# Economic, educational and cultural predictors of science learning in Lithuania and Estonia

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#### **Abstract**

The aim of the research was to assess the economic, educational and cultural predictors of the TIMSS 2003 science test results in Lithuania and Estonia. The data for the research were received from the TIMSS 2003 User Guide for the International Database. The Spearman rank correlation coefficients, calculated on the students' level and the schools level for both countries, revealed the following predictors.

The characteristics of students' socio-economic status were the most powerful predictor of their TIMSS 2003 science score. Books and computers at students' homes were related to their science score. The students' motivation was also a good predictor of their science score, especially on the individual level. The relation of the time-factor to achievement was not very clear. The time spent for homework had no relation to the score in Lithuania and even reduced the science score in Estonia. The parents' educational level was a predictor of the TIMSS 2003 science score in both countries. The parents' native land was important in Estonia but not in Lithuania.

The predictors of the TIMSS 2003 science score were concordant with the predictors of the TIMSS 2003 mathematics study and other TIMSS studies: However, some questions remained still unanswered.

**Key words**: TIMSS 2003, science learning, correlation analysis, socio-economic status, computers.

# Introduction

There are more than one hundred meta-analyses of research on the factors of educational achievement. T. A. Sipe and W. L. Curlette (1997) have made a synthesis of these meta-analyses. They found that the students' motivation had had the greatest effect on educational achievement (effect size (ES) = .82). The second effect was the students' ability level (ES = .61) and then followed the quality of instruction (ES = .39), the classroom social group (ES = .30), the leisure time use (ES = .30), and the home environment (ES = .10). The research, done after the meta-synthesis, harmonises with the conclusions above.

Y. Yang (2003) has made a short overview of the dimensions of socio-economic status related to mathematics and science achievement. The author writes, "About 50% of the school-level variance in reading achievement could be attributed to the sociodemographic factor" (Yang, 2003, 22). The correlation between the student's socio-economic status and educational attainment is about .30 at the individual level and .60 - .80 at the school level. The analysis of the TIMSS data leads the author to the conclusion that the school social background explains 35% of the differences in maths/science achievement (Yang, 2003, 35). The socio-economic

status is related to the cultural environment of students' homes. For example, I. O. Osokoya (2005) found that home environment characteristics, such as warmth and democracy in the home, interactions between parents and children, the parents' attitude to schooling, etc., explained 72% of the students' achievement in history.

Several analyses of TIMSS test results have been made in recent years to find the contribution of the students' motivational features to the test results. H. A. M. Hammouri (2004) has found that four motivational variables of students had positive effects on mathematics achievement in Jordan. J. D. House (2006 and 2007) studied the TIMSS 1999 test results in Japan and Chinese Taipei. The author concludes that the students with positive attitudes towards mathematics and science tended to have higher test scores. L. M. O'Dwyer (2005) analysed the TIMSS 1995 and TIMSS 1999 mathematics test results in 23 countries. Regression analysis in her research resulted in a positive relationship between the test results and the desire to do well in school and the positive attitude towards mathematics.

The abilities of students are measured by IQ and other tests. In the international comparison, the correlation between the nations' IQ and TIMSS results is up to .9 (Lynn and Mikk, 2007). On the individual level, the correlation is lower, it is about .5 (Jensen, 1998). The correlation reveals that the student's IQ and educational attainment have about a 25% joint variability.

In recent years, the relationship of personality traits with educational attainment has been studied intensively. For example, K. Laidra, H. Pullmann and J. Allik (2007) have found that general intelligence, agreeableness, and conscientiousness (carefulness) are important predictors of academic achievement. M. S. Chowdhury and M. N. Amin (2006) report a correlation of .33 between agreeableness and achievement in economics and a correlation of .36 between conscientiousness and achievement.

Ç. I. Üuzel and G. Berberoğlu (2005) compared the predictors of mathematical literacy in three countries: Brazil, Japan and Norway. Attitudes towards mathematics and reading literacy had a strong effect on mathematical literacy in all three countries. However, the strongest effecting factor of mathematical literacy was different in the countries: the use of technology in Brazil, communication with parents in Japan, and attitudes towards reading in Norway. Some characteristics had a positive effect in one country and negative in another; for example, a disciplined classroom environment fostered the success of students in Japan, but in Brazil a reversed result was found. The predictors of educational achievement may be different in different countries.

