SOME INTERESTING ASPECTS OF TIMSS-99 ANALYSIS IN SLOVAKIA

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Abstract

In this paper I would like to highlight some interesting results of the national TIMSS analysis in Slovakia. Diametrical differences in the performance of 14-year-old students attending Basic versus Gymnasium schools called for separate analysis of these two school types. The analysis was produced using the statistic system SPSS and employing methods of univariate and multivariate analysis. We reveal a significant difference in achievement of students attending Basic schools and those attending Gymnasiums and also a difference in content areas according to the type of school. We also provide cluster analysis of the students according to the achievement in Math and Science. Differences between Basic schools and Gymnasiums are very important. Understanding these difference can help the Ministry of Education realize that both types of school have their specific role in educational system. Factor analysis reveals two factors – talents for math and science, which determined the performance of the students in TIMSS study. Further, we divide the students into four categories according to their talent for math and science and look for correlation of the parents', education with the categories. We show surprisingly high correlation between the school achievement in mathematics and in science. The results of our analysis may assist in the decision-making policy in Slovak National Institute for Education, which is under the direct control of Ministry of Education.

INTRODUCTION

The Slovak Republic was one of the 38 countries that took part in TIMSS 99 testing. In Slovakia the testing took place in 145 schools with 3497 students, and Slovakia's National Institute for Education (SPU) handled the study (SPU is supervised by The Ministry of Education). Slovak attendance in this international comparative study was financially supported by the IEA (World Bank) and by The Slovak Ministry of Education. The study was carried out under the supervision of the International

Association for the Evaluation of Education Achievement (IEA). Many thanks are due to IEA, International Study Center at Boston College, DPC Hamburg and Statistics Canada for supervising and supporting every area of the study.

Sample

It is very important to first explain the decision to analyze the two types of Slovak schools separately. In Slovakia most students attend Basic school. Basic school is a primary and lower secondary school with eight grades. Gymnasium is a secondary (lower-upper) school with eight grades. Exams in math and the Slovak language are required for entrance to the Gymnasium. The preliminary analysis showed that the differences in achievement at Basic schools and Gymnasium were pedagogically highly significant. The statistical analysis showed some unexpected deviation, teaching decision makers to the decision to analyze each type of school separately. At the age of TIMSS testing (14 years old), students in the Basic schools (Bas) were in the 8^{th} grade and those in Gymnasium (**Gym**) were in the 4^{th} grade.

In Slovakia the testing sample comprised **145** schools with 3497 students. The sample was composed of **115** Basic schools with 2632 students and **30** Gymnasium schools with 865 students.

Objectives

In this paper we would like to highlight some interesting aspects of a TIMSS-R 1999 secondary analysis we undertook in Slovakia.

The following questions were the focus of our investigation.

1) What is the difference in achievements in math and science between Bas and Gym students and respective schools?
2) Is there any correlation between math and science achievement? Is the correlation characteristic for both types of schools?
3) What are the outcomes of comparisons of the student achievement according to the content areas (with the accent on math)?
   a) What are the basic descriptive statistics?
   b) What content areas, show the biggest differences in achievement? Which are pedagogically significant according to the type of school?
   c) Content area relationships. What areas are close to each other?
4) Can we reduce the content areas into factors that can explain the results?
5) How can we divide all the students into groups (clusters) according to their achievements in content areas and the type of school?
   a) Could the education of the parents discriminate the students in the clusters?
   b) What are the educational aspirations of students in the different clusters?
   c) Which free time activities discriminate the students in the clusters?

ANALYSIS

For all analysis we use statistical system SPSS version 11.5.

