

Mathematics Self-Efficacy and Student Expectations.

Results from PISA 2003.

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Introduction

Student performance is generally viewed as the main criterion variable when analysing equity in the outcomes of education. However, there is evidence that even with increasing equity in achievement, inequity in other important learning outcomes might still prevail. Self-beliefs like *mathematics self-efficacy*, i.e. students' judgements of their own ability to solve tasks in mathematics, are often viewed as crucial learning outcomes, which affect the process of learning and are an important predictor of educational career choices. The second survey of the Programme for International Student Assessment (*PISA 2003*) provides data on self-related cognitions, motivations, learning behaviours and student performance in the area of Mathematics from 30 OECD and 10 non-OECD countries.

It is deemed important to analyse the role of *mathematics self-efficacy* in conjunction (or comparison) with other self-beliefs like *mathematics self-concept* and *mathematics anxiety*. This paper will provide research findings on factors influencing self-efficacy beliefs as a learning outcome, review its predictive power for career expectations and discuss the importance of this construct when analysing equity in outcomes of education

Most research in this area has typically been based on data from smaller surveys from just one country. PISA 2003 provides a unique opportunity to analyse the above relationships based on national representative samples and from a cross-national perspective. It also allows to review to what extent differences in these relationships are conditioned by educational systems and cultural contexts.

Theoretical Framework

Self-efficacy can be defined as the students' "judgements of their capabilities to organise and execute courses of action required to attain designated types of performances" (Bandura, 1986, p. 391) and is deemed to have a strong influence on individual choices, efforts, perseverance and emotions related to the tasks. Self-efficacy can be regarded as one part of a comprehensive personal theory about the learner's own learning process, which directs his or her own learning (Bandura 1993).

In educational research, self-efficacy has often been measured through a rather general self-assessment of an individual's capacities to master a subject. Such self-assessments require students to respond to questions that tap their general beliefs about being able to master a subject. This approach might be seen as one that assesses the students' *confidence* in having the necessary resources to succeed in a particular domain. This approach is problematic as the measures are often generated '*without any clear academic activity or task in mind*' (Pajares 1996). Students who consider themselves proficient in mathematics in general, may give different answers when confronted with more specific tasks.

According to Bandura (1986), self-efficacy plays an important role in determining behaviour and feelings of confidence about a specific problem are crucial to an individual's capacity to solve that problem. Research has generally confirmed a

relationship between mathematics self-efficacy and student performance, though different sizes of correlation were reported, often depending on the types of self-efficacy measures that were used (Multon, Brown and Lent, 1991).

It should be noted, however, that the relationship between self-efficacy and student performance is most likely a non-recursive one: Though student performance is likely to have a decisive effect on students' perceptions of their own abilities, self-efficacy beliefs are also expected to influence learning behaviour and test performance. Bandura (1986) contends that human motivation and behaviour influence each other reciprocally, so that though self-beliefs are reflection of the individuals' assessment of their own capacity, intervention and strengthening of these beliefs are able to enhance academic achievement.

The importance of self-efficacy beliefs goes beyond the immediate learning context: A student's educational pathways and career might depend on the amount of confidence in one's abilities to solve mathematical tasks (Hackett, 1995). Hackett and Betz (1989) concluded that (task-specific) mathematics self-efficacy was a better predictor of career choice than test performance. It has also been suggested that perceived teacher and parental support in pursuing mathematics would enhance self-efficacy beliefs and increase its impact on performance and career choice (Hackett, 1985).

A concept related to self-efficacy is *self-concept*, which Coopersmith and Feldman (1974) described as "beliefs, hypotheses, and assumptions that the individual has about himself". Positive *Self-concept* can be seen as a desirable outcome variable of education (Branden, 1994), and its enhancement is one of the goals of policy-makers. It can be assumed that students evaluate their own performance through social comparison processes and it has been observed that the school average of achievement tends to have a negative effect on self-concept and that students with same proficiency levels often have different levels of self-concept depending on the overall performance of a school (Marsh, 1990).

Pajares and Schunk (2001) describe the difference between self-concept and self-efficacy as follows: Whereas self-concept refers to an *evaluative judgement of one's own self-worth* and is a global self-judgement, self-efficacy relates to the *confidence in one's own abilities* and may vary according to the tasks used to measure this confidence. Both constructs have in common, that their correlation with achievement is higher when measured with regard to the same particular subject area. Marsh, Walker and Debus (1991) argue that judgements of self-concept are based on social and self-comparisons within the individual's context whereas self-efficacy is less influenced by context as it is related to specific tasks. However, there is evidence that self-efficacy judgements are also influenced by social comparisons (Schunk and Hanson, 1985).

Another related construct is *mathematics anxiety*, which is concerned with feelings of helplessness and emotional stress when dealing with mathematics. Many studies have confirmed that Mathematics Anxiety is negatively associated with achievement but this relationship was found to change depending on the students' social and academic background (Ma, 1999). There is evidence that Mathematics Anxiety has rather

indirect effects on achievement, once self-related cognitions such as self-efficacy and self-concept are taken into account (Meece, Wigfield and Eccles, 1990). Research has shown that feelings of mathematics anxiety are negatively correlated with mathematics self-efficacy and self-concept (Hackett, 1985; see Cooper and Robinson, 1991).

Internationally comparative analyses of *gender* on learning outcomes have shown a decline in gender differences in the areas of Mathematics and Science (Tate, 1997). However, many concerns remain in particular regarding personal beliefs about mathematics and career choices involving mathematics (Fennema, 1996). Correll (2001) in her analysis of the impact of gender-differentiated perceptions on career choice using data from the U.S. National Educational Longitudinal Study of 1988 (NELS-88) could show that males assess their own mathematical competence to be higher than their (equally mathematically competent) female counterparts.

Whereas gender differences are less pronounced in early school years, at secondary level females were found to be more likely to underestimate their abilities (Pajares, 2005; Wigfield, Eccles and Pintrich, 1996). Similar evidence can be found for mathematics self-concepts (Marsh, 1988). In view of the importance of self-efficacy beliefs for career choice, lower self-confidence and not lack of knowledge and skills among females might be responsible for their higher avoidance rates of mathematics-related careers (Hackett and Betz, 1989).

First results from analysis of the PISA 2003 data have shown that though gender differences were small and often not significant for student performance in mathematics, self-related cognitions were consistently lower for females across participating countries (OECD, 2004, 151ff.).

Educational outcomes are influenced by family background in many different and complex ways (Saha, 1997): *Socio-economic status* of families has been consistently found to be an important variable in explaining variance in student achievement. In international studies additional caveats are imposed on the validity of background measures and cross-national comparability of family background measures is a precondition for any comparative analysis (Buchmann, 2000). *Immigrant status and language* is another important factor that might have a unique impact on learning outcomes after controlling for socio-economic background. International studies have shown differences in reading literacy for language and immigrant status (see Elley, 1992; OECD, 2001) but also for mathematics literacy (Mullis *et. al.* 2000). Family background variables are also viewed as an important factor in the development of self-efficacy beliefs (Schneewind, 1995).

Research Questions

This paper seeks to address the following research questions based on data from OECD countries collected in the PISA 2003 survey:

- What is the relationship among the self-beliefs assessed in the PISA survey (Mathematics self-efficacy, self-concept and anxiety) and their association with mathematics literacy? Prior research suggests that self-efficacy is highly correlated with other self-beliefs and that it is the self-belief having the strongest association with test performance.
- What is the relationship of self-efficacy and other self-beliefs with gender and socio-economic background? Self-efficacy is likely to be less influenced by the social context of the student and to have stronger correlations with socio-economic background than self-concept or anxiety.
- What is the impact of school differences on self-beliefs? As self-efficacy is measured with task-specific items, it is assumed that it is less influenced by social comparison and that it varies more across schools than mathematics self-concept or anxiety.
- Which factors have an effect on mathematics self-efficacy? Two-level model with gender, home background and school-related as predictors will be estimated and the outcomes of the analyses will be compared with those from a similar model predicting student performance.
- To what extent does mathematics self-efficacy influence student expectations about education and occupation? Predictions of student expectations to complete a university degree and to work in a mathematics-related occupation will be based on logistic regression models with gender, background variables, mathematics literacy, interest and self-efficacy as predictors.

Method

Data Collection

In all 30 OECD countries and 10 non-OECD countries a minimum of around 4500 students were selected in a two-stage sampling process. However, in some countries subgroups or regions were over-sampled and larger sample sizes were obtained. Schools were sampled proportional to size and (on average 35) 15-year-old students were randomly selected within each school. The sampling plan for each country was approved by the International Sampling Referee to guarantee that the procedures were the same in all countries. OECD sampling standards require a minimum of 85 percent school participation rate and a participation rate of 80 percent within schools. The analyses included in this paper will be based on data from OECD countries only. Data from the United Kingdom are included in the tables, but it should be noted that school and participation rates were too low to ensure comparability.