The aim of the present research was to study the predictors of science achievement in Lithuania and in Estonia relying on the TIMSS 2003 study in the eighth grade. The study was carried out on the students' and the school level. The effectors of mathematics achievement in Lithuania have been studied by A. Elijio and J. Dudaite (2005). However, no such research is available for science test results in Estonia or in Lithuania.

## Method

The data for the research were received from the TIMSS 2003 User Guide for the International Database (Martin, 2005). The database includes detailed data for every participating student in every country: the students' answers to every test item and his/her answers to the questions in the questionnaire. The database also includes the answers of teachers and school principals to every item in their questionnaires. All

the data can be downloaded by countries and by the type of the questionnaire or the test. The advantage of the data is that these are gathered from the large representative samples of students and schools in every participating country.

The present research relies on the students' and the school principals' questionnaire in Lithuania and Estonia. The students' questionnaires also included their test results in science. The standardised science raw scores (afterwards science score) for the eighth grade students were used. The science score summarised the students' results in biology, chemistry, physics, earth science and environmental studies. The average science score in every school was calculated from the data in the students' questionnaire and added to the school principals' questionnaire.

The answers to the questions were coded on the rank scale. Therefore, the Spearman rank correlation coefficients were used to find the predictors of science learning in Lithuania and in Estonia. For the same reason, the distribution of answers, between various options in a question, is used instead of the arithmetical mean. However, the Pearson linear correlation coefficients differed from the rank correlation coefficients by less than .01 on average in the students' database. All the calculations were made with the SPSS programme.

#### Results and discussion

In Lithuania, 143 schools with 4,964 students participated in the TIMSS 2003 eight grade science study. In Estonia, 151 schools with 4,040 students took part in the TIMSS test. Some students did not answer some questions and therefore the actual numbers of cases are usually lower than the numbers indicated above. However, the correlation coefficients over .04 in the absolute value are statistically significant in the students' data and over .20 in the school principals' data.

Table 1 presents the correlation coefficients between some students' characteristics and their science score in the TIMSS 2003 study. These characteristics, which had the correlation coefficient over .01 at least in one country, are included in the table. Many students' characteristics have the negative correlation coefficient with the science score. This is because the scale for coding students' answers was often opposite to the name of the characteristic. For example, the students' answers to the question about the home possession of a computer were coded as follows: 1 - yes; 2 - no. The bigger number indicates not having a computer and in this case the science score is lower (the negative correlation in both countries). Actually, a computer at home facilitated science test results. To understand the signs before the correlation coefficients, the coding is briefly described in Table 1 after the headings of some characteristics.

Four characteristics of the students' socio-economic status had statistically significant correlation coefficients with the TIMSS 2003 science score. The highest correlation was with the number of books in students' homes; the characteristic predicted 4 – 6% of the science test results. An analogous relationship was with the TIMSS 2003 mathematics test results (Elijio and Dudaite, 2005). More books are likely to be available in the families with a higher income and this explains the relationship between educational attainment and the socio-economic status (Arellano and Fullerton, 2005; O'Dwyer, 2005; Thorpe, 2006).

The role of computers is not simple. In Lithuania and Estonia, computers at home facilitated science learning (Table 1); in Norway and Japan the use of technology had no, or negative, effect on mathematical literacy (Üuzel and

Berberoğlu, 2005). One explanation of the controversy can be found in the research by Papanastasiou, Zembylas, and Vrasidas (2005). The authors established that the frequent use of computers at home for writing papers etc. related to higher science achievement in the USA and Germany. The students who had computers at school and used them frequently for programming had lower results in the PISA science test.

Table 1
The Spearman correlation coefficients
between the students' characteristics and the TIMSS 2003 science score

between the students characteristics and the Thylog 2003 science score			
Characteristic	Correlation	Correlation	
	in Lithuania	in Estonia	
Number of books in your home	.26	.20	
Home possession of a computer: (1 – yes)	19	18	
Use a computer at home: (1 – yes …)	19	17	
Home possession of a dictionary: (1 – yes …)	12	05	
Highest educational level of mother: (1 - no school)	.10	.23	
Highest educational level of father: (1 - no school)	.04	.22	
Parents' highest educational level: (1 - finish uni)	27	24	
How far in school do you expect to go: (1 - ISCED3)	.22	.26	
Students' education aspiration relative to parents: (1-	31	29	
student university and parent university)			
Agree that students try their best	.08	.13	
Spend time: play, talk with a friend: (1 – no time)	10	11	
Spend time: do jobs at home: (1 – no time …)	13	16	
Spend time: work paid job: (1 – no time …)	12	17	
Spend time: do homework: (1 – no time …)	.00	11	
Mother born in the country: (1 – yes …)	02	12	
Father born in the country: (1 – yes)	.01	12	