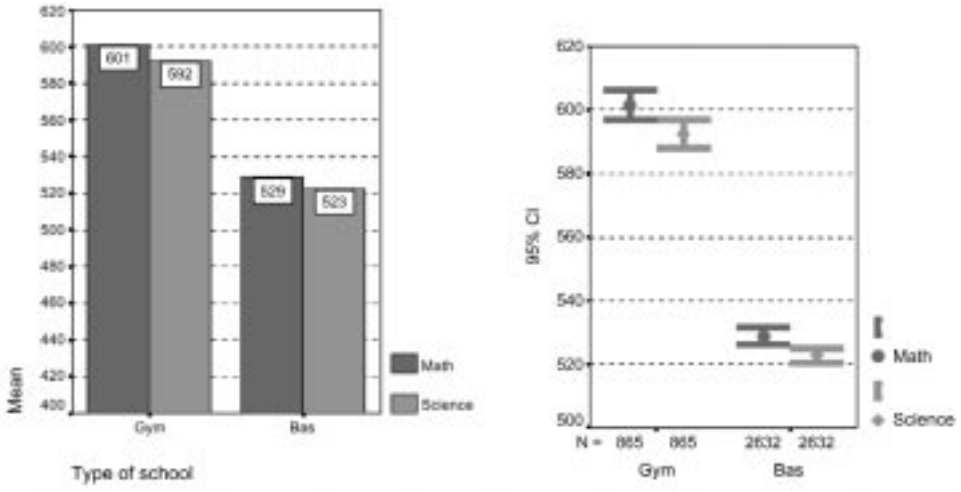
To answer the above questions, we used the following methods of univariate and multivariate analysis: Descriptive statistics; Pearson correlation, Scatter plot; Post Hoc Multiple Comparisons LSD criterion, Effect size (biserial coefficient of correlation), Multidimensional scaling; Factor analysis – Method of Principal Components; Two Step cluster analysis; and Crosstabs, Chi-square test, Cramer's V.

The outcomes of the analysis will be useful for the decision-making policy at The Slovak National Institute for Education and also for the Ministry of Education.

What is the difference in math and science achievements between Bas and Gym students and respective schools?

Basic school – Bas - is intended for students aged 6 to 15; Gymnasium –Gym - is a secondary school, attended by talented students aged 11 to 18. In the Slovak Republic 3497, 14-year-old students, were tested, specifically, 2632 students in the 8th grade of the Basic School and 865 in 4th grade of Gymnasium.

Figure 1: Achievement at Gymnasium and Basic school. 95 % Confidence interval of mean



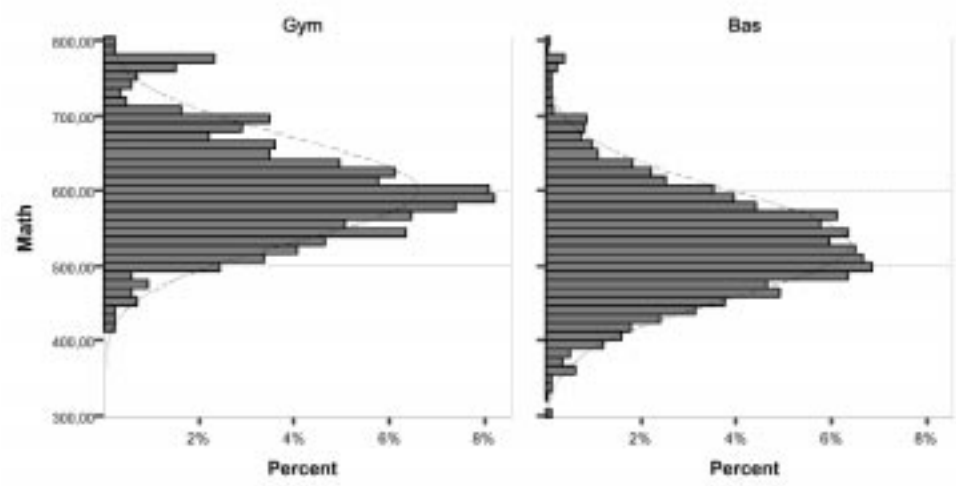
Achievements: **Math** **Gym** - M=601, SE=2.37, **Bas** – M=529 SE=1.40

Science **Gym** - M=592 SE= 2.25, **Bas** – M=523 SE=1.26

Students of Gym schools performed in the TIMSS testing significantly better than the students of Bas schools.

(Values of correlation measure of effect size or pedagogical significance are 0.40 and 0.42)

Figure 2: Histograms of student achievement at Gymnasium and Basic school



Is there any correlation between math and science achievement? Is the correlation characteristic for both types of schools?

In Slovakia, a representative sample of 115 Basic schools and 30 Gymnasiums was used for TIMSS-R testing.

