Change of Mathematical Achievement in the Light of Educational Reform in Lithuania

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Abstract

The article deals with Basic School student's mathematics achievement change through 1995-2003 in Lithuania. For the analysis data from TIMSS 1995, 1999 and 2003 is used. The cycles of TIMSS and the scaling methodology used for calculating the scores provide the possibility for participating countries not only to compare their results with the ones from other countries, but also to track the changes in their students' achievements throughout the years. It is of particular importance to those countries that are experiencing considerable changes in their educational systems. Lithuania is one of such countries as it was undergoing a large educational reform since 1990's. Participation in the three TIMSS cycles which had their main surveys in 1995, 1999, and 2003, gave a reliable source to measure the impact of the reform to the Basic School Grade 8 students' achievements in mathematics. The question is analyzed using content analysis and classical statistical investigation (main statistical software used was SPSS 12.0).

Keywords: *educational reform, mathematics achievements.*

Introduction

For the last century, educational reforms in various countries have become a part of a daily routine in the life of an educational institution (Kinsler, 2001, Horne, 2001). Many researchers examine the results of the reforms in various countries. Some praise those reforms (Draper, 2002, Gamoran, 1997), others say that the reforms do not reach the desired results (Horne, 2001). Speaking namely about the reforms in mathematics, some of the authors mention a positive influence of the reforms – for example, by connecting the content of mathematics with a real life and work context, the students found mathematics more interesting to learn (Nicol, 2004), by paying extra attention to the training of girls in mathematics, their performance and their attitudes towards mathematics improved (Richardson, 2003), by reforming the content of mathematical education, students began to understand some of the Algebra chapters better (Krebs, 2003), having changed the traditional lecture-type teaching method with active and problem-solving methods, students improved their results of mathematics (Sawada, 2002) and so on. However, other authors claim that inspite of large efforts in reforming the content of mathematical education, teaching methods, instructional aids, the reforms most often do not reach the desired results (Vann, 1993). The desire to reform mathematical programs, comes not only from the new expectations of this time for a school and for a level of mathematical abilities (Kelly, 2000), but also, and usually, from the students' low mathematics achievements (Hess, 2002, Betts, 2001, Frykholm, 2004). Thus, one of the main goals of the reform is the improvement of the students' results of mathematics. Therefore the success of the reform is frequently measured by the changes of the students' achievements (Finnan, 2003). However these students' achievements' improvement results are not easy to measure (Sawada, 2002), especially in a short time, as it is usually wanted (Grissmer, 2001). The real results of the reform in respect to the students' achievements sometimes are difficult to measure because the high standards of the reformed mathematical programs force teachers to train students only out of the topics that will be tested, also, the intention to show better results force the students to cheat during the test (Hess, 2002). Sometimes after a reform, a quick jump in the students' achievements is observed, however after a few years the achievements begin to worsen again – the results of the reforms are

often equated to the normal distribution curve (Vann, 1993). Many authors state, that the reforms do not give any positive changes in the students' mathematics achievements, even on the contrary – can worsen their achievements (Alsup, 2003). This can be explained by the too-quick introduction of the reform, by having tried it only in a few schools, in a very shot period of time. In these cases, the intended guidelines of the reform are not sufficiently well grounded. Sometimes the results that are expected from the reform are unmeasurably high (Gordon, 2004) or the goals of the reform are so highly „raised", that to measure the results of the reform after some time becomes pointless, because they then come to be understood as not beeing realistic enough – for example, to train graduates who would know mathematics better than any other graduates of every country in the world (Hill, in Internet). Also, it can be fruitless to try to imporve students' mathematics results because of the incompatibility of the reform theory and the practice, as well, because of the teachers' reluctance / incompetence to take in the ideas of the reform and to implement them (Kyriakides, 1997, Finnan, 2003). A large part of the researchers, who say that the reforms usually do not give the expected improvement of students' mathematics achievements, state that this is so because the reforms are focused only on the changes in a class and school education environment, but schools are not islands (Fullan, 2003), and learning achievements of a student are strongly connected with his or her home socio-educational environment, as well as other nonschool environments (Viadero, 1996, Rotberg, 2000, Cohen, 2000, Green, 1987). It can also be said that the students' achievements are more dependent on these nonschool environments (Coleman, from Edmonds, 1987, Barton, 2001). There are examples stating, that the school itself can have an influence on the students' achievements (Fullan, 1998), but for the school „alone" this is extremely difficult (Barton, 2001).

So, from this context it is clear, that many researchers analyze the influence that the educational reform has on the students' mathematics achievements, however as it can be seen, some see positive results of the reform, others think that due to various reasons the reforms do not give any results in the long run (or any at all). Educational reforms are associated with the schooling educational environment, while the effectiveness (at the same time the changes in students' achievements) depend also from the students' home socio-educational environment. Every country has it's own specific schooling and social environments. Therefore, it is worth to analyze specific countries', specific educational reform's, specific results.

Lithuania – one of the countries that for some time has been implementing the educational reform. After Lithuania claimed independence in 1991, radical changes in the society brought the nesecity for changes in the educational system (Želvys, 1999). Re-written *Study Programs*, *Educational Standards*, published new textbooks, modified teaching priorities and goals. A more modern view was formed about teaching and learning. By using the experience of other countries it was and it is still hoped, to form a national school. By observing the experience of other countries, it was attempted to go from the academic teaching style in basic shool to the basic literacy, from knowledge to skills, from „dry" theory to more real-life situations. The prevailed model of reproductive educational system is rejected, while an interpretative educational system version is created. Teaching methods are being changed – besides the prevailed lecture-type teaching method various active teaching methods are being used.

