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EVALUATION OF LATVIA'S SCIENCE EDUCATION IN THE IEA TIMSS AND OECD PISA FRAMEWORK

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Abstract. The article deals with the two largest international comparative studies in science, the first cycles of which took place in the last years of the previous century and which go on today as well - IEA TIMSS (Trends in Mathematics and Science Study) and OECD PISA (Programme for International Student Assessment). The average achievements of Latvia's students in science in each of the studies are different but the general situation of science education in Latvia is satisfactory and corresponding to our economic situation. We support the opinion that improving of Latvia's economics and correct developing of the country's educational system will advance students' achievements. At the same time there are several spheres, which need immediate improvement. Especially, it concerns our students' skills to apply the knowledge gained in science lessons to real life situations.
Key words: science education, international comparative education research, TIMSS, PISA, achievement.

Latvia has been participating in IEA TIMSS (Trends in Mathematics and Science Study) study already since 1995. The study indicates they measure students' achievements in mathematics and science in the context of the educational system, school and grade. In the first study (TIMSS 1995) we participated in all three researched age groups – Grades 3 and 4, grades 7 and 8, Grade 12. The second study in 1999 (TIMSS 1999) focused only on Grade 8. At present we are getting ready for the third cycle of the study in 2003 where there will be two age groups researched – Grade 4 and Grade 8.

Latvia has also joined the Programme for International Student Assessment (PISA) of the OECD countries. The first cycle of the data collection in this study took place in year 2000 and its main emphasis was placed on the reading literacy of the 15-year-old students, it also included tasks in scientific and mathematical literacy. The 15-year-old students in Latvia basically learn in Grades 9 and 10 (or in the corresponding year in the technical school or vocational school). The coming PISA cycle in the year 2003 will put emphasis on mathematical literacy, though it will also present possibilities to see the tendencies in reading literacy and scientific literacy.

The achievements of Grade 8 students in TIMSS 1999 are being seen in Table 1. (Martin et al., 2000).

Table 1. Science Achievement in TIMSS 1999

Country	Average Scale Score (Standard Error)
Chinese Taipei	569(4.4)
Singapore	568(8.0)
Hungary	552(3.7)
Japan	550(2.2)
Korea, Rep. of	549(2.6)
Netherlands	545(6.9)
Australia	540(4.4)
Czech Republic	539 (4.2)
England	538 (4.8)

Finland	535 (3.5)
Slovak Republic	535 (3.3)
Belgium (Flemish)	535 (3.1)
Slovenia	533 (3.2)
Canada	533 (2.1)
Hong Kong, SAR	530 (3.7)
Russian Federation	529 (6.4)
Bulgaria	518 (5.4)
United States	515 (4.6)
New Zealand	510 (4.9)
Latvia	503 (4.8)
Italy	493 (3.9)
Malaysia	492 (4.4)
Lithuania	488 (4.1)
Thailand	482 (4.0)
Romania	472 (5.8)
Israel	468 (4.9)
Cyprus	460 (2.4)
Moldova	459 (4.0)
Macedonia, Rep. of	458 (5.2)
Jordan	450 (3.8)
Iran, Islamic Rep.	448 (3.8)
Indonesia	435 (4.5)
Turkey	433 (4.3)
Tunisia	430 (3.4)
Chile	420 (3.7)
Philippines	345 (7.5)
Morocco	323 (4.3)
South Africa	243 (7.8)

Trends are shown in Table 2. (Martin et al., 2000), it includes only the countries, which participated also in TIMSS study in 1995.

Table 2. Trends in Science Achievement in TIMSS 1995 – 1999

Country	Difference 1999 - 1995 (Standard Error)
Latvia (LSS)	27(5.9)
Lithuania	25(5.7)
Hong Kong, SAR	20(6.8)
Canada	19(3.3)
Hungary	16(4.9)
Australia	14(6.0)
Cyprus	8(3.3)
Russian Federation	7(7.9)
England	5(5.8)
Netherlands	3(9.1)
Slovak Republic	3(4.5)
Korea, Rep. of	3(3.4)
United States	2(7.2)
Belgium (Flemish)	2(7.1)
Romania	1(7.8)

Italy	1(5.9)
New Zealand	-1(6.9)
Japan	-5(3.0)
Slovenia	-8(4.4)
Singapore	-12(9.8)
Iran, Islamic Rep.	-15(5.2)
Czech Republic	-16(6.1)
Bulgaria	-27(7.5)

The PISA results in science are shown in Table 3. (Knowledge and Skills for Life. First results from the OECD Programme for International Student Assessment – PISA, 2001).