Instrumentation

Mathematics was the major domain in the PISA 2003 cycle. Mathematics literacy was assessed in 2-hour rotated test design that included smaller subtests for Reading, Science and Problem Solving. Questionnaires were administered to students and school principals.

The student questionnaire included questions on student characteristics, home background, educational career, school/classroom climate, learning behaviour and self-related cognitions in the area of Mathematics. Scale scores were obtained as weighted likelihood estimates from the IRT (Item Response Theory) Partial Credit Model (see a detailed description of the scaling methodology in Schulz, 2005). All questionnaire scales scores have an OECD average of 0 and standard deviation of 1 across equally weighted countries.

Mathematics Self-Efficacy was assessed through student ratings of their confidence in solving eight real-life mathematical tasks (see item wording in Appendix A). The tasks were chosen in accordance with the PISA approach to assess mathematical literacy with test questions related to real-world problems and not with mathematical tasks derived from the curriculum (OECD, 2004, p. 37ff). The resulting scale has an average reliability of .83 across OECD countries and ranged between .75 and .87.

Mathematics Self-Concept was measured with five Likert-type items asking students to rate their agreement with self-judgements regarding mathematics (see item wording in Appendix A). The internal consistency ranged from .78 to .93 across OECD countries with a median of .89.

Mathematics Anxiety was assessed using five Likert-type items asking students to rate their agreement with statements indicating emotional stress when learning mathematics (see item wording in Appendix A). Scale reliabilities for this construct range from .65 to .87 across OECD countries with a median of .82.

Confirmatory factor analysis of these three self-related cognitions based on random sub-samples showed a satisfactory model fit in most OECD countries, the median RMSEA across countries was .077 (CFI = .91, NNFI = .89) (see details in Schulz, 2005).

The index of *Economic, Social and Cultural Status* (ESCS) was derived from three variables related to family background: highest level of parental education (in number of years of education according to the ISCED¹ classification), highest parental occupation (SEI scores²) and number of home possessions.

Perceived teacher support was measured using five Likert-type items where students were asked to rate the frequency with which events reflecting teacher support in mathematics lessons happen. The median scale reliability across OECD countries was .83.

¹ Student reports on parental education were classified according to the *International Standard Classification of Education* (ISCED) (OECD 1999) and then mapped to (approximate) years of education.

² Student reports on parental occupation were coded to four-digit ISCO 1988 codes (ILO, 1990) and then mapped to the SEI index (Ganzeboom, de Graaf and Treiman, 1992).

Perceived disciplinary climate was derived from student ratings of the frequency of events reflecting disruptive behaviour in mathematics lessons. The median reliability across OECD countries was .83. In this paper only the aggregated student scores at the school level are used as an indicator of school climate.

Interest and Enjoyment of mathematics was measured using four Likert-type items where students rated their agreement with the statements a) "I enjoy reading about Maths", c) "I look forward to my Mathematics lessons", d) "I do Mathematics because I enjoy it" and f) "I am interested in the things I learn in Maths". The median scale reliability across OECD countries is .90.

In addition, PISA data on students' study programme, grade, country of birth, instructional time in mathematics per week and expected educational level (classified according to the ISCED classification) were used for the analyses. Study programmes of students were classified according to ISCED.

As an international option, some countries collected data on the students' expected occupations (coded with ISCO 88) at age 30, mathematics teacher marks in their last school report and enrolment in advanced mathematics courses.

Data Analysis

Data from 30 OECD countries will be used to analyse the relationship between self-related cognitions, mathematics literacy, gender, socio-economic background and school-related variables. As the PISA design is cross-sectional in nature, no measures of prior achievement are available for the sampled students which imposes constraints on the analyses based on these data. In particular, analysis of the relationship between test performance and self-efficacy cannot be controlled for general ability or prior achievement. Only in a sub-group of countries data on mathematics teacher marks in the last students' last school report were collected.

The analyses presented in this paper will include the following steps:

- Firstly, the bivariate relationships between self-related cognitions, performance, gender, ESCS and school-related variables will be reviewed.
- Secondly, hierarchical linear modelling (HLM) will be used to take context effects at the school level into account (see Bryk and Raudenbush, 1992).
- Thirdly, the role of mathematics self-efficacy for student career expectations will be analysed using logistic regression models (see Hosmer and Lemeshow, 1989) predicting expectations of tertiary qualifications and job expectations in mathematics-related areas.

Results

Confirmatory factor analysis of the self-related cognitions included in PISA 2003 has shown that all three constructs are highly correlated. Mathematics self-efficacy is negatively correlated with mathematics anxiety and positively correlated with self-concept (Schulz, 2005). The median latent correlation across OECD countries obtained from structural equation models is -.52 and .62 respectively. Though conceptually clearly different constructs, mathematics anxiety and self-concept have very high negative correlations around -.80. The strengths of the estimated latent correlations are also very similar across OECD countries.

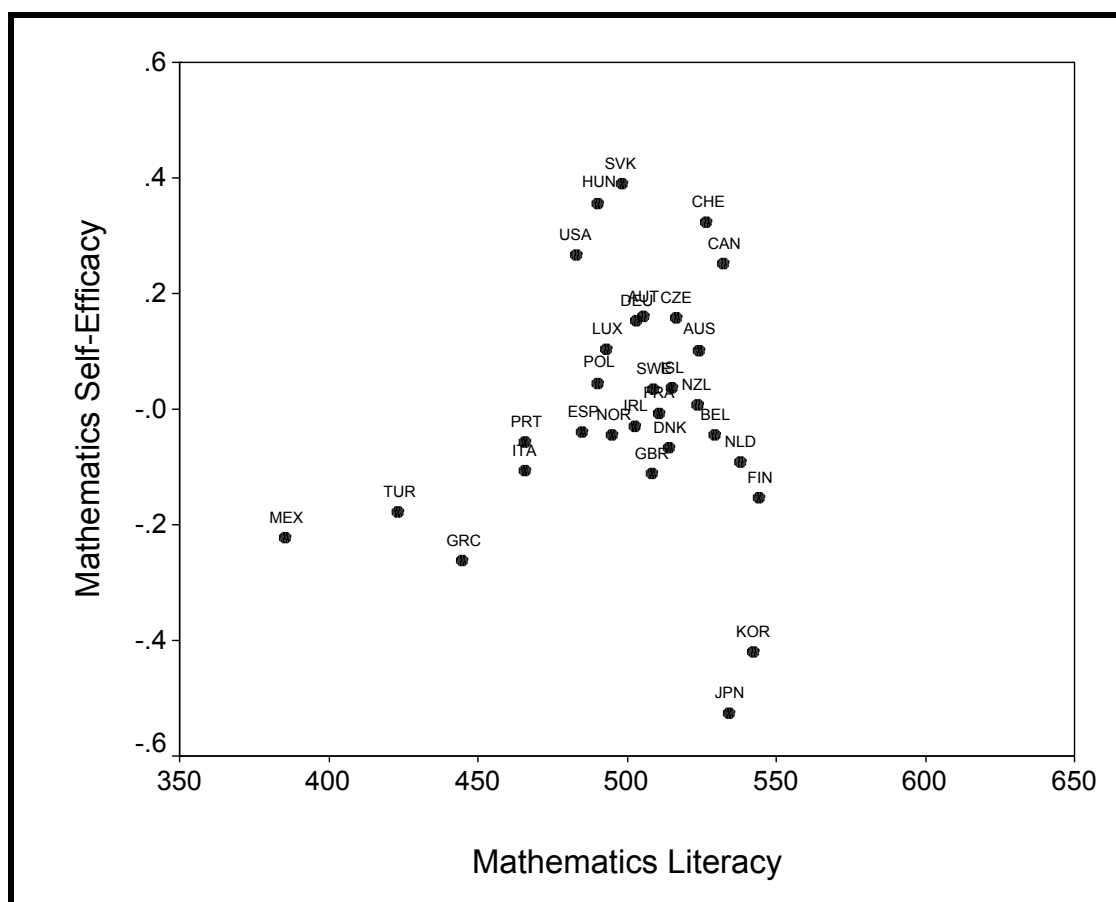
Table 1: Correlations between Mathematics Literacy and Self-Belief Scales

COUNTRY	Mathematics		
	Self-efficacy	Self-concept	Anxiety
Australia	.53	-.36	.41
Austria	.49	-.31	.29
Belgium	.43	-.24	.22
Canada	.54	-.40	.44
Czech Republic	.56	-.41	.39
Denmark	.52	-.51	.53
Finland	.52	-.44	.57
France	.50	-.24	.32
Germany	.50	-.34	.27
Greece	.44	-.35	.41
Hungary	.56	-.32	.26
Iceland	.51	-.40	.52
Ireland	.53	-.36	.37
Italy	.46	-.29	.27
Japan	.59	-.14	.20
Korea	.58	-.22	.46
Luxembourg	.47	-.32	.23
Mexico	.31	-.29	.23
Netherlands	.46	-.22	.24
New Zealand	.52	-.44	.41
Norway	.55	-.50	.56
Poland	.55	-.49	.46
Portugal	.53	-.33	.40
Slovak Republic	.59	-.41	.41
Spain	.44	-.26	.36
Sweden	.57	-.45	.50
Switzerland	.55	-.33	.27
Turkey	.51	-.34	.33
United Kingdom ¹	.55	-.34	.38
United States	.52	-.39	.38
OECD Median	.52	-.34	.38

¹ Response rates too low to ensure comparability.