Research questions and methods

The educational school environment (while together with political changes also the social and home environments) changed, while does this reflect in the students' mathematics achievements? *Does the mathematical literacy level change while an educational reform is taking place? Do the students know mathematics better now, than at the beginnig of the educational reform?*

These questions can be answered not only by analyzing the present situation, but also by the comparison of this situation with the situation at the begining of the political Independance of

the country. Therefore, there is a need of a long run study, during which information about the students' mathematics achievements would be collected, together with information about the factors that have a relation with those achievements, at the beginning of the reform and now. The only research of this type conducted in Lithuania is TIMSS (Trends in International Mathematics and Science Study), organized by the IEA (International Association of the Evaluation of Educational Achievement). Lithuania has participated in the three cycles of this research, whose main data collection were conducted in 1995, 1999 and 2003.

The continuing participation in the TIMSS reseach, alows a posibility to evaluate the effectiveness of Lithuania's educational development, to identify the changes, to find out the general problems in education. The TIMSS uses the IRT (Item Response Theory) scaling methodology (in a scale the average was set to 500 and the standard deviation – to 100), which alows to compare each countrie's results of all the three cycles (in Lithuania only the 8 grades were tested during those three cycles).

This is the only reseach, consistently made in the time of Lithuanian enducational reform. The information that was registered in this research was about students who learned from mathematics textbooks, translated from Russian language (1995 research cycle), also about the students, who had studied from textbooks, written by Lithuanian authors (1999 and 2003 research cycle). Therefore it can be said that the TIMSS is the only reseach, that has registered the changes in the students' achievements during the time of the educational reform.

Lithuanian students' TIMSS results and their changes have not been analyzed very much. Only a few authors have analized the TIMSS 1995 results (Zabulionis, 1997a, 1997b, 2001, Trakas, 1997). Also, a few reports of the TIMSS study have been published, but they were limited only with the presentation of the results, without any analysis (Cekanavicius, et. al., 1997, Mackeviciute, Zabulionis, 2001, Dudaite, et. al., 2004). Change in Lithuanian students' mathematics results in the period of 1995-2003 was analyzed by Dudaite (Ed.) (2006).

In this paper, a further analysis of the change in the results of Lithuanian students' mathematics achievement in the TIMSS assessment will be presented. The research population of the article are Grade 8 students. In 1995, 2547 Grade 8 students from Lithuania participated in the study, in 1999 – 2361 student, and in 2003 – 5737 students.

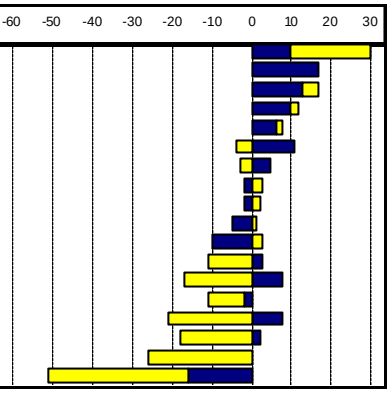
The main goal of the analysis of this paper is to view how Lithuanian Grade 8 students' mathematics tests' results in TIMSS study have changed from 1995 to 2003 and what would be the possible explanations for that change. For this purpose databases of TIMSS study done in 1995, 1999, and years 2003 are used. The research questions are analyzed using content analysis and classical statistical investigations (main statistical software used is statistical package SPSS 12.0).

Review of the Lithuanian students' mathematics results

Analysis of the TIMSS results shows that in general the mathematics achievements of Lithuanian Grade 8 students are constantly improving. The difference between the TIMSS 1995 and 1999 students' mathematics achievement is not very high (10 points of the scale, SE=6.1 – the difference is not statistically significant), but between the TIMSS 1999 and 2003 – the difference is much higher (20 points of the scale, SE=5.0 – the difference is statistically significant (Mullis, et. al., 2004)). But is it high increase of the resulta or not? To answer this question let's compare the Lithuanian results with results of other countries. According to Exhibit 1, Lithuanian students' achievements' increase is the highest among all countries that have participated in TIMSS assessments all of the three times (In Exhibit 1 the average mathematics achievement differences between 1995 and 1999 are marked in dark color, in bright color – achievement differences between 1999 and 2003. The column, intercepted on the right side of the Exhibit, signifies increase in average mathematics achievement and the column, intercepted on the left, – decrease).

Exhibit 1. Comparison of Average Mathematics Achievement of the countries that have participated in all 3 TIMSS studies.

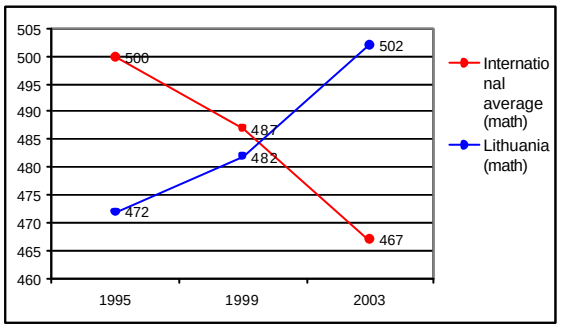
Countries	TIMSS 1995	1999	2003
Lithuania	472	482	502
Latvia	488	505	505
Hong Kong	569	582	586
USA	492	502	504
Korea	581	587	589
Netherlands	529	540	536
Hungary	527	532	529
Romania	474	472	475
England	498	496	498
Singapore	609	604	605
New Zealanc	501	491	494
Iran	418	422	411
Cyprus	468	476	459
Japan	581	579	570
Belgium (Fl.)	550	558	537
Russia	524	526	508
Slovak	534	534	508
Bulgaria	527	511	476



In comparison, Latvia, neighbour country of Lithuania, from 1995 to 1999 has made a progress of 17 points in mathematics achievement, but in 2003 Latvian results of the TIMSS study were the same as in 1999. Meanwhile the results of average mathematics achievement of Russia – another neighbour country of Lithuania – from 1995 to 2003 decreased. The highest decrease in mathematics achievement from the first TIMSS assessment in 1995 to the third assessment in 2003 was in Bulgaria (51 point).

While comparing Lithuanian students' average mathematics results with International average (see Exhibit 2), it is seen that during all three cycles of the TIMSS study International average decreased from 500 to 467 points of the scale, and Lithuanian average increased from 472 to 502 points of the scale.