Table 3. Scienctific Literacy Achievement in PISA 2000

Country	Average Scale Score (Standard Error)
Korea	552 (2.7)
Japan	550 (5.5)
Finland	538 (2.5)
United Kingdom	532 (2.7)
Canada	529 (1.6)
New Zealand	528 (2.4)
Australia	528 (3.5)
Austria	519 (2.6)
Ireland	513 (3.2)
Sweden	512 (2.5)
Czech Republic	511 (2.4)
France	500 (3.2)
Norway	500 (2.8)
United States	499 (7.3)
Hungary	496 (4.2)
Iceland	496 (2.2)
Belgium	496 (4.3)
Switzerland	496 (4.4)
Spain	491 (3.0)
Germany	487 (2.4)
Poland	483 (5.1)
Denmark	481 (2.8)
Italy	478 (3.1)
Liechtenstein	476 (7.1)
Greece	461 (4.9)
Russian Federation	460 (4.7)
Latvia	460 (5.6)
Portugal	459 (4.0)
Luxembourg	443 (2.3)
Mexico	422 (3.2)
Brazil	375 (3.3)

Both studies have chosen the scale with the mean value of 500 and standard deviation of 100.

As it can be seen, the average results of Latvia's students in each of the tables are different. In TIMSS 1999 the average results of our students are close to the international average of all other participating countries. As regards trends in science achievement, Latvia stands at the top of the table having very high trends. However, in Table 3, presenting students' achievements in

PISA, Latvia is a way below the average and leaves only a few countries behind it. How can this situation be explained?

Firstly, an essential difference in the study framework should be taken into account. TIMSS framework is (Mullis et al. 2001) oriented towards the common part of the curriculum of the school science subjects. The study framework and the test items are developed by questionnairing (consulting) all the participating countries, involving their experts and internationally recognized specialists in science education. When being developed, the particular contents to be included in five Science Content Domains (Life Science, Chemistry, Physics, Earth Science, Environmental Science) and three Science Cognitive Domains (Factual Knowledge, Conceptual Understanding, Reasoning and Analysis) were carefully weighed**.** The test items were developed to be maximally short, easily readable and eliminating any unnecessary information. Although the most part of TIMSS tests are multiple-choice ones, it also includes the tests requiring short or extended types of answers. For example, let's have a look at two tests (out of 150) included in the science test for Grade 8 students:

Example 1 (Physics)
The walls of building are to be painted to reflect as much light as possible. What color should they be painted?
A. White
B. Red
C. Black
D. Pink

Example 2 (Life Science)
Ethan hammered a nail into the trunk of young tree. Explain why the nail was still at the same height from the ground twenty years later even thought the tree had grown to height of 22 meters.

When developing the PISA framework, the international experts and representatives from the participating countries did not attempt to include testing of knowledge and skills of science subjects taught at school in a traditional way but tested students' scientific literacy, trying to establish students' ability to see the science issues in real-life situations and making the appropriate conclusions. Thus, the test items were not defined in the form usually used in the textbooks. Assessment units presented students with a real-life situation, taken from an authentic source, and a series of questions about it (Measuring Student Knowledge and Skills – A New Framework for Assessment, 2000). These authentic sources included, for example, parts from the article published in the scientific journal (the text was adapted), parts of the diary written by some 19th century doctor and scientist, newspaper articles, etc. It means, that the student has first to read carefully almost a page long text and then provide many science based answers of which almost a half is the so called free answers.

Certainly, scientific literacy depends on good science knowledge and skills which includes the following topics: the structure and properties of matter, atmospheric change, chemical and physical changes, energy transformations, forces and movement, form and function, human biology, physiological change, biodiversity, genetic control, ecosystems, the Earth and its place in the universe, geological change. However, to be able to function efficiently in the modern society scientific literacy means much more: it depends on a skill to use the scientific research processes and methods, for example,

- a skill to recognize nature and limitations of such research;
- a skill to find and to analyze the evidence in the text in order to answer science questions;
- a skill to conclude, evaluate and to discuss the conclusions.

Secondly, a very close connection between reading literacy and scientific literacy in PISA tests should be taken into account. The average students' achievements of all the 32 participating

countries in reading and scientific literacy correlate very closely (R = 0,95). Also the average achievements of Latvia's students correlate very closely. The correlation ratio among the average achievements in reading literacy and scientific literacy is R = 0,84 (2150 students), among the average results of schools– R = 0,94 (154 schools). Usually girls' achievements in reading literacy are higher than those of boys. The same was in PISA where girls and boys from Latvia showed the greatest difference (approximately 50 points or ½ of the standard deviation). Taking into consideration all these correlations and the way test items were defined in the PISA study, there is no surprise that the girls' average results in science in Latvia are considerably higher than those of boys. It should also be mentioned that the achievement difference between the girls and boys' performance in science was the highest one in Latvia among all the participating countries. Thus, we can unequivocally state that the PISA scientific literacy scale also includes a large part of reading literacy. However, the TIMSS study pays more attention to the fact that the component of the reading literacy in the scientific literacy scale is as small as possible.