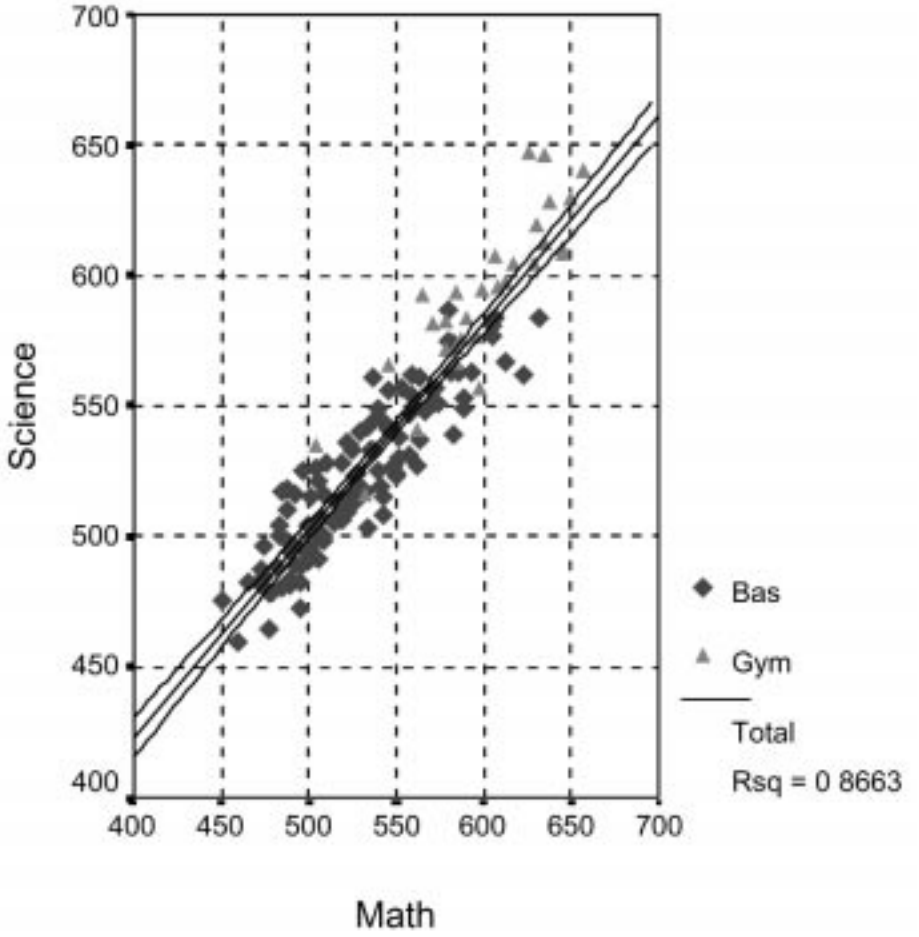
When we analyzed the achievement of all 145 schools we found that the determination coefficient was equal to 86%; for Gym schools 76% and for Bas 81%. This clearly indicates that schools with good results in math will have also good results in science and vice versa. This finding is very interesting, because it is a common characteristic of both types of school.

Correlations

School Type		*Math*	*Science*
		Pearson Correlation	*Pearson Correlation*
Gym	Math	1	,869**
	Science	,869**	1
Bas	Math	1	,897**
	Science	,897**	1

** Correlation is significant at the 0.01 level (2-tailed).

Figure 3: Correlation between the school achievement in mathematics and in sciences



This correlation is very interesting for educators, as it justifies the opinion that math and science support each other. Moreover a school's math or science achievement could be considered to characterize the education level of school.

We also analyze the correlation between math and science at individual student level. The coefficient of determination is not as high, because of the large number of students (3497/145) and larger variance. It is 46% at Bas schools and 29% at Gym school.

These results support the hypothesis that at the Bas schools excellent students are excellent both in math and science, and at the Gym schools it is more characteristic that students are specialized either in math or in science.

What are the outcomes of comparisons of student achievement according to the content areas (with the accent on math)?

Table 1: Bas and Gym means according to content areas

Basic school Descriptive Statistics		
	Mean	*Std. Deviation*
Algebra	527	75
Fractions	524	83
Measure	541	75
Data Rep.	522	83
Geometry	529	74
Chemistry	528	86
Life Sc.	536	76
Earth Sc.	537	80
Physics	515	80
Environ.	513	86
Sc. Inquiry	507	82