Exhibit 2. Shift of International Average Achievement and Lithuanian Average Achievement of Grade 8 students.



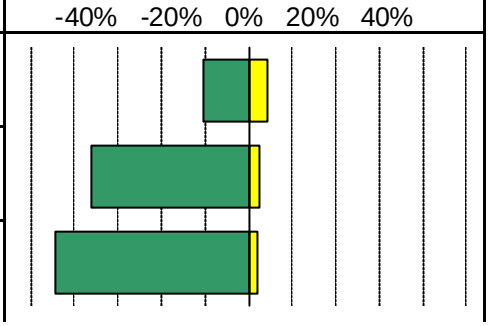
In 1995 Lithuanian average achievement was significantly lower than International average – the Lithuanian results were at the bottom of the country list. However, in 1999 Lithuanian average achievement was similar to the International average. While in 2003 Lithuanian students proved themselves very successfully and outstripped the International average with a marked difference. By that time the international average strongly decreased. International achievement average would remain more constant if only the same countries would participate in each TIMSS cycle. The comparison between the International average of TIMSS 1995 and the Lithuanian results of TIMSS 2003 shows, that Lithuanian Grade 8 students in 2003 have reached International average of 1995. Consequently, it could be said that Lithuania outstripped the International benchmark not by 35 points but only by about 2 points. It is more

expedient to establish measure with the international average of 1995 because in that time the TIMSS study had participants almost only from West European and Asian countries, to which ones Lithuania wants to match as an example because of their high achievement results. In 2003 the list of participating countries was very much expanded and included many developing countries.

Having analyzied the general averages of Lithuanian Grade 8 students' mathematics results, we will now analyze those results in more detail.

Exhibit 3. How many times Lithuanian Grade 8 students, by solving a certain item, came to be in the list of the 5 top and the 5 bottom countries in 1995-1999-2003

Lithuania	Share of items in TIMSS math test, on which Lithuania is in the group of 5 bottom countries	Share of items in TIMSS math test, on which Lithuania is in the group of 5 top countries
TIMSS 2003	10.3%	4.1%
TIMSS 1999	36.1%	2.4%
TIMSS 1995	44.6%	1.9%

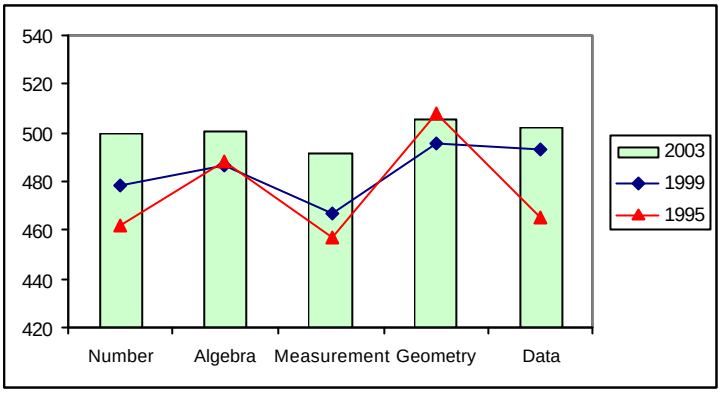


Each single TIMSS item might be analized as some international mathematics mini-contest. Therefore, it is interesting to observe, on how many times Lithuanian students had wone or lost these competitions, and how these results are changing per years. The leaders of these contests undoubtedly are Asian countries: Singapour, Japan, Hong Kong, South Korea, Taiwan. Compared with only countries who have participated in the TIMSS study all three times, Lithuania in TIMSS 1995 was in the top 5 countries only on 1,9% of items (from 155 items), and in the bottom 5 countries on 44,6% of items (from 155 items). For TIMSS 2003 the first result was improved almost twice (4,1%, from 194 items), and the second – decreased more than four times (10,3%, from 194 items) (see Exhibit 3). With the previous result, Lithuania takes lead amongst all of the countries who have participated in the study all three times.

By observing Lithuanian students' results through the mathematics content areas it can be seen that in 1995 the students' knowlege and abilities in five content areas were very different (see Exhibit 4).

In 1995, the best solved items were those of Geometry (508 scale points), then, Algebra items (488 scale points). The results of the other three mathematics content areas were much worse (Measurement – 457, Number – 462, Data – 465 scale points). In 1999, the difference between the students' results in mathematics content areas became a little smaller, the best improvement of the results was observed in Data (28 scale points). The result of the reform is that in 2003 the students' achievements of different mathematics content areas became very similar. In a period of eight years, the results that least changed were those of Geomety and Algebra, while results in Number and Data improved significantly.

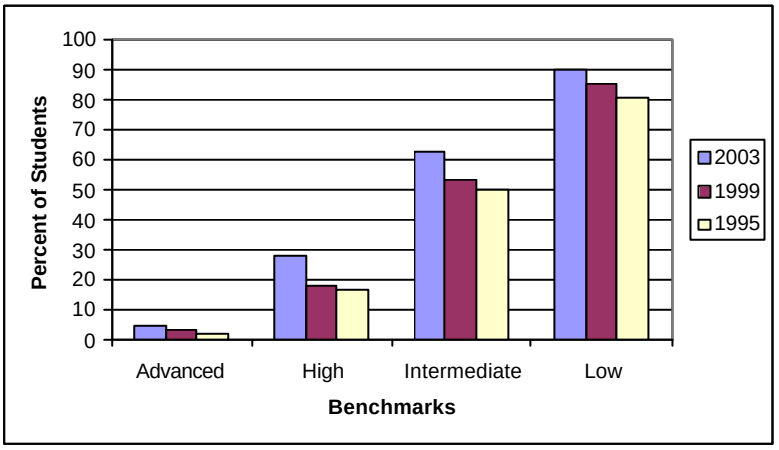
Exhibit 4. Changes in students' results by mathematics content areas.