Thirdly, it should be taken into account that actually students' average results in countries participating in TIMSS and PISA are not contradictory. Picture 1 indicates the interrelation **(relationship)** between students' average achievements in science in TIMSS and PISA studies. The correlation between these achievements is high (R = 0,58).

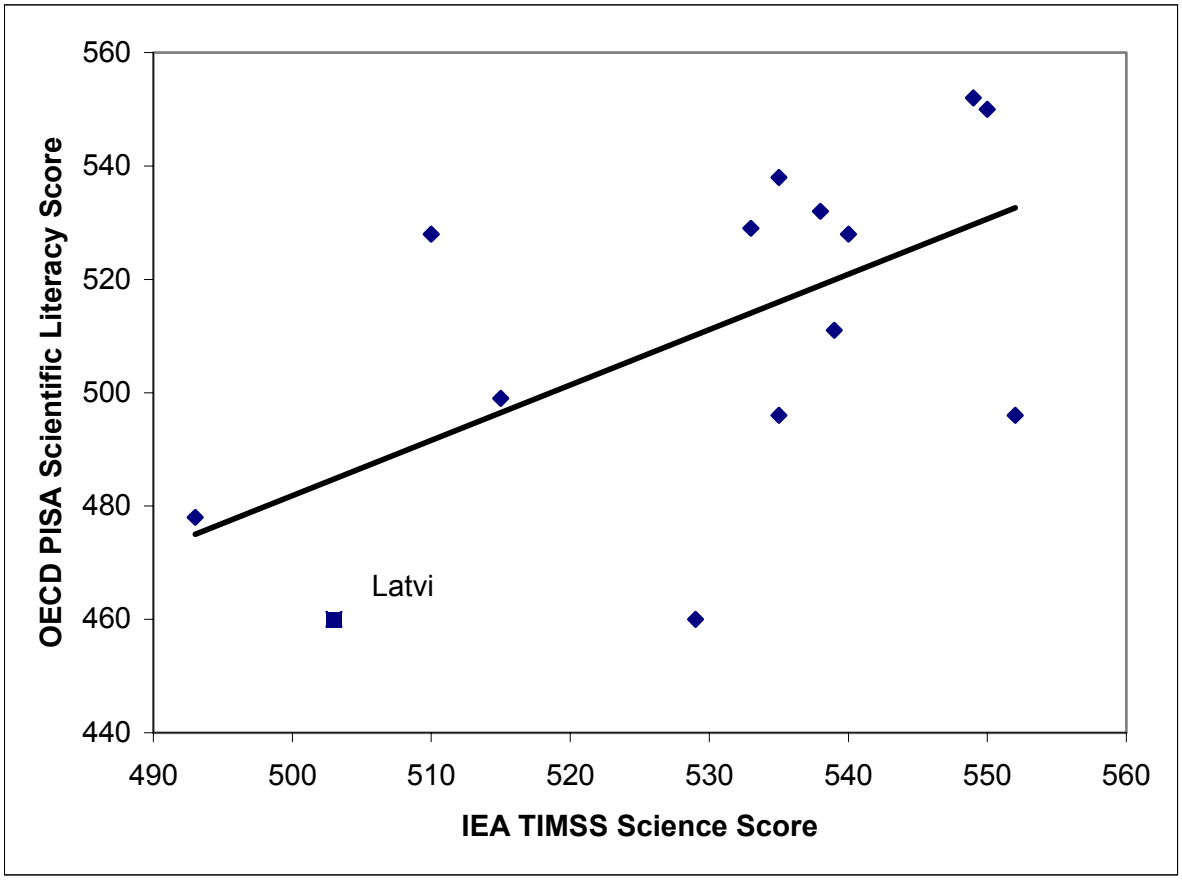
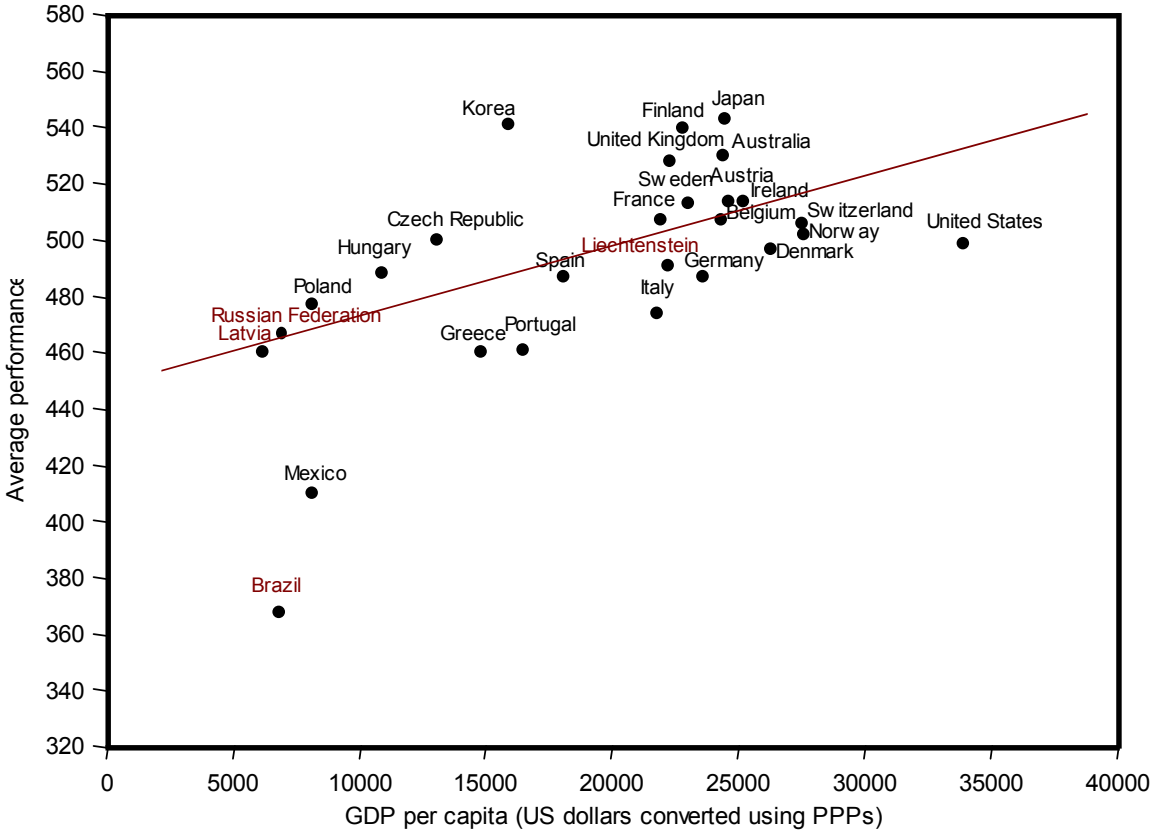