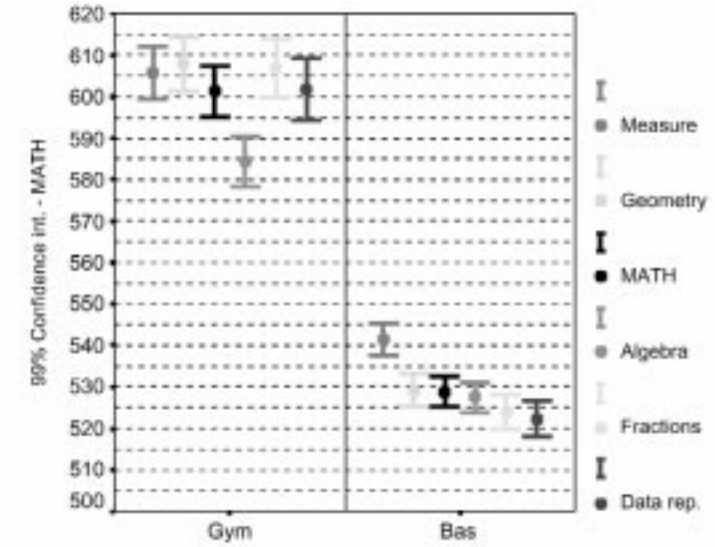
a. Type of school = Bas

Gym Descriptive statistics		
	Mean	*Std. Deviation*
Algebra	584	70
Fractions	607	82
Measure	606	72
Data Rep.	602	85
Geometry	608	74
Chemistry	609	80
Life Sc.	617	83
Earth Sc.	606	85
Physics	587	85
Environ.	584	73
Sc. Inquiry	553	70

a. Type of school = Gym

What content areas show the biggest differences in achievement? Which are pedagogically significant according to the type of school?

Figure 4. 99% Confidence Int. for MATH areas in Gymnasium and Basic schools



We can propose the hypothesis that at the Basic schools there is greater accent on mechanical skills, e.g., Measurement; whereas at Gymnasium the emphasis is on creative work, e.g., Geometry and Fractions, and Algebra is less important.

Figure 5: 99% Confidence Int. for SCIENCE areas in Gymnasium and Basic schools

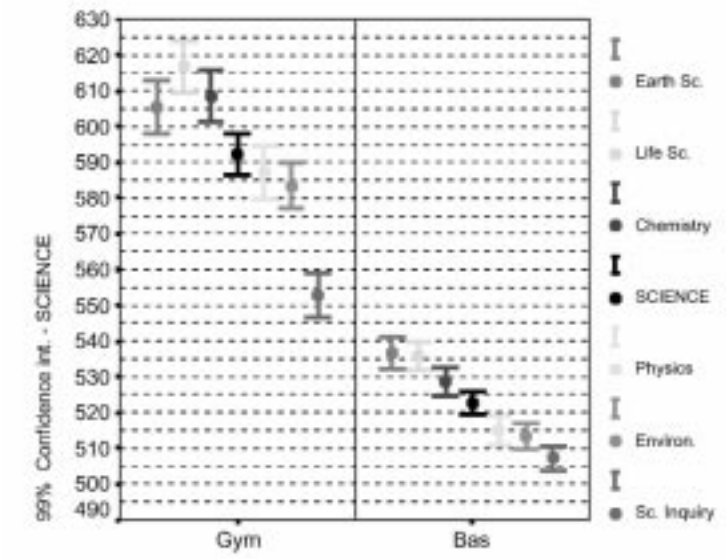
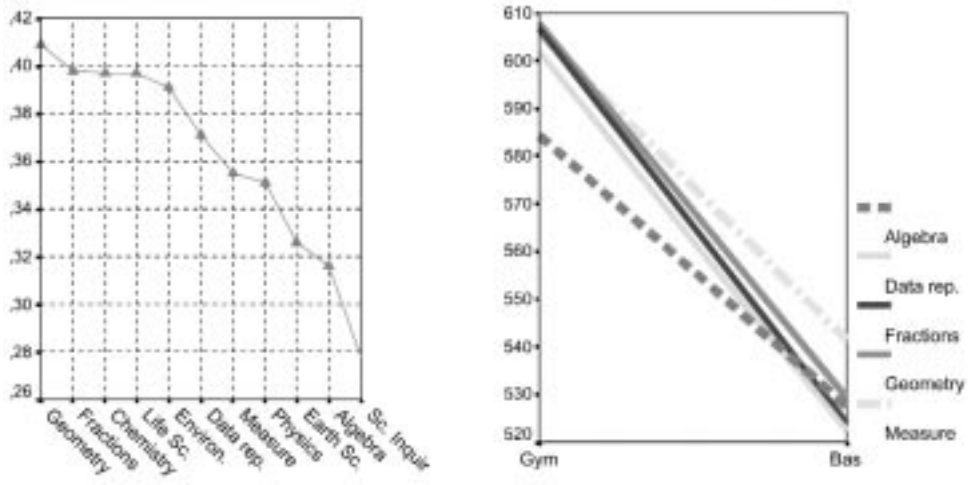