	Number	Algebra	Measurement	Geometry	Data
1995	462	488	457	508	465
1999	479	487	467	496	493
2003	500	501	492	506	502

Analysing Lithuanian students' results according to the International Benchmarks it can be seen that each TIMSS cycle students' results are constantly improving (see Exhibit 5; here Advanced Benchmark is defined as 625 or more points of the scale, High – 550-624 points, Intermediate – 475-549 points, and Low – 400-474 points). Less students did not reach the Low Benchmark in 2003 (10 %) than in 1995 (19 %).

Exhibit 5. Trends in percentages of students reaching the TIMSS International Benchmarks.



In summary, it can be said that from 1995 to 2003 average mathematics achievement of Lithuanian Grade 8 students has improved. But what could be the possible explanations for that improvement?

Possible explanations of the Lithuanian students' achievements improvement

Certainly, results of the TIMSS assessment were strongly influenced by the educational reform. In particular Lithuanian results in mathematics achievement were affected by newly

established *Educational Standards*, rewritten *Study Programs* and mathematics textbooks written in TIMSS "spirit". After Lithuania participated in the TIMSS assessment for the first time and recieved very low results, educational reform (including school mathematics) was deflected more towards the style of the TIMSS items. This means that it was realized, that one of the main objectives of the educational reform should be the transformation from the conveyance of knowledge to the education of competence, from academic style mathematics to mathematics literacy. As TIMSS assesses namely students' mathematics literacy it was a good impulse for this change. In part, low results of Lithuania in the first TIMSS assessment could be explained referring to the fact that in 1995 in Lithuanian schools mathematics literacy was not emphasized and surely not taught. Lithuanian students were used to a different type of mathematics, therefore they were not able to demonstrate their knowledge in the TIMSS 1995. TIMSS 2003 was executed after the educational reform was implemented so it assessed students that are educated in contemporary Lithuanian schools. That is a solid argument in explaining why in 2003 Lithuanian results jumped up so considerably.

Lithuanian mathematics *Study Programs* and the TIMSS Frameworks.

Let's analyze the differeneces and the similarities between the TIMSS research Frameworks and Lithuanian mathematics *Study Programs* as well as the changes within them.

In 1995 and in 1999, the structure of the TIMSS research had the following three dimentions (Robitaille, D., et. al., 1993):

Content:
- Numbers;
- Measurement;
- Geometry;
- Proportionality;
- Functions, relations, equations;
- Data, probability, statistics;
- Elementary analysis;
- Validation and structure.

Performance Expectations:
- Knowing;
- Using routine procedures;
- Investigating and problem solving;
- Mathematical reasoning;
- Communicating.

Perspectives:
- Attitudes;
- Careers;
- Participation;
- Increasing interest;
- Habits of mind.

In 2003, the structure of the TIMSS research was somewhat changed, two structural dimensions were left, and they were fixed a little bit (Mullis, I., et. al., 2001):

Content Domains:
- Number;
- Algebra;
- Measurement;
- Geometry;

- Data.

Cognitive Domains:

- Knowing Facts and Procedures;
- Using Concepts;
- Solving Routine Problems;
- Reasoning.

By analizing Lithuanian *Study Programs* it can be seen that the programs, written during the reform, differ from those, written before the reform. The reformed programs contain new themes such as Statistics Elements, Elements of Probability Theory, Combinatorics, Elements of Economics, Elements of Computer Science, and Problem Solving (mathematical reasoning). The detailed theames of Algebra, Geometry, Number remain almost the same as they were before the reform (Lietuvos TSR švietimo ministerija, 1988, Lietuvos Respublikos švietimo ir mokslo ministerija, 1997a, Lietuvos Respublikos švietimo ir mokslo ministerija, 1997, Dudaite, 2000).

By comparing the study content of mathematics in Lithuania with the TIMSS mathematics content it can be seen that the pre-reform Lithuanian mathematics study content differed more from the TIMSS 1995 Frameworks because it did not contain Data Representation, Probability and Statistics topics, as well as Elementary Analysis, Validation and Structure, as were in the TIMSS 1995 Frameworks. By comparing in detail other mathematics content themes it can be seen that there is no difference between the TIMSS 1995, 1999, 2003 Frameworks and the pre-reformed and also the reformed Lithuanian mathematics study programs. So only one conclusion is clear, the lower students' results in the TIMSS 1995 could be due to the fact that TIMSS partly tested questions, which Lithuanian students had not learned. However, by counting in the concrete how many of the TIMSS 1995 items matched with the Lithuanian pre-reform mathematics study programs we get quite a hight result – 95.7% (Beaton, E.A., et. al., 1996). So, if only 4.3% of the TIMSS 1995 items did not match the Lithuanian mathematics *Study Programs*, then this could not have caused such low Lithuanian students' results. Besides, Lithuanian students' Data Representation, Probability and Statistics domain's (Data) results of TIMSS 1995 are not the lowest (465 scale points; in comparison: Number – 462, Measurement – 457). So it can be seen that the improvement of Lithuanian students' mathematics results in the TIMSS research can be explained by the change of Lithuanian mathematics study content only in part.

Lithuanian mathematics teaching goals and the TIMSS Frameworks.

By comparing the goals of mathematics teaching that were brought up before the reform with the ones formed as the reform took place, more differences can be seen than in the mathematics content areas case.

In 1988, before the educational reform, the main mathematics teaching goals were formulated like these (Lietuvos TSR švietimo ministerija, 1988):

To give **knowledge**
To form **skills** To train **logical thinking**
To teach to **use** the knowledge **in mathematics related subjects**
To **prepare** students in such a way that they would be able to **continute their studies**

The teaching goals formulated during the educational reform in 1997 sound different (Lietuvos Respublikos švietimo ir mokslo ministerija, 1997):

To develop mathematical **communication**
To teach to solve **standart** mathematical **procedures** To teach to solve **mathematical problems** and to **investigate**
To seek for a **mathematical reasoning** To train prositive **attitudes** towards mathematics
To encourage mathematical, scientific, as well as technological **careers**
To promote the **studying** of mathematics To form a mathematical, scientific thinking **habit**

Besides, in the reformed *Study Programs* of 1997, the main purpose of mathematics teaching is stated – to guarantee the *mathematical literacy* for all members of society.