Comparison of the correlation between mathematics literacy scores and those for mathematics self-efficacy, self-concept and anxiety confirm the expected relationships between these variables (see Table 1). Both self-efficacy and self-concept are positively related to mathematics literacy scores whereas anxiety is negatively correlated with performance. Self-efficacy has consistently higher correlations with the achievement measures than the other two self-related cognitions. The size of the coefficients is highly consistent across country, in particular for self-efficacy beliefs and performance.

Figure 1: OECD country averages of Mathematics Self-Efficacy and Mathematics Literacy



Weighted country averages.

One of the findings of international comparative research on the relationship between attitudinal measures and performance has been that students from countries with high performance tend to show less motivation and less positive attitudes toward mathematics. Figure 1 shows the relationship between mathematics self-efficacy and performance at the country level. Though low achieving countries typically also have lower levels of self-efficacy beliefs, there are some notable exceptions. In particular, Japan and Korea, both countries with high levels of students' mathematics literacy have substantially lower average scores on the self-efficacy scale than any other

OECD country. The correlation at the country level between the two variables is .19, without Japan and Korea the correlation is .39. Mathematics anxiety has a high negative correlation of -.69 at the country level whereas self-concept has a zero correlation with performance estimates.

Table 2: Effect Sizes for Gender on Mathematics Self-Beliefs and Literacy

COUNTRY	Mathematics			
	Self-efficacy	Self-concept	Anxiety	Literacy
Australia	-.38	-.34	.32	<i>-.06</i>
Austria	-.47	-.45	.37	<i>-.08</i>
Belgium	-.37	-.36	.32	<i>-.07</i>
Canada	-.35	-.33	.34	<i>-.13</i>
Czech Republic	-.43	-.36	.26	<i>-.16</i>
Denmark	-.46	-.49	.39	<i>-.18</i>
Finland	-.58	-.46	.40	<i>-.09</i>
France	-.31	-.38	.39	<i>-.09</i>
Germany	-.48	-.51	.39	<i>-.09</i>
Greece	-.45	-.31	.26	-.21
Hungary	-.36	-.24	.20	<i>-.08</i>
Iceland	-.25	-.23	.27	<i>.17</i>
Ireland	-.30	-.23	.29	<i>-.17</i>
Italy	-.37	<i>-.14</i>	<i>.17</i>	<i>-.19</i>
Japan	-.32	-.37	.26	<i>-.08</i>
Korea	<i>-.20</i>	-.26	<i>.14</i>	-.26
Luxembourg	-.44	-.50	.45	<i>-.19</i>
Mexico	<i>-.18</i>	<i>-.15</i>	<i>.13</i>	<i>-.13</i>
Netherlands	-.62	-.57	.39	<i>-.06</i>
New Zealand	-.37	-.36	.31	<i>-.15</i>
Norway	-.37	-.43	.36	<i>-.07</i>
Poland	<i>-.17</i>	<i>-.18</i>	<i>.03</i>	<i>-.06</i>
Portugal	-.24	-.21	.22	<i>-.14</i>
Slovak Republic	-.34	-.30	.25	<i>-.20</i>
Spain	-.28	-.26	.34	<i>-.10</i>
Sweden	-.27	-.36	.31	<i>-.07</i>
Switzerland	-.56	-.72	.45	<i>-.17</i>
Turkey	-.26	<i>-.19</i>	<i>.20</i>	<i>-.15</i>
United Kingdom ¹	-.38	-.41	.39	<i>-.07</i>
United States	<i>-.19</i>	-.27	.23	<i>-.07</i>
OECD Median	-.37	-.35	.31	<i>-.10</i>

Effect Sizes > .20 or < -.20 in **bold**.

¹ Response rates too low to ensure comparability.

Table 2 shows the effect sizes³ for gender on mathematics self-efficacy, self-concept, anxiety and literacy. Both self-efficacy and self-concept show substantial gender

³ Effect sizes (Cohen's d) are standardised differences between two groups (here: males and females), the standardisation is based on the pooled standard deviations.

differences with females expressing lower levels of confidence and self-esteem in most OECD countries. Females also express higher levels of mathematics anxiety in almost all of these countries. However, though in all countries except Iceland boys tend to have higher scores on mathematics literacy, differences are generally smaller than those for self-related cognitions.

Table 3: Correlations between ESCS and Mathematics Self-Beliefs and Literacy

COUNTRY	<i>Mathematics</i>			Literacy
	Self-efficacy	Self-concept	Anxiety	
Australia	.27	.13	-.11	.37
Austria	.27	.06	-.08	.40
Belgium	.28	.04	-.05	.49
Canada	.24	.12	-.11	.32
Czech Republic	.33	.15	-.19	.44
Denmark	.29	.20	-.23	.42
Finland	.24	.22	-.13	.33
France	.30	.10	-.08	.44
Germany	.30	.04	-.10	.48
Greece	.34	.28	-.22	.40
Hungary	.38	.07	-.14	.52
Iceland	.26	.23	-.18	.25
Ireland	.28	.15	-.15	.40
Italy	.23	.08	-.11	.37
Japan	.30	.05	-.02	.34
Korea	.35	.24	-.10	.38
Luxembourg	.26	.05	-.12	.41
Mexico	.17	.05	-.09	.41
Netherlands	.22	.04	-.05	.43
New Zealand	.31	.15	-.17	.41
Norway	.31	.28	-.24	.38
Poland	.33	.19	-.21	.41
Portugal	.38	.25	-.20	.42
Slovak Republic	.39	.14	-.19	.47
Spain	.29	.18	-.10	.37
Sweden	.33	.21	-.19	.39
Switzerland	.27	.01	-.05	.41
Turkey	.31	.18	-.18	.47
United Kingdom ¹	.32	.12	-.10	.44
United States	.32	.16	-.17	.44
OECD median	.30	.14	-.12	.41

¹ Response rates too low to ensure comparability.

Table 3 illustrates the correlations of the index of Economic, Social and Cultural Status (ESCS) with mathematics self-beliefs and literacy. Whereas correlations with mathematics performance range from .25 to .42 with a median of .41, self-beliefs tend to have weaker correlations with socio-economic background. However, mathematics self-efficacy has a consistently stronger relationship with socio-economic background than self-concept and anxiety. This is in line with the expectations that self-efficacy is

less dependent on the frame of reference in the social context of the individual: Feelings of self-esteem and emotional distress are developed relative to the average achievement levels within a school (which are often influenced by socio-economic factors), this is less pronounced with beliefs of (task-specific) self-efficacy. Mathematics literacy has consistently stronger correlations with socio-economic background than any of the self-related cognitions.

Table 4: Percentages of School-level Variance for Mathematics Self-belief and Literacy Scales across OECD Countries

COUNTRY	Mathematics			
	Self-efficacy	Self-concept	Anxiety	Literacy
Australia	8	3	3	21
Austria	19	6	6	53
Belgium	14	2	3	46
Canada	6	4	3	17
Czech Republic	22	5	7	48
Denmark	5	3	4	13
Finland	3	2	2	5
France	15	5	2	46
Germany	12	1	2	52
Greece	10	5	4	36
Hungary	22	5	6	58
Iceland	4	2	1	4
Ireland	7	3	3	16
Italy	15	5	3	52
Japan	26	3	3	53
Korea	21	10	2	42
Luxembourg	8	1	2	32
Mexico	7	6	5	39
Netherlands	9	4	4	58
New Zealand	6	2	4	18
Norway	4	2	3	7
Poland	5	2	2	13
Portugal	11	3	3	34
Slovak Republic	23	6	6	42
Spain	7	5	4	20
Sweden	6	3	3	11
Switzerland	12	3	4	34
Turkey	20	7	7	55
United Kingdom ¹	9	4	4	22
United States	6	4	3	26
OECD Median	9	3	3	34

Estimates derived from two-level models with random school intercepts.

¹ Response rates too low to ensure comparability.