Students in Lithuania and Estonia had better science test results if their parents had a higher level of education (Table 1). In Lithuania, the relationship was tighter with mothers' education than with fathers' education. We may hypothesise that in Lithuania, mothers have more interest in children's learning and have a bigger influence on the cultural climate at homes than fathers do. On the other hand, the relationship was stronger in Estonia than in Lithuania. One possible explanation of the fact is that, in Estonia, educated parents are more interested in their child's studies but in Lithuania all parents are interested. Some support to the explanation can be found in Table 2 in which we see that the percentage of students who intend to finish university and whose parents did not go to university is twice as high in Lithuania as compared to Estonia. The relationship between parents' education and students' success in school was also found in the TIMSS 2003 mathematics study (Elijio and Dudaite, 2005, Jürges and Schneider, 2004). However, the predicting value of parents' education is not high, being about 6%. The school achievement of a student depends on very many factors.

The students' motivation has an important effect on their success in science learning (Table 1). The students' educational aspirations had the highest correlation coefficients in the group. The loftier the aspirations, the better the science test results are. Of course, the desire to finish university studies is also strengthened by positive achievement. Therefore, these characteristics are interdependent. The average science

test scores in Estonia are a little higher than in Lithuania in every aspiration group but the percentage of students who intend to finish university studies is much greater in Lithuania (Table 2).

Science test results according to the educational aspirations of students

Table 2

Educational aspirations	Lithuania		Estonia	
	Percentage of students	Science score	Percentage of students	Science score
Finish university studies and either parent went to university	26.3	54.8	23.4	55.0
Finish university studies but neither parent went to university	30.0	50.2	16.8	51.7
Not to finish university studies regardless of parents' education	17.3	46.6	31.7	48.2

Four characteristics of students' time (Table 1) had statistically significant correlation coefficients with the TIMSS science score. The more students spent time playing, doing jobs at home or working on a paid job, the lower the test results were. An analogous relationship was found in the TIMSS 2003 mathematics study (O'Dwyer, 2005).

We believe that the more time students spend doing homework, the better is their achievement. The belief is not confirmed by the data in Table 1. There is no relationship between the time for homework and the students' test results in Lithuania. In Estonia, the students who studied longer at home had even lower test scores. The result can be explained by two reasons. 1. Some students are rapid learners and they achieve good results even if they spent a small amount of time on homework. 2. The overall study burden is too great for students and a long time spent sitting at homework will not facilitate acquiring the study material (Mikk, 2006).

The birthplace of mother and father had no relation to the student's TIMSS science score in Lithuania but it did in Estonia. The students whose mother/father was born in Estonia had the higher test results (Table 1). H. Jürges and K. Schneider (2004) assert the same regarding the TIMSS 2003 mathematics study. However, the correlation coefficient is very low; it explains only one per cent of the variability in the science score. The absence of the relationship in Lithuania leads to the hypothesis that the Russian speaking minority group in Lithuania is better integrated in society than in Estonia.

To conclude the discussion of the student level predictors of the TIMSS 2003 science score, we have to admit that the observed characteristics have a rather low predictive validity. The highest of them, the students' educational aspirations had a 9 per cent joint variability with the science score. The analogous conclusion has been drawn by other researches as well. J. D. House (2004) reports even lower correlation coefficients. L. O'Dwyer (2005) could explain only 20% of the within classroom variance with her model for the mathematics score in the TIMSS 1995 and 1999 study. Her model for the between classroom variance explained 50% of this.

The correlation coefficients of the school level characteristics with the science score are given in Table 3. Once more, the student's economic background is a good predictor of achievement in both countries. The students' economic background had the highest correlation coefficients, which explain up to 16% of the science test score variability. Students from economically disadvantaged families need teachers' attention more.