One main thing, which is very important – the appearance of the notion of *„mathematical literacy"*. Untill the reform, as it was mentioned earlier, schools were teaching more academic style of mathematics. Mathematical literacy was not something to be aimed for.

By comparing the mathematics teaching goals that were formulated before and during the reform with the TIMSS Frameworks (Robitaille, D., et. al., 1993) it can be seen, that the mathematics teaching goals that were formulated in 1997, are equivalent to the TIMSS 1995 and 1999 Frameworks' structural dimensions: „Performance Expectations" (all parts except the first one – „Knowing") and „Perspectives" (all parts). Thus, the goals of mathematics teaching formulated before the reform, are equivalent only with TIMSS 1995 Frameworks' „Performance Expectations" structural dimention's two first parts – „Knowing" and „Using routine procedures". This shows that the Lithuanian mathematics teaching goals that were raised during the time of the reform (in 1997) in essence are quivalent to the TIMSS research format, what can not be said about the goals raised before the reform. So, Lithuanian students, participating in the TIMSS 1999 and 2003, were already trained in the TIMSS „spirit". By this, the significant improvement of the Lithuanian students' mathematics results can be explained.

Lithuanian mathematics textbooks and the TIMSS Frameworks.

From Lithuanian *Study Programs* and *Educational Standards* the goals of mathematics teaching, mathematics content areas, as well as detailed topics can be derrived. However from those documents it is not possible to know how much time is spent for each one of the mathematics topics in the school. This can be approximately determined by the analysis of the mathematics textbooks.

The students, who had participated in the TIMSS 1995, in Grade 5 and 6 studied from textbooks that were translated from Estonian language :

Nurkas, E., Telgma, A. (1990). Matematika. Vadovelis V klasei, Šviesa, Kaunas;
Nurkas, E., Telgma, A. (1991). Matematika. Vadovelis VI klasei, Šviesa, Kaunas.

In Grade 7 and 8 students studied from textbooks that were translated from Russian language:

Teliakovskis, S. (1991). Algebra. Vadovelis VII klasei, Šviesa, Kaunas;
Teliakovskis, S. (1990). Algebra. Vadovelis VIII-IX klasei, Šviesa, Kaunas;
Atanasianas L., et. al. (1991). Geometrija. Vadovelis VII-IX klasei, Šviesa, Kaunas.

The students, who participated in the TIMSS 1999 and 2003, had already studied from the textbooks that were writen by Lithuanian authors, according to the reformed mathematics *Study Programs* and *Educational Standards*:

Strickiene, M., Cibulskaite, N. (1996). Matematika 5, TEV, Vilnius;
Strickiene, M., Cibulskaite, N. (1996). Matematika 6, TEV, Vilnius;
Cibulskaite, N., et. al. (1998). Matematika 7, TEV, Vilnius;
Cibulskaite, N., et. al. (1998). Matematika 8, TEV, Vilnius.

By analizing Lithuanian mathematics textbooks one main conclusion can be made, that in the new mathematics textbooks Algebra and Geometry topics are shortened, while more attention is paid to Number, Measurement topics (Zybartas, 1999). Besides, new themes are introduced: Statistics, Probability Theory, Combinatorics and Mathematical Reasoning. By this it can be explained why throughout the three TIMSS cycles Lithuanian students' achievements' results changed least in Algebra and Geometry, while the areas that improved most were those of Number and Data (Statistics and Probability).

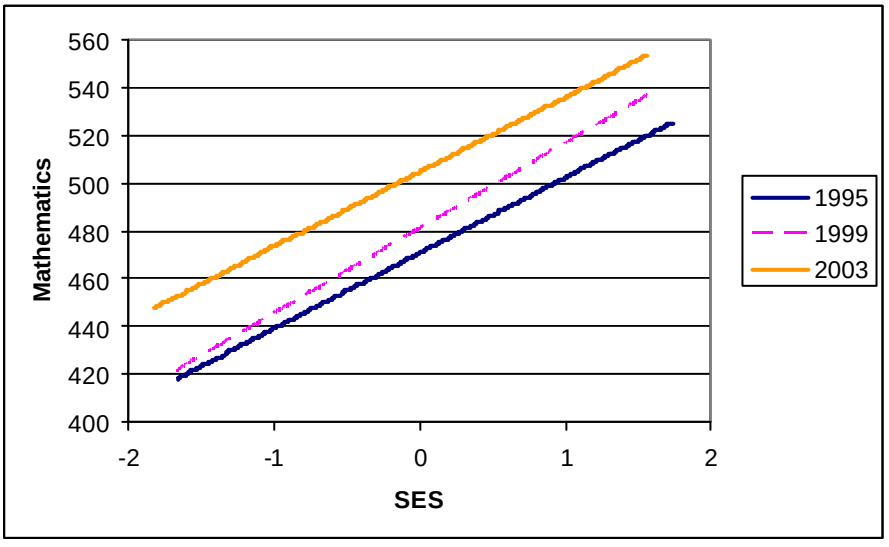
Students' socio-educational home factors.

On the other hand, we cannot speak about the changes in Lithuanian students' mathematics results without considering societal factors such as changes in students' economical and educational home environment. The results of many researches show that home socio-educational environment has a large relation with the students' mathematics achievements. So perhaps the Lithuanian students' mathematics achievements changes can be explained by the fact that a home socio-educational environment has changed? Let's analyze this question.

Let's form a home socio-educational environment factor. Because the indicators that need to be taken must be in all of the three TIMSS cycles, then possible indicators are these: mother's and father's highest education, number of books at home, the owning of encyclopedia, dictionary, calculator and having a work table. Let's take all of these possible indicators and form a home socio-educational environment factor SES (Cronbach Alpha: TIMSS 2003 – 0,631, TIMSS 1999 – 0,557, TIMSS 1995 – 0,383). Regressional analysis shows, that Lithuanian students' mathematics results have a strong relationship with SES (see Exhibit 6).