It is important to analyse to what extent self-beliefs are influenced by school-level factors. A decomposition of the variance into between-school and within-school variance gives useful information on this issue. Table 4 shows the results of two-level

model analyses with random school intercepts for each OECD country. As shown in earlier PISA reports (OECD, 2004, pp. 160ff), the percentage of between-school variance is high in countries with selective and tracked educational systems (for example in Austria, Belgium, German or Hungary) and low in countries with non-selective, comprehensive systems (for example in Finland, Iceland, Norway and Sweden). It is interesting to observe, that though between-school differences are substantially lower for all three self-related cognitions, mathematics self-efficacy has still a considerably higher between-school variation than self-concept and anxiety. This provides further evidence for assuming a more "relative" nature of self-concept and anxiety. The percentages of between-school variance for self-efficacy and literacy are highly correlated at the country-level (.81): Countries with high levels of between-school variance in performance also tend to have higher levels of school variation in self-efficacy beliefs.

Table 5: Correlations between Teacher Marks/Advanced Courses and Mathematics Self-Beliefs and Literacy

Country	Mathematics			
	Self-efficacy	Self-concept	Anxiety	Literacy
	...with Teacher Marks			
Austria	.20	.55	-.45	.21
Belgium	.18	.57	-.42	.15
Czech Republic	.36	.59	-.49	.46
Finland	.01	.02	-.04	.05
Germany	.40	.67	-.56	.32
Hungary	.33	.55	-.49	.43
Iceland	.57	.71	-.50	.56
Ireland	.41	.57	-.46	.36
Italy	.34	.61	-.38	.35
Korea	.43	.56	-.36	.49
Poland	.51	.61	-.54	.61
Portugal	.46	.46	-.33	.68
Slovak Republic	.34	.58	-.46	.47
Median	.36	.57	-.46	.43
	...with Advanced Mathematics Course Taking			
Australia	.40	.36	-.22	.48
Germany	.29	.25	-.20	.28
Greece	.31	.35	-.28	.22
Iceland	.42	.43	-.32	.50
Ireland	.44	.29	-.20	.61
Korea	.29	.32	-.19	.33
Median	.35	.33	-.21	.41

Teacher marks standardised to having country means of 0 and standard deviations of 1, higher scores reflecting positive evaluations. **Advanced mathematics courses** coded as dummy variables with 1 indicating students attending this type of lessons.

Table 5 shows the correlation of mathematics self-beliefs and literacy with teacher marks and advanced mathematics course taking for those OECD countries, which administered these questions. In most countries self-concept has higher correlations

with teacher marks than other self-related cognitions, often the relationship is also stronger than the one between literacy and teacher marks. As teacher marks often tend to be evaluative judgements relative to the school or study programme context, this is a plausible finding.

Attending advanced mathematics courses has a positive correlation with self-efficacy, self-concept and literacy and a negative correlation with anxiety. The causality of this relationship is not clear: Advanced courses may have increased self-judgements and self-efficacy beliefs as well as achievement, but these variables may also have contributed to the selection of these courses.

Two-level regression models with students nested within schools were estimated in order to analyse, which factors influence beliefs of self-efficacy. In view of the unclear causality between these constructs, other self-related cognitions and performance were not included as predictors in this model. Gender (female), the ESCS index and an indicator for students who were born in another country were included as student demographics.

As some countries have selective educational system with students enrolled in study programmes without access to tertiary education, an indicator of academic programme was included classifying vocational or pre-vocational programmes and general lower secondary programmes without access to the upper secondary level as non-academic (0) and all other programmes as academic (1). As PISA collects age-based samples where students may come from different year levels, it was deemed necessary to include a grade indicator, which reflects the difference between students' grade and the national modal grade. The grade is not only an indicator of educational progress but can also be seen as an indicator of problems in the past educational career, in particular in countries where retention of low-achieving students is common.

Student reports of the hours of mathematics instruction were included as an indicator of learning time. Following suggestions from earlier research, *perceived mathematics teacher support* was chosen as another predictor variable related to the learning of mathematics at school.

School-level variables were the average ESCS and average student reports on disciplinary climate in mathematics lessons. Both variables have shown to be important predictors of between-school variables in previous analyses of PISA data (see OECD, 2004, pp. 255ff.).

All of these variables were included as fixed (non-random) variables in the model, only school intercepts were treated as random. The analyses were carried out using the SAS Mixed procedure (see Littell et. al., 1996). These models were estimated both for mathematics self-efficacy and literacy in order to see whether similar patterns can be observed. The results for mathematics literacy are presented in Appendix B (Table 10a and 10b).

Table 6a: Regression Coefficients from Two-level Models in OECD Countries for Mathematics Self-Efficacy

Country	Gender (female)	ESCS	Born in other country	Academic programme	Relative grade
Australia	-.39 (0.02)	.24 (0.01)	.06 (0.03)	.19 (0.03)	.22 (0.02)
Austria	-.46 (0.03)	.14 (0.02)	-.06 (0.05)	.30 (0.07)	.17 (0.03)
Belgium	-.41 (0.02)	.13 (0.01)	.00 (0.04)	.36 (0.03)	.19 (0.02)
Canada	-.41 (0.01)	.26 (0.01)	.10 (0.02)		.34 (0.01)
Czech Republic	-.44 (0.02)	.19 (0.02)	.13 (0.08)	.41 (0.06)	.21 (0.03)
Denmark	-.41 (0.03)	.26 (0.02)	.02 (0.06)		.26 (0.04)
Finland	-.54 (0.02)	.27 (0.01)	-.02 (0.07)		.23 (0.03)
France	-.34 (0.03)	.17 (0.02)	.17 (0.06)	.26 (0.06)	.38 (0.03)
Germany	-.53 (0.03)	.16 (0.02)	.14 (0.05)	.06 (0.05)	.23 (0.02)
Greece	-.39 (0.02)	.23 (0.01)	-.03 (0.04)	.24 (0.06)	.14 (0.03)
Hungary	-.43 (0.03)	.18 (0.02)	.08 (0.08)	.23 (0.05)	.24 (0.02)
Iceland	-.27 (0.04)	.32 (0.03)	-.02 (0.08)		
Ireland	-.31 (0.03)	.26 (0.02)	.00 (0.06)	.09 (0.04)	.11 (0.02)
Italy	-.31 (0.02)	.11 (0.01)	.24 (0.04)		.21 (0.02)
Japan	-.38 (0.03)	.14 (0.02)	-.35 (0.21)	-.12 (0.06)	
Korea	-.16 (0.03)	.20 (0.02)	.46 (0.26)	.22 (0.05)	.19 (0.11)
Luxembourg	-.50 (0.03)	.16 (0.02)	-.05 (0.04)	.15 (0.08)	.30 (0.03)
Mexico	-.17 (0.01)	.07 (0.01)	-.18 (0.03)	.05 (0.04)	.05 (0.01)
Netherlands	-.54 (0.03)	.11 (0.02)	.00 (0.06)	.32 (0.05)	.18 (0.02)
New Zealand	-.33 (0.03)	.28 (0.02)	.18 (0.04)		.35 (0.04)
Norway	-.36 (0.03)	.38 (0.02)	-.02 (0.07)		.25 (0.14)
Poland	-.18 (0.03)	.34 (0.02)	1.12 (0.61)		.35 (0.05)
Portugal	-.24 (0.02)	.18 (0.01)	.02 (0.04)	.19 (0.04)	.25 (0.02)
Slovak Republic	-.35 (0.02)	.26 (0.01)	-.03 (0.09)	.33 (0.09)	-.01 (0.03)
Spain	-.29 (0.02)	.19 (0.01)	.00 (0.04)		.34 (0.02)
Sweden	-.27 (0.03)	.34 (0.02)	-.03 (0.05)		.25 (0.06)
Switzerland	-.60 (0.02)	.21 (0.01)	.03 (0.03)	.25 (0.07)	.29 (0.02)
Turkey	-.30 (0.03)	.11 (0.02)	-.09 (0.14)		.00 (0.02)
United Kingdom ¹	-.40 (0.02)	.27 (0.01)	.07 (0.04)		.09 (0.02)
United States	-.27 (0.03)	.33 (0.02)	.14 (0.05)		.16 (0.02)
OECD Median	-.37	.21	.01	.23	.22

Standard errors in parentheses and significant effects ($p < .05$) in **bold**. Two-level models with fixed coefficients.

¹ Response rates too low to ensure comparability.

Table 6a and 6b show the unstandardised regression coefficients for mathematics self-efficacy. Gender (female) has a consistently negative effect on self-efficacy beliefs, whereas student-level ESCS has positive effects. Birth in another country has no effect in most countries but positive effects on self-efficacy beliefs in a number of countries. When comparing these results with the results of the same model for mathematics literacy, it can be observed that gender effects are weaker (though still significant) and that the positive effects of student-level ESCS are roughly of the same strength. Within-school effects of ESCS tend to be stronger in countries where schools have rather similar socio-economic intakes and less school mean variation (as

for example in countries with more comprehensive educational systems like Finland, Iceland or Norway).