Table 3
The Spearman correlation coefficients between school characteristics and TIMSS 2003 science score

Characteristic	Correla-	Correla-
	tion in	tion in
	Lithuania	Estonia
Students' background: economic disadvantages (1 – 0	40	27
to10%)		
Students' background: economic affluence (1 – 0 to 10 %	.28	.43
)		
Type of community (1 – more than 500,000 people)	27	06
Computers available for students' instruction	.20	.09
Shortage: computer support staff (1 – none …)	24	.04
Help: anyone available, teachers use technology (1 – yes …)	22	04
Teachers expect students' achievement (1 – very high)	-12	27
Parents support students achievement (1 – very high)	32	10
Students desire to do well (1 – very high …)	26	16
Activity percentage: supervising teachers and other staff	.02	25
Activity percentage: public relations and fundraising	.01	.21
Elsewhere behaviour: absenteeism (1 – not a problem)	26	18
Elsewhere behaviour: skipping class (1 – not a problem)	22	19
Elsewhere behaviour: intimidation of students (1 – not a	20	02
problem)		
Good school/class attendance (1 – high)	22	17

The type of community is important in Lithuania and not important in Estonia. In Lithuania, students in big cities have higher test scores. L. M. O'Dwyer (2005) and J. H. Williams (2005) also have found higher mathematics' test performance in urban areas. It can be related to the different socio-economic status of people in rural and urban areas. However, there are exceptions from the rule (Williams, 2005) and Estonia is one of the countries in which the correlation between the type of community and science test results is statistically not significant. There is not one big city (over 500,000 inhabitants) in Estonia.

The availability of computers and the computer support staff in schools was conductive to science learning in Lithuania but not in Estonia. The ways of using computers in schools need further study, as became clear from the research of Papanastasiou, Zembylas, and Vrasidas (2005).

Teachers' high expectations facilitated science learning in Estonia. In Lithuania, parents' support and students' desire to do well lead to higher test results. The differences between the countries are non-significant although the three characteristics had the statistically significant correlation coefficient only in one country.

According to Table 3, school principals' activities were not related to students' achievement in Lithuania. In Estonia, school principals' engagement in public relations and fundraising were supportive to science learning in the school. However, the principals supervising of teachers and other staff reduced the students' science score. To understand the unexpected relationship, we can look at the division of the principals' time in Estonia and Lithuania (Table 4). In Estonia, principals spend more time on administrative duties and fundraising. In Lithuania, the principals use more time for instructional leadership and teaching.

School principals' activities

Other

belloof principals activities				
(as a percentage of the work-time)				
School principal activities	Mean in	Mean in		
	Lithuania	Estonia		
Administrative duties (hiring, budgeting, scheduling, etc)	26.6	30.2		
Instructional leadership (developing curriculum and pedagogy, etc)	24.4	21.5		
Supervising and evaluating teachers and other staff	17.1	16.4		
Teaching	13.1	7.8		
Public relation and fundraising	11.2	15.0		

7.7

Table 4

9.7

Three characteristics of disruptive behaviour (absenteeism, skipping class, and intimidation of students) predicted lower science test scores. Good school/class attendance facilitated science learning, at least in Lithuania. An analogous relationship was found for the TIMSS 2003 mathematics study (Jürges and Schneider, 2004). The predictive validity of these characteristics is up to 6%.

### Conclusion

The students' socio-economic status was the most powerful predictor of their TIMSS 2003 science score. The number of books in students' homes and the principals' assessment of the percentage of the students from economically affluent homes had the highest correlation coefficients with academic achievement. The correlation coefficients on the school level were higher than the correlation coefficients on the individual level.

One of the indicators of socio-economic status is the availability of computers at schools and homes. The students from homes with computers had the higher science score in both countries. In Lithuanian schools, computers facilitated science learning but there was no such relationship in Estonia. The ways of using computers need further exploration.

The students' motivation was also a good predictor of their science score, especially on the individual level. It explained up to 9% of the variability in the

The relation of the time-factor to achievement was not very clear. Students' extra-learning activities reduced their science score in both countries but the time spent for homework had no relation to the score in Lithuania and even reduced the science score in Estonia. School principals' time division between different activities had no relation to students' achievement in Lithuania. In Estonia, the science score was lower in schools in which principals devoted more time for supervising teachers and other staff and the scores were higher in the schools in which principals were more engaged in public relations and fundraising.

The students' disruptive behaviour had negative correlation coefficients with the science score in Lithuania. In Estonia, the effect was the same; however, none of the correlation coefficients reached five per cent significance.

The parents' educational level was a predictor of the TIMSS 2003 science score in both countries. However, its validity was not very high; it was about 6%. The parents' native land was important in Estonia but not in Lithuania.

The predictors of the TIMSS 2003 science score were concordant with the predictors of the TIMSS 2003 mathematics study and other TIMSS studies. Most of the studies use correlation as a research instrument. Correlation detects relationships but it is not able to make clear which of the related variables is the cause and which is the consequence or if there is a third variable which causes changes in the both studied variables. For example, the research carried out is not able to clarify to which degree education fosters economic development and to which degree economic wellbeing facilitates education.

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