In the graph it can be seen that relation between students' mathematics achievements and their home socio-educational environment is strong. Also it can be seen that students of the same home socio-educational environments each time collected more mathematics points.

Exhibit 6. Relationship between the Lithuanian students' home socio-educational environment and the mathematics results throughout the 3 years.

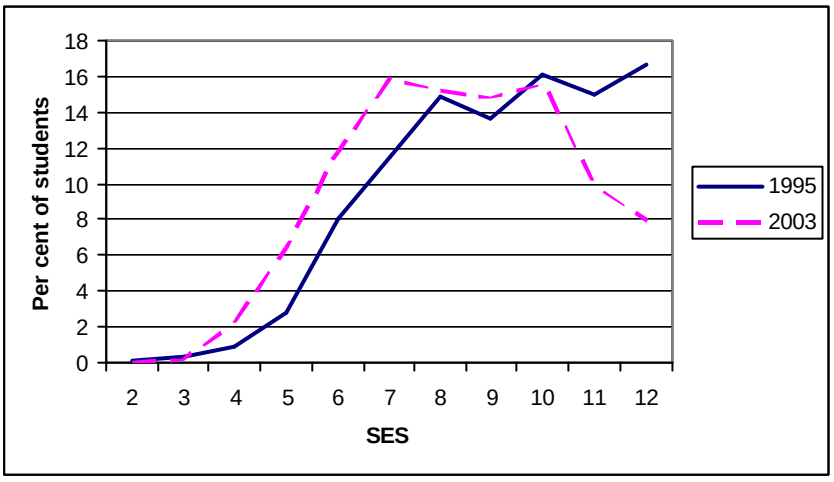


TIMSS	B	B_1	Sig.
1995	470.644	31.525	0.000
1999	481.157	35.597	0.000
2003	504.675	31.253	0.000

It is interesing to see, how the actual home socio-educational environment has changed over the 8 year period. For this, let's form an index with the already used indicators: highest parental education, number of books at home, the owning of a calculator, having a work table, an encyclopedia, and a dictionary (here we will take the highest education of the parents by putting it into three groups: lower or equal to ISCED 3, ISCED4, equal or higher than ISCED5) (see Exhibit 7).

As it can be seen, the home socio-educational environment index over the 8 years has worsened. So, even though Lithuanian students' mathematics results do have a strong relationship with the home socio-educational environment, Lithuanian students' mathematics achievements improvement can not be explaned by the change of the home socio-educational environment.

Exhibit 7. Changes in the students' home socio-educational environment from 1995 to 2003.

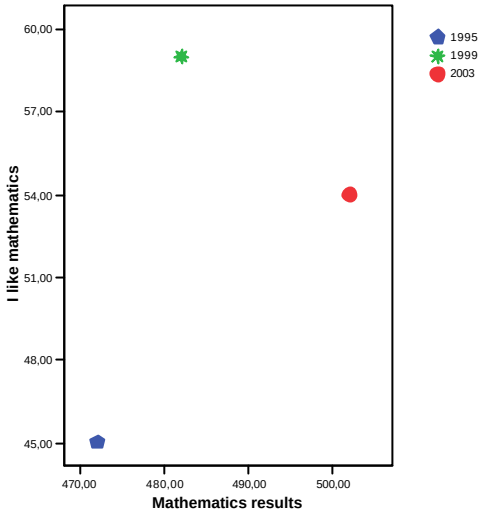


Students' attitudes towards mathematics.

Another explanation for the high improvement of Lithuanian students' mathematics achievements could be related with the changes in the attitudes towards mathematics as a subject. The correlation between the students achievements and the attitudes towards mathematics (measured with the statement, how much „I like mathematics") in the TIMSS 1995 was 0.230, in TIMSS 1999 – 0.288, in TIMSS 2003 – 0.239. Then, maybe over the 8 year period, together with the mathematics results, the attitudes towards mathematics improved as well. However from Exhibit 8 it can be seen, that the clear improvement of attitudes towards mathematics was only in 1999, while in 2003 the attitudes towards mathematics worsened again, although the mathematics results, in the period from 1999 and 2003 rose more than in the period of 1995 and 1999. This can be associated with the introduction of new mathematics textbooks in 1996, which largely differed from the previous textbooks not only with their designs, but also with the larger variety of types of exercises. This should have risen the students' interest in studying mathematics. However, after some time, as it is natural, to become accustomed to new things, textbooks and at the same time the mathematics as a subject again becomes less interesting. Although it can be that the

consequences of the stronger interst in mathematics in 1999, reflect in the higher test results in 2003.

Exhibit 8. Relationship between the students' attitudes towards mathematics and their mathematics achievements.



Learning to solve multiple choice item format tests.

Another possible explanation for the Lithuanian students' achievements of mathematics is that the students simply learned to solve the multiple choice item format tests. By participating in the TIMSS 1995, the students were not accustomed to the multiple choice format questions – more than likely the students never had encountered such questions in mathematics instructions, because this type of questions were almost never used in mathematics textbooks before the reform. Therefore, it is less probable that students would know the multiple choice answer format questions solving strategies (for example, to solve a quesion by veryfying the given answers, to guess an answer, etc.). The analysis of omitted (not solved) TIMSS items, illustrates this (see Exhibit 9, the table shows average percent of students, which omit item without solving it, all TIMSS 1995 and 2003 items are analysed).

Exhibit 9. The difference between the omitted items of TIMSS 1995 and 2003.

TIMSS	MC Omitted (%)	OR Omitted (%)
1995	**7,50 (SE=0,55)**	20,52 (SE=1,84)
2003	**3,60 (SE=0,24)**	23,38 (SE=1,60)

As it can be seen, students omitted the multiple choice answer format items twice as often in 1995 than in 2003, while there is no significant difference between the omitting open response answer format items.