Figure 1. Mean perfomance in PISA and TIMSS

It should be mentioned that students' average achievements also largely depend on the economic situation of the country. Picture 2 presents students' average achievements in the PISA study in the combined scale (includes reading, mathematical and scientific literacy) and the GDP per capita relation (Knowledge and Skills, 2001).



Trend line does not take non-OECD countries into account

Figure 2. Student performance and national income. Relationship between average performance across the combined reading, mathematical and scientific literacy scales and GDP per capita, in US dollars, converted using purchasing power parities (PPPs)

Thus, the comparatively high results of Latvia's students in TIMSS study and low results in PISA study can also be explained by the economic differences of the participating countries. Students from many economically weak countries showed results below the international average in the TIMSS study.

Conclusions

Though the average achievements of Latvia's students in science are not high, we have to regard them as satisfactory. It should be taken into account that students' average results in each country depend on that country's economic situation. We may hope that along with the improvement of our economics and correct development of our educational system, the quality of science education will also improve. The positive trends in the TIMSS study testify to that. At the same time there are several spheres, requiring immediate improvement. Particularly, it concerns our students' skills to apply the knowledge gained in science lessons to real life situations.

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Резюме

ОЦЕНКА ДОСТИЖЕНИЙ ПО ПРЕДМЕТАМ ЕСТЕСТВЕННЫХ НАУК В ЛАТВИИ В РАМКАХ ИССЛЕДОВАНИЙ IEA TIMSS И OECD PISA

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Латвия участвует в двух больших международных сравнительных исследованиях, в которых исследуются также естественно-научные предметы в школе. В статье проводится сравнительный анализ результатов исследований IEA TIMSS 1995 – 1999 гг. и OECD PISA 2000 г.

Хотя общие результаты наших учеников невысокие в международном сравнении, зная нашу ситуацию в образовании в прошлом десятилетии, мы удовлетворены этими результатами. Основываясь на тенденциях развития нашей экономики и системы образования, мы прогнозируем улучшение знаний и навыков наших учеников в естественно-научных предметах. Об этом свидетельствуют новейшие результаты исследований IEA TIMSS 1995 – 1999 гг.

Ключевые слова: естественнонаучное образование, международное сравнительное исследование образования, TIMSS, PISA, достижение.

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