Table 6b: Regression Coefficients from Two-level Models in OECD Countries for Mathematics Self-Efficacy (continued)

Country	Mathematics instruction	Mathematics teacher support	School Mean ESCS	Disciplinary Climate
Australia	.07 (0.01)	.16 (0.01)	.12 (0.03)	.13 (0.04)
Austria	.00 (0.01)	.11 (0.01)	.24 (0.07)	.09 (0.05)
Belgium	.08 (0.01)	.09 (0.01)	.12 (0.04)	-.07 (0.05)
Canada	.01 (0.00)	.21 (0.01)	.05 (0.03)	.15 (0.03)
Czech Republic	.12 (0.02)	.08 (0.01)	.42 (0.04)	.10 (0.04)
Denmark	.00 (0.01)	.19 (0.02)	.06 (0.05)	.15 (0.05)
Finland	.03 (0.01)	.20 (0.01)	.00 (0.05)	.09 (0.05)
France	.02 (0.01)	.12 (0.01)	.16 (0.04)	.04 (0.04)
Germany	.01 (0.01)	.11 (0.01)	.24 (0.05)	.20 (0.05)
Greece	.08 (0.02)	.09 (0.01)	.02 (0.04)	.06 (0.06)
Hungary	.04 (0.01)	.09 (0.01)	.35 (0.04)	.12 (0.04)
Iceland	.00 (0.01)	.24 (0.02)	.07 (0.07)	.09 (0.06)
Ireland	.01 (0.01)	.10 (0.01)	.23 (0.05)	.18 (0.05)
Italy	.03 (0.00)	.08 (0.01)	.14 (0.03)	.16 (0.03)
Japan	.03 (0.01)	.12 (0.02)	.83 (0.08)	.26 (0.06)
Korea	.01 (0.01)	.12 (0.02)	.43 (0.05)	.25 (0.07)
Luxembourg	.01 (0.01)	.11 (0.01)	.14 (0.08)	.25 (0.17)
Mexico	.00 (0.00)	.18 (0.00)	.10 (0.01)	.08 (0.03)
Netherlands	.06 (0.01)	.08 (0.02)	.02 (0.06)	.05 (0.05)
New Zealand	.03 (0.01)	.14 (0.01)	.06 (0.05)	.08 (0.05)
Norway	.01 (0.01)	.28 (0.02)	.04 (0.07)	.10 (0.06)
Poland	.00 (0.02)	.12 (0.01)	.08 (0.04)	.07 (0.04)
Portugal	.02 (0.01)	.12 (0.01)	.05 (0.02)	.12 (0.05)
Slovak Republic	.00 (0.01)	.06 (0.01)	.51 (0.04)	.26 (0.04)
Spain	.03 (0.01)	.11 (0.01)	.05 (0.03)	.09 (0.03)
Sweden	.03 (0.01)	.15 (0.02)	.15 (0.06)	.06 (0.06)
Switzerland	.03 (0.01)	.10 (0.01)	.23 (0.05)	.26 (0.04)
Turkey	.09 (0.01)	.16 (0.01)	.32 (0.05)	.38 (0.09)
United Kingdom ¹	-.02 (0.01)	.20 (0.01)	.22 (0.04)	.16 (0.04)
United States	.02 (0.01)	.19 (0.01)	.11 (0.04)	.03 (0.05)
OECD Median	.02	.12	.13	.11

Standard errors in parentheses and significant effects ($p < .05$) in **bold**. Two-level models with fixed coefficients.

¹ Response rates too low to ensure comparability.

In most OECD countries with differentiated study programmes, being in a non-academic or vocational track is associated with lower feelings of self-efficacy. This is particularly pronounced in countries with highly selective educational. It should be noted that in these countries academic programme is (sometimes highly) correlated with individual and school mean ESCS. This may be one reason why in Germany with its highly selective and tracked educational system there is no effect of academic

programme on self-efficacy beliefs. Only in Japan students being in a non-academic programme has slightly positive effect on self-efficacy.⁴ Not surprisingly, effects of academic study programme on mathematics literacy are stronger than those on self-efficacy beliefs (see Table 10a).

Grade has a considerable and positive effect on feelings of self-efficacy in most countries in this model. Being in lower grade is due to late starting age at primary school or retention during earlier years of education. Whereas feelings of self-concept and anxiety are not associated with grade, both self-efficacy and literacy are positively correlated with this variable (see Appendix B, Table 11). Effects of grade on mathematics literacy tend to be stronger than those on self-efficacy.

In about half of the countries, the amount of mathematics instruction has rather small significant positive effects on feelings of self-efficacy. Similar findings are found for mathematics literacy (see Table 10b).

Perceived mathematics teacher support at the student-level has notable positive effect on self-efficacy. This is found (in varying degrees) across all OECD countries and provides some support for the hypothesis that the perception of being helped by the teacher increases student confidence. For mathematics literacy, in contrast, there are hardly any direct within-school effects of teacher support on performance (see Table 10b).

School mean ESCS has a substantial effect in many countries. However, the effects are not as strong as on mathematics literacy (Table 10b; see also OECD, 2004, pp. 159ff.). It is interesting that in countries where the socio-economic composition of the student body has a large impact on mathematics literacy, it also has a notable effect on self-efficacy. Typically, in countries with comprehensive educational system the school mean ESCS has less impact on mathematics literacy and no impact on self-efficacy beliefs (as for example in Denmark, Finland, Iceland and Norway).

Schools' average perceived disciplinary climate in mathematics lessons has substantial effects in a number of countries but no significant effect on self-efficacy in about half of the OECD countries. In many countries, there are stronger effects of this variable on mathematics literacy.

⁴ This is due to the inclusion of the (pre-vocational) technical college students in the non-academic group who also have higher performance levels than students in the academic track. Students in the vocational programmes have the lower performance and self-efficacy beliefs than students in the academic programme.

Table 7: Percentages of school variance and explained variance by two-level models for Mathematics Self-Efficacy and Literacy

Country	Mathematics Self-efficacy			Mathematic Literacy		
	<i>% overall Between schools</i>	<i>% explained by model Between schools</i>	<i>Within schools</i>	<i>% overall Within schools</i>	<i>% explained by model Between schools</i>	<i>Within schools</i>
Australia	8	5	11	21	16	10
Austria	20	14	5	52	43	4
Belgium	13	8	11	46	40	17
Canada	6	1	13	17	9	12
Czech Republic	21	16	8	48	40	5
Denmark	6	3	14	13	10	14
Finland	3	0	18	5	1	14
France	14	12	8	46	42	8
Germany	11	8	14	52	43	11
Greece	10	8	12	37	31	4
Hungary	22	20	8	58	52	4
Iceland	4	2	10	4	2	6
Ireland	7	5	9	16	14	13
Italy	15	8	6	53	31	4
Japan	26	21	4	54	43	1
Korea	21	18	3	42	33	2
Luxembourg	9	7	11	32	29	13
Mexico	7	3	6	37	27	4
Netherlands	9	7	12	58	53	8
New Zealand	6	5	12	18	14	11
Norway	4	2	16	7	4	13
Poland	6	3	11	13	9	14
Portugal	11	10	14	34	32	18
Slovak Republic	19	16	7	42	34	5
Spain	7	4	11	19	13	20
Sweden	7	3	12	10	8	14
Switzerland	12	5	15	33	21	14
Turkey	20	13	5	55	45	3
United Kingdom ¹	9	6	14	22	17	10
United States	6	4	12	26	19	11
OECD Median	9	6	11	33	28	10

Explained variance computed as percentages of total variance (sum of between- and within-school variance).

¹ Response rates too low to ensure comparability.

When comparing the amounts of explained variance in mathematics self-efficacy and literacy by these models (see Table 7), it becomes clear that the predictors included in the model predict more variance in literacy than in self-efficacy beliefs. However, this difference is largely due to the explanation of between-school variance, where around 28 percent are explained for mathematics literacy and only 6 percent for mathematics self-efficacy. It can be observed that in countries where more within-school variance is explained in mathematics literacy, the same holds for self-efficacy.

These results show that self-efficacy beliefs are generally influenced by similar factors as mathematics performance but that they are likely to be "more relative" measures, as they are probably influenced by social comparison within the school context. It is also clear that model used to explain self-efficacy beliefs does not include all relevant variables. Including other self-cognitions as for example self-concept as predictor would certainly increase the amount of explained variables (see an example in Randhawa, Beamer and Lundberg, 1993) but, as pointed out earlier, the causal relationship between these constructs is rather unclear.