We get a simmilar result by analyzing only the TIMSS 1995 and 2003 trend items (see Exhibit 10).

Exhibit 10. Differences between omitting of the TIMSS 1995 and 2003 trend items (only MC answer format items).

TIMSS	OMITTED	DIFF
1995	**6,83 (SE=0,84)**	57,12 (SE=3,48)
2003	**3,18 (SE=0,37)**	61,45 (SE=3,09)

Once again it can be seen, that the students omitted the multiple choice answer format items twice as often in 1995 than in 2003. In comparison the difficulty of the items is given, there was not much change in this.

With the intention of making sure, that Lithuanian students in the 8 years began omitting the multiple choice answer format items less, at the same time showing that they had learned to solve the tests, a comparison can be made between how students in 1995 and in 2003 omitted the most difficult and the most easy items. Let's take the 10 most difficult and the 10 easiest TIMSS 1995 and 2003 multiple choice answer format items (see Exhibit 11).

Exhibit 11. The difference between omitting the 10 most difficult and 10 easiest TIMSS 1995 and 2003 items (only MC answer format items).

TIMSS	10 most difficult items		10 easiest items	
	DIFF	OMITTED	DIFF	OMITTED
1995	24,03 (SE=1,96)	**12,31 (SE=3,59)**	86,55 (SE=1,16)	1,48 (SE=0,49)
2003	24,36 (SE=2,18)	**5,77 (SE=0,73)**	85,65 (SE=1,38)	0,81 (SE=0,10)

From Exhibit 10 once again it can be clearly seen, that Lithuanian students in 2003 omitted the multiple choice answer format items about two times less in 2003 than in 1995. Thus this shows that Lithuanian students learned more test solving strategies.

Conclusions

1.1. From 1995 to 2003 average mathematics achievement of Lithuanian Grade 8 students has improved significantly.

1.2. Out of the countries that participated in the TIMSS all three times Lithuanian Grade 8 students' mathematics achievements improved most.

1.3. In 2003, Lithuanian Grade 8 students' achievements of different mathematics content domains became more similar amongst themselves than in 1995.

1.4. From 1995 to 2003 the results of Lithuanian Grade 8 students that improved most were those of Data and Number. The results of Algebra and Geometry changed least.

1.5. By solving a certain item, Lithuanian Grade 8 students came to be in the list of the 5 top countries 2 times more in 2003 than in 1995, and came to be in the list of the 5 bottom countries 4 times less in 2003 than in 1995.

1.6. Less Lithuanian Grade 8 students did not reach the Low International Benchmark in 2003 than in 1995.

2.1. The improvemet of Lithuanian students' mathematics achievements over the period of 1995-2003 can best explained by the reformed mathematics *Study*

Programs, *Educational Standards,* mathematics textbooks, that were written in the TIMSS „spirit".

2.2. The improvemet of Lithuanian students' mathematics achievements over the period of 1995-2003 can not be explained by the changes of students' home socio-educational environment.

2.3. The improvemet of Lithuanian students' mathematics achievements over the period of 1995-2003 partly can be explaned by the change of students' attitudes towards mathematics.

2.4. The improvemet of Lithuanian students' mathematics achievements over the period of 1995-2003 partly can be explaned by the fact that students learned to do multiple choice item format tests.

References

1. Alsup, John K., Sprigler, Mark J. (2003). A Comparison of Traditional and reforming Mathematics Curricula in an Eighth-grade Classroom. Education, Vasara 2003, Vol.123, Nr.4, p.689.
2. Barton, Paul E. (2001). Facing the Hard Facts in Education Reforms, New Jersy.
3. Betts, Jullian, R. and Costrell, Robert, M. (2001). Incentives and Equity under Standards-Based Reform. Knygoje Ravitch, Diane (2001). Education Policy, Brookings Institution Press, Washington D.C., p.9-74.
4. Cekanavicius V., Trakas G., Zabulionis A. (1997). Trecioji tarptautine matematikos ir gamtos mokslu studija. 7–8 kl. moksleiviu tyrimo statistine ataskaita, Vilnius.
5. Cohen, David K. (2000). Instructional Policy and Classroom Performance: The Mathematics Reform in California. Teachers College Record; Balandis 2000, Vol.102, Nr.2, p.294.
6. Draper, Roni Jo (2002). School Mathematics reform, Constructivism and Literacy. A case for Literacy Instruction in the Reform-Oriented Math Classroom. Journal of Adolescent & Adult Literacy; Geguže 2002, Vol.45, Nr.6, p.520.
7. Dudaite, Jolita (2000). Pagrindines mokyklos matematikos egzaminu kaita Lietuvoje nuo 1919 iki 1999 metu, Unpublished Master thesis.
8. Dudaite, Jolita, Elijio, Aiste, Urbiene, Živile, Zabulionis, Algirdas (2004). Tarptautinis matematikos ir gamtos mokslu tyrimas TIMSS 2003. Ataskaita, Vilnius.
9. Dudaite, Jolita (Ed.) (2006). Tarptautinis matematikos ir gamtos mokslu tyrimas TIMSS 2003. Rezultatu analize. Matematika, VIII klase, Vilnius.
10. Edmonds Ron (1987). A discussion of the Literature and Issues Related to Effective Schooling. In Carlson, Robert, V., Ducharme, Erdward, R. (1987). School Improvement – Theory and Practice. A book of Readings, University Press of America, p.7-46.
11. Finnan, Christine, Schnepel, Katherine C., Anderson, Lorin W. (2003). Powerful Learning Enviroments: The Critical Link Between School and Classroom Cultures. Journal of Education for Students Places at Risk, Nr.8(4), p.391–418.

12. Frykholm, Jeffrey (2004). Teachers' Tolerance for Discomfort: Implications for Curricular Reform in Mathematics. Journal of Curriculum and Supervision, Žiema 2004, Vol.19, Nr.2, p.125–149.

