0.244	0.105	0.260
ST31Q08	0.731	0.260	0.161	0.189
ST32Q01	0.149	0.146	0.799	0.019
ST32Q02	0.116	0.044	0.833	-0.045
ST32Q03	0.124	0.117	0.795	0.122
ST32Q04	0.322	0.299	0.147	0.700
ST32Q05	0.139	0.145	0.790	0.173
ST32Q06	0.348	0.306	0.131	0.731
ST32Q07	0.285	0.364	0.114	0.734
ST32Q08	0.144	0.093	0.788	0.162
ST32Q09	0.317	0.299	0.189	0.705
ST32Q10	0.162	0.184	0.738	0.100

Table 5.
Mean, standard deviation and reliability coefficients of the components

	Mean	Standard deviation	Cronbach Alpha
SE	2.29	1.456	.93
IM	2.32	1.391	.93
MA	2.74	1.320	.90
SC	2.92	1.370	.89

Post-hoc analysis revealed that female students have significantly higher mean SE score (M = 2.35, SD = 1.317) than males (M = 2.12, SD = 1.419); meaning, due to reverse scoring, that females have significantly lower self-efficacy than males.

All socioeconomic levels showed significant SE mean differences in multiple comparisons as follows, very low (M = 3.26, SD = 2.457), low (M = 2.74, SD = 1.849), medium (M = 2.37, SD = 1.409), high (M = 2.03, SD = 1.142), and very high (M = 1.74, SD = 1.012); hence self-efficacy increases significantly as socioeconomic level increases.

For geographic regions, there were significant SE mean differences between all regions, except between EU countries and Oceania: South-East Mediterranean (M = 2.86, SD = 2.348), South America (M = 2.48, SD = 1.717), Asian countries (M = 2.42, SD = 1.349), non-EU countries (M = 2.21, SD = 1.583), EU countries (M = 2.14, SD = 1.183), North America (M = 2.05, SD = 1.223) and Oceania (M = 2.04, SD = 1.050). Looking at these results, we can see that region with lowest self-efficacy is South-East Mediterranean, while Oceania have highest self-efficacy.

Interest and Motivation (IM)

GLM analysis on IM showed significant mean differences with respect to gender, $F(3, 272134) = 110.60$, $p=.001<.05$; socioeconomic status $F(4, 272133) = 84.33$, $p=.001<.05$; and geographic region, $F(6, 272131) = 961.93$, $p=.001<.05$.

Post-hoc analysis revealed that female students have significantly higher IM mean score (M = 2.34, SD = 1.262) than males (M = 2.20, SD = 1.347); meaning that males have higher interest and motivation than females.

All socioeconomic levels showed significant IM mean differences in multiple comparisons, except between very low and low, and between high and very high: very low (M = 2.53, SD = 2.291), low (M = 2.25, SD =1.653), medium (M = 2.33, SD = 1.332), high (M = 2.23, SD = 1.177), and very high (M = 2.14, SD = 1.159); as a result, very high socioeconomic level students have highest interest and motivation, and very low socioeconomic level students have the lowest interest and motivation.

For geographic regions, there were significant IM mean differences between all regions, except between non-EU countries and North America: non-EU countries (M = 2.38, SD = 1.453), EU countries (M = 2.36, SD = 1.180), North America (M = 2.20, SD = 1.336), South America (M = 2.20, SD = 1.615), Asian countries (M = 2.18, SD = 1.179), Oceania (M = 2.09, SD = 1.084) and South-East Mediterranean (M = 2.00, SD = 1.505). These results indicate students with highest interest and motivation come from South-East Mediterranean countries, whereas students from non-EU countries have the least interest and motivation.

Mathematics Anxiety (MA)

GLM analysis on MA showed significant mean differences with respect to gender, $F(3, 272134) = 1694.76$, $p=.001<.05$; socioeconomic status $F(4, 272133) = 426.65$, $p=.001<.05$; and geographic region, $F(6, 272131) = 317.74$, $p=.001<.05$.

Post-hoc analysis revealed that female students have significantly lower MA mean score (M = 2.56, SD = 1.207) than males (M = 2.83, SD = 1.271). Hence, keeping the reverse scoring in mind, males have significantly lower mathematics anxiety than females.