Table 8: Logistic Regression Model Estimates for Expected Higher Tertiary Education (ISCED 5A)

Country	Gender (female)	ESCS	Born in other country	Academic programme	Relative grade	Mathematics		
						Literacy	Self-efficacy	Interest
Australia	2.77	2.01	2.39	2.08	.90	1.90	1.55	1.38
Austria	1.12	2.25	1.99	7.24	1.12	1.55	1.38	1.09
Belgium	1.82	2.10	1.95	4.35	1.09	2.05	1.31	1.31
Canada	2.46	2.23	2.86		1.16	1.72	1.26	1.40
Czech Republic	3.00	2.56	2.56	9.97	.76	2.77	1.75	1.15
Denmark	1.57	1.97	2.83		1.32	1.49	1.48	1.32
Finland	1.45	1.77	1.90		.94	1.40	1.25	1.26
France	2.14	1.54	2.12	10.70	2.80	1.65	1.38	1.31
Germany	1.49	1.95	2.69	4.95	1.15	1.73	1.40	1.12
Greece	2.94	2.12	.72	21.98	1.82	2.46	1.36	1.19
Hungary	3.19	2.77	1.21	7.77	1.28	2.64	1.22	1.06
Iceland	1.92	2.08	1.43			1.90	1.28	1.07
Ireland	3.00	1.84	1.23	.76	.92	1.84	1.65	1.04
Italy	2.86	2.29	1.00		2.46	1.36	1.31	1.30
Japan	.68	2.46	3.10	6.05		2.51	1.43	1.02
Korea	1.28	1.82	.92	6.96	2.69	1.93	1.17	1.11
Luxembourg	1.35	1.79	2.51	4.48	1.38	2.69	1.19	1.02
Mexico	2.36	1.72	.84	2.64	1.40	1.72	1.22	1.17
Netherlands	1.38	1.52	2.46	7.10	1.43	1.72	1.35	1.08
New Zealand	1.46	1.62	1.92		1.40	1.60	1.55	1.17
Norway	1.95	2.39	1.70		1.75	1.40	1.34	1.19
Poland	2.94	2.64	.00		1.03	2.05	1.63	.90
Portugal	3.03	1.54	.97	3.06	2.44	2.01	1.79	1.12
Slovak Republic	3.00	2.66	1.49	7.03	0.88	3.25	1.58	1.00
Spain	2.75	2.05	3.78		4.44	2.51	1.22	1.30
Sweden	1.90	1.97	3.00		1.36	1.25	1.43	1.31
Switzerland	1.42	2.69	2.64	2.77	1.62	2.23	1.38	.93
Turkey	2.08	1.49	.58		1.72	2.23	1.28	1.19
United Kingdom ¹	2.08	1.84	1.68		1.03	2.27	1.42	1.13
United States	1.45	2.05	1.30		1.27	1.39	1.28	1.22
OECD Median	2.02	2.03	1.91	6.05	1.34	1.90	1.37	1.16

Unstandardised Effect coefficients (odds-ratios), significant coefficients ($p < .05$) in **bold**. Standard errors computed using replication methods (Fay's BRR).

¹ Response rates too low to ensure comparability.

Logistic regression models were estimated to analyse to what extent mathematics self-efficacy has an effect on students' expectation to complete an academic tertiary programme (ISCED 5A or 6). Gender, ESCS, country of birth, academic programme, grade, mathematics literacy and mathematics self-efficacy were included as predictor. Mathematics interest and enjoyment was added as an additional motivational predictor.

For logistic regression models there is no exact measure of explained variance similar to the R Square measure in ordinary linear regression. However, comparisons between the deviances for the 'empty' or null model and the model with predictors can be used to assess model fit, so-called Pseudo R² are calculated from the deviances comparing the null model (without predictors) and the full model (including predictors).⁵ *McFadden's R Square* can be interpreted as proportional reduction in the $-2\log$ likelihood statistics and parallels the formula for OLS R Squares (Menard, 2000). Table 12 in Appendix B shows the model summary statistics for the logistic regression model explaining expected higher tertiary education. The results show that there is a considerable reduction due to predictor variables in most countries, the Pseudo R Squares range between .10 and .45.

Table 8 shows the odds ratios for all OECD countries, which have a more sensible interpretation than the regression coefficients in logistic regression. Coefficients below 1 show negative effects and those greater than 1 indicate positive effects.⁶

The results show that in most countries females are more likely to expect an academic tertiary education than males. Socio-economic background has also a positive effect on these expectations, across OECD countries 1 score point (i.e. one OECD standard deviation) increases the likelihood of expecting a university degree by 2. Birth in another country is positively associated with these expectations in a number of countries. It should be noted that this is a result of a multivariate model so that *after* controlling for socio-economic background, performance and other factors, students with an immigrant background tend to have higher expectations than other students.

Academic study programme has a strong effect in those countries with more selective and tracked educational system. This is hardly surprising as many students in non-academic programmes have few possibilities to gain access to tertiary education. Grade has an effect on tertiary expectations only in some of the OECD countries, in particular in France, Italy, Korea, Portugal and Spain.

An academic tertiary education does not necessarily require mathematical literacy but it certainly can be regarded as a key competency and mathematics literacy has a substantial effect in all OECD countries. Self-efficacy beliefs in this subject still increase the likelihood of expecting higher education, which supports the view that

⁵ This statistics is derived as $R^2_{MF} = 1 - \log L(M) / \log L(0)$ with $\log L(M)$ being the likelihood for the fitted model and $\log L(0)$ being the likelihood for the "null" model without predictors.

⁶ An odds-ratio of .5 for gender, for example, means that a female would have only 50 percent likelihood to expect a university degree compared to males, whereas an odds-ratio of 3 means that a female is three times more likely to expect such a degree as a male. Similar interpretations hold for variables with more than one category.

this variable contributes to career expectations of students. Interest in mathematics does also influence student expectations in most of these countries.

In some of the OECD countries students were asked about their expected in job as an adult. Responses were coded using the ISCO-88 classification, which allows an approximate recoding of the responses into *mathematics-related* and other jobs. Occupational categories with a clearly mathematics-related profile (such as engineer, statistician, mathematician) were coded as 1, all other categories as 0. Across countries with data on expected occupation, around 13 percent of the students expected a mathematics-related occupation as defined for this analysis.

Table 9: Logistic Regression Model Estimates for Expected Mathematics-related Occupations

Country	Gender (female)	ESCS	Born in other country	Academic programme	Relative grade	Mathematics		
						Literacy	Self-efficacy	Interest
Australia	.24	.98	1.40	1.15	1.02	1.19	1.16	1.51
Austria	.18	.89	1.25	1.88	.85	1.52	1.17	1.19
Belgium	.30	.92	1.27	6.62	.96	1.30	1.13	1.60
Czech Republic	.40	1.15	1.35	19.49	1.13	1.38	1.26	1.57
Germany	.53	.91	.98	1.39	.98	1.55	1.07	1.30
France	.38	1.04	1.54	1.16	1.12	1.35	.96	1.49
Greece	.49	1.30	1.15	.71	1.09	1.20	.97	1.48
Hungary	.26	.91	1.02	6.11	1.14	1.20	1.11	1.32
Ireland	.44	.92	1.34	.95	.88	1.62	1.09	1.63
Iceland	.33	1.08	1.09			1.09	1.21	1.26
Italy	.34	.84	1.08		1.19	1.51	1.16	1.38
Korea	.31	.91	.00	.51	.86	1.27	1.05	1.09
Mexico	.42	1.02	.79	1.00	1.23	1.30	1.13	1.20
Poland	.58	.78	.00		2.94	1.42	1.13	1.21
Portugal	.25	1.04	1.32	.26	1.17	1.16	1.17	1.38
Slovak Republic	.25	.95	1.28	9.49	1.01	1.68	1.15	1.25
United States	.22	.97	1.43		1.17	1.43	1.12	1.45
OECD Median	0.33	0.95	1.25	1.16	1.11	1.35	1.13	1.38

Unstandardised effect coefficients (odds-ratios), significant coefficients ($p < .05$) in **bold**. Standard errors computed with replication method (Fay's BRR).

The Pseudo R Square statistics in Table 13 (Appendix B) demonstrate that the proportional reduction for the fitted model ranges only between .04 and .15 across OECD countries. This indicates a rather weak explanatory power of this model, which may be due to the omission of potential predictor variables and/or a lack of reliability in the criterion variable (due to the approximate nature of classifying the expected occupations).

Table 9 shows the results of a logistic regression model for expected mathematics-related occupations. Gender has a strong negative effect across countries; females are less than half as likely to expect such an occupation. ESCS and country of birth do not have significant effects in most countries whereas studying in an academic

programme is a decisive factor in Austria, Czech Republic, Hungary and Slovak Republic. Both mathematics literacy and interest in mathematics influence expectations to have mathematics-related occupation, whereas self-efficacy beliefs have weaker effects which are significant in only about two-thirds of the countries.