13. Fullan, Michael (1998). Pokyciu jegos. Skverbimasis i reformos gelmes, Tyto alba, Vilnius.

14. Fullan, Michael (2003). Change Forces with a Vengeance, Routledge Falmer, Taylor & Francis Group, London and New York.

15. Gamoran, Adam (1997). Curriculum change as a Reform Strategy: Lessons from the United States and Scotland. Teachers College Record; Vasara 1997, Vol.98, Nr.4, p.608–620.

16. Gordon, Arnold, B. (2004). Symbolic Politics and Institutional Boundaries in Curriculum Reform: The Case of National Sectarian University. The Journal of Higher Education, Rugsejis/Spalis 2004, Vol.75, Nr.5.

17. Green, Robert, L. (1987). Tips on Educational Testing: What Teachers & Parents Should Know. Knygoje Carlson, Robert, V., Ducharme, Erdward, R. (1987). School Improvement – Theory and Practice. A book of Readings, University Press of America, p.475-488.

18. Grissmer, David and Flanagan, Ann (2001). Searching for Indirect Evidence for the Effects of Statewide Reforms. Knygoje Ravitch, Diane (2001). Education Policy, Brookings Institution Press, Washington D.C., p.181-230.

19. Hess, Frederick, M. Reform, Resistance, …Retreat? The Predictable Politics of Accountability in Virginia, in Ravitch, Diane (2002). Brookings Papers on Education Policy 2002, Brookings Institution Press, Washington, D. C.

20. Hill, Paul T., Harvey, James. A Fresh Assessment: Why Reform Initiatives Fail, www.brookings.edu.

21. Horne, Matthew (2001). Transformation not Reform. Education Review, Vol.15, p.87–91.

22. Kelly, Anthony, E., Lesh, Richard, A. (2000). Handbook of Research Design in Mathematics and Science Education, Lawrence Erlbaum Associates, Publishers, Mahwah, New Jersey.

23. Kinsler, Kimberly and Gamble, Mae (2001). Reforming Schools, Continuum, London and New York.

24. Krebs, Angela S. (2003). Middle Grades Students' Algebraic Understanding in a Reform Curriculum. School Science & Mathematics; geguže 2003 m., Vol.103, Nr.5, p. 233.

25. Kyriakides L. (1997). Primary Teachers' Perceptions of Policy for Curriculum Reform in Mathematics. Educational Research and Evaluation 1997 m., Vol.3, Nr.3, p.214–242.

26. Lietuvos Respublikos švietimo ir mokslo ministerija. Bendrojo išsilavinimo standartai. I –X klases. Projektas. 2, - Vilnius, 1997a.

27. Lietuvos Respublikos švietimo ir mokslo ministerija. Lietuvos bendrojo lavinimo mokyklos bendrosios programos. I – X klases, - Vilnius, 1997.

28. Lietuvos TSR švietimo ministerija. Vidurines bendrojo lavinimo mokyklos programos. Matematika V-XII kl., - Kaunas, 1988.

29. Mackeviciute, Aiste, Zabulionis, Algirdas (2001). Trecioji tarptautine matematikos ir gamtos mokslu studija – 1999. Matematika, Vilnius.

30. Mullis I. V. S., Martin M. O., Gonzalez E. J., Chrostowski S. J. (2004). TIMSS 2003 International Mathematics Report, Boston College.

31. Nicol, Cynthia, Tsai, Li-Ling, and Gaskell, Jim (2004). Students and Applied Academics: Learner Agency in a Changing Curriculum. Canadian Journal of Science, Mathematics and Technology Education.

32. Richardson, Green, Hammrich, Penny L., and Livingston, Beverly (2003). Improving Elementary School Girls' Attitudes, Perceptions, and Achievements in Science and Mathematics: Hindsights and New Visions of the Sisters in Science Program as an Equity Reform Model. Journal of Women and Minorities in Science and Engineering, Vol.9, p.333– 348.

33. Robitaille, D. F., McKnight, C. C., Schmidt, W. H., Britton, E. D., Raizen, S. A., Nicol, C. (1993). TIMSS monograph No.1. Curriculum frameworks for mathematics and science, Pacific Educational Press, Vancouver.

34. Rotberg, Iris C. (2000). What are We Doing to Our Schools? Education Week; Lapkritis 2000, Vol.20, Nr.9, p.44.

35. Sawada, Daiyo, Piburn, Michael D., Judson, Eugene, Turley, Jeff, Falconer, Kathleen, Benford, Russel, Bloom, Irene (2002). Measuring Reform Practices in Science and Mathematics Classrooms: The Reformed Teaching Observation Protocol. School Science & Mathematics; Spalis 2002 m., Vol.102, Nr.6, p.245.

36. TIMSS 1995, 1999, 2003 databases of Grade 8 students.

37. Trakas, Gediminas (1997). Testo informacija ir jos taikymai, www.leidykla.vu.lt.

38. Viadero, Debra (1996). Teen Culture Seen Impending School Reform. Education Week; 6/05/96, Vol.15, Nr.37, p.1

39. Zabulionis, Algirdas (1997a). A First Approach to Identifying Factors Affecting Achievement. In Vari, Peter (Ed.) (1997). Are we similar in math and science? A study of grade 8 in nine central and eastern European countries, IEA, p. 147-168.

40. Zabulionis, Algirdas (1997b). Student Achievement. In Vari, Peter (Ed.) (1997). Are we similar in math and science? A study of grade 8 in nine central and eastern European countries, IEA, p. 131-147.

41. Zabulionis, Algirdas (2001). Similarity of Mathematics and Science Achievement of Various Nations // Education Policy Analysis Archives, Volume 9, Number 33.

42. Želvys, Rimantas (1999). Švietimo vadyba ir kaita, Garnelis, Vilnius.

43. Zybartas, Saulius (1999). Matematikos mokymo lyginamoji analize Skandinavijos šaliu ir Lietuvos švietimo sistemose, Vilniaus pedagoginis universitetas, Doctoral Theses.