All socioeconomic levels showed significant MA mean differences in multiple comparisons, except between very low and high: very low (M = 2.92, SD = 2.100), low (M = 2.64, SD =1.583), medium (M = 2.62, SD = 1.283), high (M = 2.74, SD = 1.114), and very high (M = 2.94, SD = 1.035). These results show that students with highest mathematics anxiety are coming from medium socioeconomic level, while students in highest and lowest socioeconomic levels have the lowest mathematics anxiety.

Looking at geographic regions, it is seen that there were significant MA mean differences between all regions, except between non-EU countries and Oceania, and between Asia and South-East Mediterranean: North America (M = 2.83, SD = 1.197), Oceania (M = 2.80, SD = 1.028), South America (M = 2.79, SD = 1.566), non-EU countries (M = 2.73, SD = 1.363), EU countries (M = 2.68, SD = 1.141), South-East Mediterranean (M = 2.66, SD = 1.593) and Asian countries (M = 2.45, SD = 1.105).

Self-Concept (SC)

GLM analysis on SC showed significant mean differences with respect to gender, $F(3, 272134) = 393.20$, $p=.001<.05$; socioeconomic status $F(4, 272133) = 156.652$, $p=.001<.05$; and geographic region, $F(6, 272131) = 160.77$, $p=.001<.05$.

Post-hoc analysis revealed that female students have significantly higher SC mean score (M = 2.99, SD = 1.236) than males (M = 2.75, SD = 1.363), meaning that, males have significantly higher self-concept than females.

All socioeconomic levels showed significant SC mean differences in multiple comparisons: Very low (M = 3.24, SD = 2.214), low (M = 2.98, SD =1.666), medium (M = 2.93, SD = 1.324), high (M = 2.81, SD = 1.176), and very high (M = 2.66, SD = 1.161). Again, as socioeconomic level increases, self-concept increases.

There were significant SC mean differences between all regions, except between EU countries and Oceania: South America (M = 2.97, SD = 1.649), non-EU countries (M = 2.92, SD = 1.145), EU countries (M = 2.91, SD = 1.163), Oceania (M = 2.79, SD = 1.122), Asian countries (M = 2.77, SD = 1.216), North America (M = 2.77, SD = 1.283) and South-East Mediterranean (M = 2.62, SD = 1.674), hence region with highest self concept is South-East Mediterranean and lowest self-concept is South America.

Conclusion

The aim of this study was to investigate mathematics anxiety, motivation, mathematical self-efficacy and self-concept of approximately 15-year-old students around the world using the data collected in the international study PISA 2003. More than 270,000 students from 41 countries participated in this study; hence the results allow making international comparisons among many variables. In the current study, the researchers were interested in the differences with respect to gender, socioeconomic status and geographical regions in the constructs mentioned above, and significant differences were observed in most of the cases.

Gender Differences

Significant gender differences are found in all categories, in favor of boys. Results show that boys have higher self-efficacy, self-concept, motivation and lower mathematics anxiety than girls. These results are parallel to the findings of Baloğlu and Kolçak (2006), Skaalvik & Skaalvik (2004), Githua & Mwangi (2003) and Ho et al.(2000). Else-Quest et al. (2010) have conducted a meta-analysis on TIMSS 2003 and PISA 2003 data, to examine gender differences in mathematics. They also conclude that despite there is an overall similarity in results regarding mathematics achievement, boys had less anxiety and more confidence about their mathematical abilities than girls. Boys were also more motivated, intrinsically and extrinsically, to do well at mathematics. These results confirm that girls are still less secure about their mathematical abilities.

Socioeconomic Status

There are significant differences in mathematics self-efficacy with respect to socioeconomic status of the students. Differences between all socioeconomic levels are significant; where self-efficacy increases as socioeconomic levels increases. Keeping in mind that socioeconomic status is measured by looking at parental education and occupation, and number of home possessions, it can be concluded that students with higher socioeconomic status are more confident. It seems they can accomplish mathematical tasks because the necessary resources and materials are available for them.

Motivation differs significantly with respect to socioeconomic status of the participants; differences between all levels of socioeconomic status were significant, except between the levels very low and low, and high and very high. Motivation also increases as socioeconomic level increases, with one exception: medium level has lower motivation than low level of socioeconomic status. Having a more comfortable study environment at home may be helping the students focus and give them the opportunity to enjoy studying.