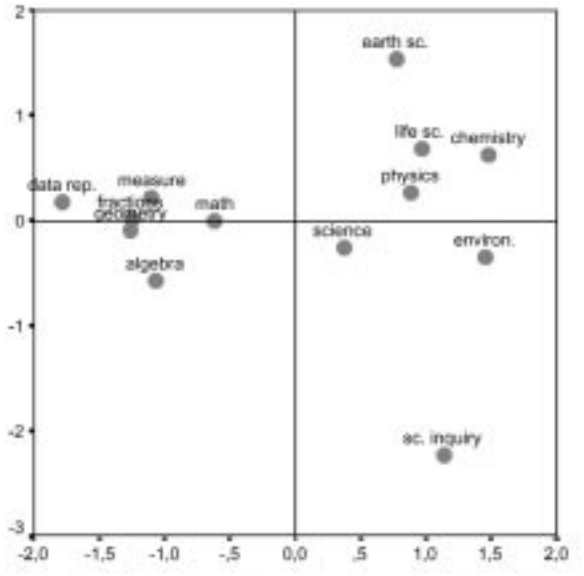
Figure 6: Pedagogical significance of the differences between the content areas at Gym and Bas type of school.



We can see from Figure 6 that the most significant content differences between the Bas and Gymnazium are in the areas of Geometry, Fractions, Chemistry and Life Science. Earth Science, Algebra and Scientific Inquiry do not differentiate between types of school.

Which content areas appear to be related?

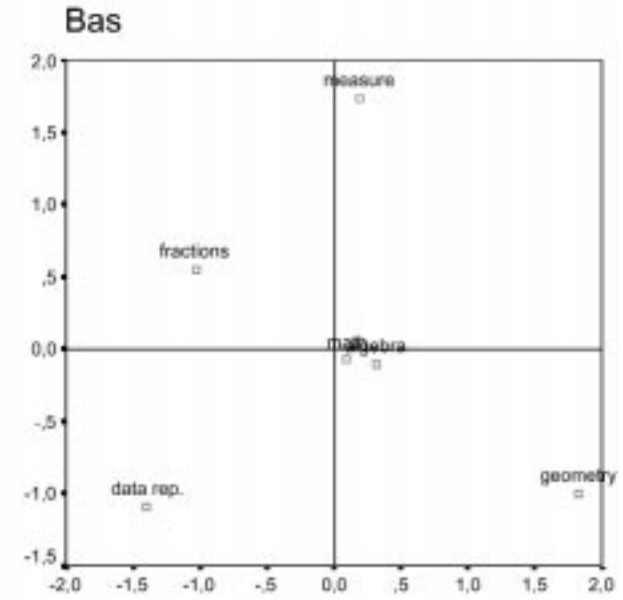
Figure 7. Correspondence map for all content areas



Using multidimensional scaling we analyzed the content areas (Figure 7).

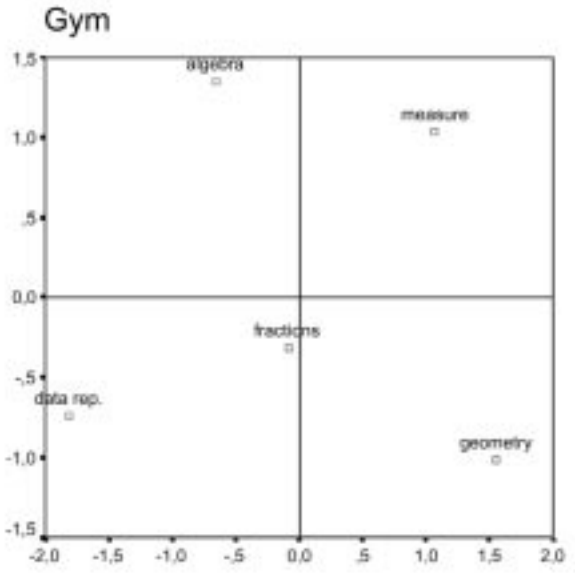
As expected, math areas formed one "cloud", but it was surprising to find Sc. Inquiry so unrelated to other scientific areas.

Figure 8. Correspondence map for math areas at Bas schools



At the Basic schools Algebra has the central position among the math content areas, while at Gymnazium, Fractions and Number sense has the central position among the math content areas.

Figure 9. Correspondence map for math areas at Gym schools



We then reduced the content areas into two factors using Principal Components Factor analysis to examine for content correlations.