Accepting the assumption that self-efficacy is an intermediate variable, which affects performance and motivation in the area of mathematics (Stevens et. al., 2004), one could interpret these findings as self-efficacy having more indirect effects on choice of mathematics-related careers. However, as shown earlier, feelings of self-efficacy contribute to the expectations of tertiary education in general, even after controlling for performance and motivation.

Discussion

Data from PISA 2003 provide a unique opportunity to analyse relationships between mathematics self-efficacy, related self-beliefs, performance, student background and indicators of schooling from a cross-national perspective. Whereas most research in this area has been based on smaller samples from within a country, PISA data were collected from many different cultures and educational systems. However, it is also necessary to recognise the constraints of the PISA, in particular its cross-sectional design and the heterogeneous instructional context (i.e. grades and study programmes) from which students are sampled in many countries. One consequence is the lack of measures of prior achievement, which could help to further analyse causal relationships between self-related cognitions and student performance.

The results of the analyses of relationships between self-beliefs and literacy in the area of mathematics largely confirm findings of earlier research. There are positive correlations between self-efficacy and self-concept and negative correlations with mathematics anxiety. Self-efficacy is the self-belief that has the strongest correlation with test performance. These findings are largely consistent across OECD countries.

The analyses also provide support for the assumption that self-concept and anxiety are relative measures strongly influenced by the school context of the individual. Self-judgements of 'being good at maths' or emotional distress related to this subject depend on self-comparisons with peers and the demands within schools and study programmes.⁷ Self-efficacy in turn, when measured as task-specific judgement is less influenced by the context of the individual. The analyses show that this constructs has stronger correlations with actual test performance than other self-beliefs and that there is considerably larger variation across schools than for self-concept or feelings of anxiety.

Among the factors explaining variation in self-efficacy beliefs gender and socio-economic background are clearly important. Females have lower feelings of self-efficacy than males and the gender gap is far more pronounced than for mathematic literacy. The effects of study programme clearly depend on the educational system of

⁷ The fact that in most countries self-concept is the construct, which has the strongest positive correlation with teacher marks provides further evidence for the 'relative nature' of this particular construct.

each country, whereas beliefs of self-efficacy tend to increase with grade in most OECD countries. The amount of instruction in mathematics has generally minor and often non-significant effects on self-efficacy. Perceived teacher support in turn is associated with higher levels of confidence, providing some evidence for the enhancement of self-efficacy through teacher supportiveness in mathematics teaching.

The socio-economic composition of the student body has effects on self-efficacy in a number of countries, typically in those where this variable also has the strongest effects on mathematics literacy. The average disciplinary climate at schools has additional positive effects, in particular in countries with higher levels of between-school variance.

Though many of these findings are consistent across OECD countries, it should be noted that beliefs of mathematics self-efficacy are clearly influenced by factors associated with the structure of the educational system. School variation in self-efficacy beliefs follows similar patterns as the one in mathematics literacy: Whereas in comprehensive educational systems differences are minor and less influenced by school intake (as measured as school mean ESCS), in highly selective and tracked educational systems there is considerable variation which can be explained by the socio-economic composition of the student body and the academic orientation of study programmes.

Comparing the model estimates for mathematics self-efficacy and for mathematics literacy, it appears that though predictors tend to have somewhat similar effects on both dimensions, the model explains substantially more of the between-school variance in literacy scores than in self-efficacy. This is plausible as self-efficacy beliefs, though measured as task-specific confidence, are still likely to be influenced by the school context of a student.

When predicting expectations to complete an academic tertiary (ISCED 5A) qualification, mathematics self-efficacy turns out to have a significant positive effect even after controlling for mathematics literacy and interest. It is clear that other interests or proficiencies might also be important factors in determining student career expectations (e.g. students might expect university careers with higher proficiency levels or interest in reading but not in mathematics). However, mathematical knowledge and skills are key qualifications for most tertiary studies and in many cases a requirement for further studies⁸.

When predicting student expectations to have an occupation in mathematics-related areas at the age of 30, mathematics self-efficacy is still a significant, though minor predictor in most countries, whereas mathematics literacy and interest are more important factors. It is noteworthy that female gender has a strong negative effect on these expectations in all countries. This confirms that in spite of rather small gender differences in mathematics literacy throughout OECD countries, gender still plays a role in mathematics-related attitudes and career expectations. Females tend to report lower levels of self-efficacy or self-concept in mathematics as well as higher levels of

⁸ It should also be noted that PISA has shown that the three key areas reading, science and mathematics measured in this study are highly correlated with each other (Adams and Carstensen, 2002, p. 153).

emotional stress when studying this subject. In addition, they are also far less likely to expect a job, which requires higher levels of mathematical skills.

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Appendix A: Items used to assess mathematics self-beliefs

Mathematics Self-efficacy

How confident do you feel about having to do the following calculations?
a) Using a <train timetable>, how long it would take to get from Zedville to Zedtown b) Calculating how much cheaper a TV would be after a 30 percent discount c) Calculating how many square metres of tiles you need to cover a floor. d) Understanding graphs presented in newspapers. e) Solving an equation like $3x + 5 = 17$. f) Finding the actual distance between two places on a map with a 1:10,000 scale. g) Solving an equation like $2(x+3) = (x + 3)(x - 3)$. h) Calculating the petrol consumption rate of a car.

Categories were "very confident", "confident", "not very confident" and "not at all confident" and inverted for scaling.

Mathematics Self-Concept

How much do you disagree or agree with the following statements about how you feel when studying Mathematics?
b) I am just not good at Mathematics.* d) I get good <marks> in Mathematics. f) I learn Mathematics quickly. g) I have always believed that Mathematics is one of my best subjects. i) In my Mathematics class, I understand even the most difficult work.

Item categories were "strongly agree", "agree", "disagree" and "strongly disagree". Item d) to i) inverted for scaling.

Mathematics Anxiety

How much do you disagree or agree with the following statements about how you feel when studying Mathematics?
a) I often worry that it will be difficult for me in Mathematics classes. c) I get very tense when I have to do Mathematics homework. e) I get very nervous doing Mathematics problems. h) I feel helpless when doing a Mathematics problem. j) I worry that I will get poor <marks> in Mathematics.

Item categories were "strongly agree", "agree", "disagree" and "strongly disagree" and inverted for scaling.

Appendix B: Additional Tables

Table 10: Regression Coefficients from Two-level Models in OECD Countries for Mathematics Performance

Country	Gender (female)	ESCS	Born in other country	Academic programme	Relative grade
Australia	-.12 (0.02)	.24 (0.01)	-.05 (0.02)	.23 (0.03)	.42 (0.02)
Austria	-.22 (0.02)	.08 (0.01)	-.28 (0.03)	.68 (0.07)	.29 (0.02)
Belgium	-.29 (0.02)	.11 (0.01)	-.19 (0.03)	.64 (0.02)	.51 (0.01)
Canada	-.17 (0.01)	.23 (0.01)	-.11 (0.02)		.52 (0.01)
Czech Republic	-.24 (0.02)	.18 (0.01)	.01 (0.07)	.39 (0.07)	.44 (0.03)
Denmark	-.19 (0.02)	.33 (0.02)	-.30 (0.05)		.48 (0.04)
Finland	-.08 (0.02)	.31 (0.01)	-.38 (0.06)		.43 (0.03)
France	-.20 (0.02)	.15 (0.01)	-.10 (0.05)	.42 (0.05)	.66 (0.02)
Germany	-.33 (0.02)	.11 (0.01)	-.11 (0.04)	.02 (0.07)	.40 (0.02)
Greece	-.24 (0.02)	.17 (0.01)	.02 (0.04)	.40 (0.07)	.25 (0.03)
Hungary	-.25 (0.02)	.12 (0.01)	-.09 (0.06)	.36 (0.06)	.33 (0.02)
Iceland	.15 (0.03)	.27 (0.02)	-.05 (0.06)		.00
Ireland	-.22 (0.03)	.29 (0.01)	.01 (0.05)	-.09 (0.04)	.21 (0.02)
Italy	-.26 (0.01)	.06 (0.01)	.09 (0.04)		.39 (0.02)
Japan	-.18 (0.02)	.04 (0.02)	-.14 (0.16)	-.18 (0.07)	.00
Korea	-.16 (0.03)	.12 (0.01)	.25 (0.22)	.48 (0.06)	.36 (0.11)
Luxembourg	-.29 (0.02)	.11 (0.01)	-.16 (0.03)	.23 (0.06)	.44 (0.02)
Mexico	-.17 (0.01)	.06 (0.00)	-.41 (0.03)	-.03 (0.04)	.26 (0.01)
Netherlands	-.16 (0.02)	.11 (0.01)	-.19 (0.04)	.65 (0.05)	.37 (0.02)
New Zealand	-.11 (0.03)	.31 (0.02)	-.05 (0.04)		.53 (0.04)
Norway	-.08 (0.03)	.40 (0.02)	-.30 (0.06)		.36 (0.12)
Poland	-.09 (0.02)	.35 (0.02)	-.50 (0.56)		.81 (0.05)
Portugal	-.23 (0.02)	.12 (0.01)	-.09 (0.04)	.25 (0.03)	.55 (0.01)
Slovak Republic	-.23 (0.02)	.21 (0.01)	-.06 (0.08)	.38 (0.08)	.17 (0.03)
Spain	-.21 (0.01)	.12 (0.01)	-.13 (0.03)		.70 (0.01)
Sweden	-.09 (0.02)	.36 (0.02)	-.50 (0.05)		.62 (0.05)
Switzerland	-.28 (0.02)	.21 (0.01)	-.32 (0.02)	.40 (0.06)	.55 (0.02)
Turkey	-.25 (0.02)	.08 (0.01)	-.13 (0.10)		.22 (0.02)
United Kingdom ¹	-.10 (0.02)	.30 (0.01)	-.12 (0.04)		.14 (0.02)
United States	-.12 (0.02)	.29 (0.01)	-.12 (0.04)		.28 (0.02)
OECD Median	-.20	.17	-.12	.38	.39

Standard errors in parentheses and significant effects ($p < .05$) in **bold**. Coefficients were multiplied with 100 so that one unit is equal to an OECD standard deviation (for equally weighted countries). First Plausible Values was used for analysis.