Significant mean differences are also found in mathematics anxiety in all socioeconomic levels, except between levels very low and high. Here, there is an interesting result; the ordering of socioeconomic levels from lowest anxiety to highest anxiety is as follows: very high, very low, high, low and medium. So the medium socioeconomic level students have the highest anxiety, whereas very high and very low socioeconomic level students have lowest mathematics anxiety. Some researchers have found that mathematics anxiety is negatively related with mathematics achievement and performance, plans to enroll in mathematics classes, and selection of mathematics related majors in collage (Ashcraft, 2002; Ho et al., 2000; Meece et al., 1990). It has also indirect affects to performance; people with high mathematics anxiety tend to avoid mathematics, they tend to have negative attitudes toward mathematics and they have lower mathematical self-concept than people with low mathematics anxiety (Ashcraft, 2002; Ho et al., 2000). It is likely that there is more pressure for medium socioeconomic level students to be successful in mathematics, in order to get good job opportunities in future. Students with very low socioeconomic status may be hopeless about their future occupations, hence do not care too much about achievement in mathematics or other courses. It should be noticed that that they also have the lowest motivation scores. Students with very high socioeconomic level have the lowest mathematics anxiety probably because they do not worry too much about future occupational opportunities.

Finally for self-concept, all mean differences are significant with respect to socioeconomic status. Results indicate that self-concept increases as socioeconomic levels increase. Similar reasoning can be done as in the case of self-concept; that the students with higher socioeconomic status feel more confident. In addition, occupational status and education levels of their parents may set an example to what they can accomplish in future, and increase their belief in their abilities.

Geographical Regions

In self-efficacy, mean differences between all regions are found to be significant with one exception: the difference between European Union countries and Oceania countries. The ordering of regions from lowest self-efficacy to highest is as follows: South-East Mediterranean countries, South America, Asia, non-EU countries, EU countries, North America and Oceania.

Significant differences were also found between regions in motivation; except between North America and non-EU countries. The ordering of regions from lowest motivation to highest is as follows: Non-EU countries, EU countries, North America, South America, Asia, Oceania and South-East Mediterranean countries.

The ordering of regions from lowest mathematics anxiety to highest is as follows: North America, Oceania, South America, non-EU countries, EU countries, South-East Mediterranean countries, and Asian countries. The mean differences between regions are significant except between non-EU countries and Oceania, and between Asia and South

Finally, ordering of the regions form lowest self-concept to highest is: South America, non-EU countries, EU countries, Asia, North America, Oceania and South-East Mediterranean countries. All mean differences are significant between the regions except between EU countries and Oceania.

These results quite mixed. But it can be seen that Oceania has high scores in self-efficacy, self-concept and motivation. It also has low mathematics anxiety scores. Living in a relatively isolated region may have resulted in a non-competitive, relaxed educational environment for students in Oceania. Asian countries have the highest anxiety, but they have medium scores in self-efficacy, self-concept and motivation. This can be a result of having educational systems with a more classical approach. It is also interesting that European countries have the lowest motivation scores.

In summary, the findings of this study indicate that, according to the PISA 2003 data, boys have significantly higher mathematical self-efficacy, self-concept, motivation and lower mathematics anxiety than girls; students with higher socioeconomic status have higher self-efficacy, self-concept and motivation whereas students with the highest mathematics anxiety are in medium socioeconomic level; and self-efficacy, self-concept, motivation and anxiety differ significantly with respect to geographical regions.

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Appendix

Table 6.
Number of students with respect to country

Country	Number of students
AUS	12551
AUT	4597
BEL	8796
BRA	4452
CAN	27953
CHE	8420
CZE	6320
DEU	4660
DNK	4218
ESP	10791
FIN	5796
FRA	4300
GBR	9535
GRC	4627
HKG	4478
HUN	4765
IDN	10761
IRL	3880
ISL	3350
ITA	11639
JPN	4707
KOR	5444
LIE	332
LUX	3923
LVA	4627
MAC	1250
MEX	29983
NLD	3992
NOR	4064
NZL	4511
POL	4383
PRT	4608
RUS	5974
SVK	7346
SWE	4624
THA	5236
TUN	4721
TUR	4855
URY	5835
USA	5456
YUG	4405
TOTAL	276165