¹ Response rates too low to ensure comparability.

Table 10b: Regression Coefficients from Two-level Models in OECD Countries for Mathematics Performance (continued)

Country	Mathematics instruction	Mathematics teacher support	School Mean ESCS	Disciplinary Climate
Australia	.04 (0.01)	.06 (0.01)	.49 (0.04)	.17 (0.05)
Austria	.01 (0.01)	-.01 (0.01)	.36 (0.07)	.14 (0.05)
Belgium	.07 (0.01)	.00 (0.01)	.45 (0.04)	.28 (0.05)
Canada	.00 (0.00)	.06 (0.00)	.26 (0.03)	.24 (0.03)
Czech Republic	.14 (0.01)	-.01 (0.01)	.82 (0.05)	.14 (0.04)
Denmark	-.04 (0.01)	.04 (0.01)	.21 (0.04)	.17 (0.05)
Finland	.03 (0.01)	.04 (0.01)	-.02 (0.05)	.07 (0.05)
France	.00 (0.01)	.02 (0.01)	.33 (0.04)	.07 (0.04)
Germany	-.01 (0.01)	.00 (0.01)	.71 (0.06)	.34 (0.06)
Greece	.05 (0.02)	.01 (0.01)	.37 (0.05)	.23 (0.08)
Hungary	.01 (0.01)	.02 (0.01)	.63 (0.04)	.21 (0.04)
Iceland	-.02 (0.01)	.08 (0.02)	.03 (0.06)	.09 (0.05)
Ireland	-.01 (0.01)	-.01 (0.01)	.40 (0.04)	.17 (0.04)
Italy	-.01 (0.00)	-.02 (0.01)	.64 (0.05)	.20 (0.05)
Japan	.02 (0.01)	.00 (0.01)	1.15 (0.09)	.54 (0.07)
Korea	.01 (0.01)	.03 (0.01)	.51 (0.06)	.47 (0.09)
Luxembourg	-.03 (0.01)	.00 (0.01)	.53 (0.08)	.26 (0.17)
Mexico	.00 (0.00)	.01 (0.00)	.36 (0.01)	.23 (0.03)
Netherlands	.04 (0.01)	.00 (0.01)	.53 (0.06)	.14 (0.06)
New Zealand	.02 (0.01)	.03 (0.01)	.47 (0.05)	.21 (0.06)
Norway	.00 (0.01)	.10 (0.02)	.16 (0.06)	.22 (0.06)
Poland	.02 (0.02)	.01 (0.01)	.25 (0.04)	.05 (0.04)
Portugal	.01 (0.01)	.01 (0.01)	.13 (0.02)	.22 (0.04)
Slovak Republic	.00 (0.01)	-.06 (0.01)	.81 (0.04)	.27 (0.05)
Spain	.01 (0.01)	.00 (0.01)	.27 (0.03)	.21 (0.04)
Sweden	-.03 (0.01)	.02 (0.01)	.18 (0.05)	.16 (0.05)
Switzerland	.02 (0.01)	.00 (0.01)	.51 (0.05)	.33 (0.04)
Turkey	.06 (0.01)	.03 (0.01)	.67 (0.05)	.70 (0.09)
United Kingdom ¹	-.03 (0.01)	.06 (0.01)	.52 (0.04)	.23 (0.04)
United States	.04 (0.00)	.05 (0.01)	.40 (0.04)	.23 (0.05)
OECD Median	.01	.01	.43	.21

Standard errors in parentheses and significant effects ($p < .05$) in **bold**. Coefficients were multiplied with 100 so that one unit is equal to an OECD standard deviation (for equally weighted countries). First Plausible Values was used for analysis.

¹ Response rates too low to ensure comparability.

Table 11: Correlations between Grade and Mathematics Self-Beliefs and Literacy

COUNTRY	<i>Mathematics</i>			
	Self-efficacy	Self-concept	Anxiety	Literacy
Australia	.27	.13	-.11	.37
Austria	.27	.06	-.08	.40
Belgium	.28	.04	-.05	.49
Canada	.24	.12	-.11	.32
Czech Republic	.33	.15	-.19	.44
Denmark	.29	.20	-.23	.42
Finland	.24	.22	-.13	.33
France	.30	.10	-.08	.44
Germany	.30	.04	-.10	.48
Greece	.34	.28	-.22	.40
Hungary	.38	.07	-.14	.52
Iceland	.26	.23	-.18	.25
Ireland	.28	.15	-.15	.40
Italy	.23	.08	-.11	.37
Japan	.30	.05	-.02	.34
Korea	.35	.24	-.10	.38
Luxembourg	.26	.05	-.12	.41
Mexico	.17	.05	-.09	.41
Netherlands	.22	.04	-.05	.43
New Zealand	.31	.15	-.17	.41
Norway	.31	.28	-.24	.38
Poland	.33	.19	-.21	.41
Portugal	.38	.25	-.20	.42
Slovak Republic	.39	.14	-.19	.47
Spain	.29	.18	-.10	.37
Sweden	.33	.21	-.19	.39
Switzerland	.27	.01	-.05	.41
Turkey	.31	.18	-.18	.47
United Kingdom ¹	.32	.12	-.10	.44
United States	.32	.16	-.17	.44
OECD median	.30	.14	-.12	.41

¹ Response rates too low to ensure comparability.

Table 12: Log Likelihood and Pseudo R Square Statistics for Logistic Regression Models Predicting Expected Higher Tertiary Education

Country	-2 Log Likelihood Null Model	-2 Log Likelihood Full Model	McFadden's Pseudo R Square
Australia	15966	12253	.23
Austria	4958	3424	.31
Belgium	10567	7703	.27
Canada	32506	25819	.21
Czech Republic	7785	5087	.35
Denmark	4679	3908	.17
Finland	7788	6977	.10
France	4980	3640	.27
Germany	3994	2793	.30
Greece	5872	3204	.45
Hungary	6322	3811	.40
Iceland	4309	3581	.17
Ireland	5211	4196	.19
Italy	15686	12306	.22
Japan	6340	4289	.32
Korea	5598	3786	.33
Luxembourg	5040	3807	.24
Mexico	36983	30358	.18
Netherlands	5073	3352	.34
New Zealand	5720	4790	.16
Norway	4443	3720	.16
Poland	5291	3924	.26
Portugal	6173	4158	.33
Slovak Republic	9809	6529	.33
Spain	14575	9716	.33
Sweden	5704	4818	.16
Switzerland	7622	5637	.27
Turkey	4740	3723	.22
United Kingdom	11008	8627	.22
United States	6731	5729	.15

Statistics based on logistic regression estimates with weights normalised at country level.

Table 13: Log Likelihood and Pseudo R Square Statistics for Logistic Regression Models Predicting Expected Mathematics-related Occupations

Country	-2 Log Likelihood Null Model	-2 Log Likelihood Full Model	McFadden's Pseudo R Square
Australia	7848	6954	.11
Austria	2943	2489	.15
Belgium	6346	5418	.15
Czech Republic	4303	3658	.15
France	2277	2111	.07
Germany	1801	1681	.07
Greece	4139	3825	.08
Hungary	4056	3547	.13
Iceland	2463	2285	.07
Ireland	2417	2181	.10
Italy	10426	9390	.10
Korea	3190	3031	.05
Mexico	15653	14850	.05
Poland	2292	2193	.04
Portugal	4198	3638	.13
Slovak Republic	4643	4080	.12
United Kingdom	553	480	.13
United States	3525	3056	.13

Statistics based on logistic regression estimates with weights normalised at country level.