Table 2: Correlation between Math content areas and Math achievement

School type		*Algebra*	*Data rep.*	*Fractions*	*Geometry*	*Measure*
Gym	Algebra	1	,800	,848	,761	,785
	Data rep.	,800	1	,815	,741	,756
	Fractions	,848	,815	1	,789	,842
	Geometry	,761	,741	,789	1	,732
	Measure	,785	,756	,842	,732	1
	MATH	,918	,909	,944	,881	,901
Bas	Algebra	1	,805	,844	,763	,815
	Data rep.	,805	1	,824	,728	,793
	Fractions	,844	,824	1	,791	,852
	Geometry	,763	,728	,791	1	,734
	Measure	,815	,793	,852	,734	1
	MATH	,923	,912	,944	,877	,815

In both types of schools, the content areas Fractions and Numbers and Algebra are most closely related with the achievement in Math (see Tables 2 and 3).

Table 3: Rotated Component Matrices at Basic school and Gymnasium

Basic school Rotated Component Matrix		
	Component	
	1	*2*
Algebra	,875	,303
Fractions	,868	,367
Measure	,849	,347
Data Rep.	,844	,334
Geometry	,810	,330
Chemistry	,264	,828
Life Sc.	,364	,826
Earth Sc.	,366	,767
Physics	,432	,754
Environ.	,240	,797
Sc. Inquiry	,249	,617

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 3 iterations.
b. Type of school = Bas

Gym Rotated Component Matrix		
	Component	
	1	*2*
Algebra	,905	,185
Fractions	,893	,302
Measure	,853	,288
Data Rep.	,870	,240
Geometry	,840	,256
Chemistry	,179	,861
Life Sc.	,244	,876
Earth Sc.	,295	,800
Physics	,368	,786
Environ.	,156	,812
Sc. Inquiry	,202	,619

Extraction Method: Principal Component Analysis
Rotation Method: Varimax with Kaiser Normalization
a. Rotation converged in 3 iterations.
b. Type of school = Gym

Using factor analysis with Principal Component Analysis extraction and Varimax rotation produced some interesting results. Two factors appear to exert significant influence on performance; in fact, these two factors can explain 76% of the performance of the students. The first factor we called "talent for mathematics" (explanatory power 39%). It is mainly absorbed in mathematics content areas. The second factor we called "talent for science" (explanatory power 37%). It is mainly absorbed in science content areas.

We can observe from Table 3 that at Gymnasium the factors divide the content areas more clearly. This result highlights the already mentioned tendency of students to specialize in either math or science. In contrast, students at the Basic schools tend to be generally good in all content areas.

How can we divide the students into groups (clusters) according to their achievement in content areas and type of school?

To analyse students according to their achievement in math and science content areas, we used Two-step Cluster analysis, method Centroid, square Euclidian Measure. As a result, students from each type of school were divided into two clusters, producing four clusters: Gym+, Gym-, Bas+, Bas-.

Table 4: Cluster frequency

School Type		*Frequency*	*Percent*	*Valid Percent*
Gym	Gym–	477	55,1	55,1
	Gym +	388	44,9	44,9
	Total	865	100,0	100,0
Bas	Bas –	1389	52,8	52,8
	Bas +	1243	47,2	47,2
	Total	2632	100,0	100,0

Table 5: MATH - Descriptives of the clusters

School Type		*N*	*Mean*	*Std Deviation*	*Std. Error*	*95% Confidence Interval for Mean*	
						Lower Bound	*Upper Bound*
Gym	Gym–	477	558	44	2	554	562
	Gym +	388	655	58	3	649	660
	Total	865	601	70	2	597	606
Bas	Bas –	1389	480	46	1	478	483
	Bas +	1243	583	55	2	580	586
	Total	2632	529	72	1	526	532

Table 6: SCIENCE - Descriptive of the clusters

School Type		*N*	*Mean*	*Std. Deviation*	*Std. Error*	*95% Confidence Interval for Mean*	
						Lower Bound	*Upper Bound*
Gym	Gym–	477	549	45	2	545	553
	Gym +	388	645	47	2	641	650
	Total	865	592	66	2	588	597
Bas	Bas –	1389	477	43	1	475	480
	Bas +	1243	573	45	1	571	576
	Total	2632	523	65	1	520	525

There are significant differences in student achievement both in Math and in Science between each pair of cluster. Students at each type of school are divided into two groups: one with lower performance (-sign) and one with higher performance (+sign).

Figure 10: Means of math and science in clusters

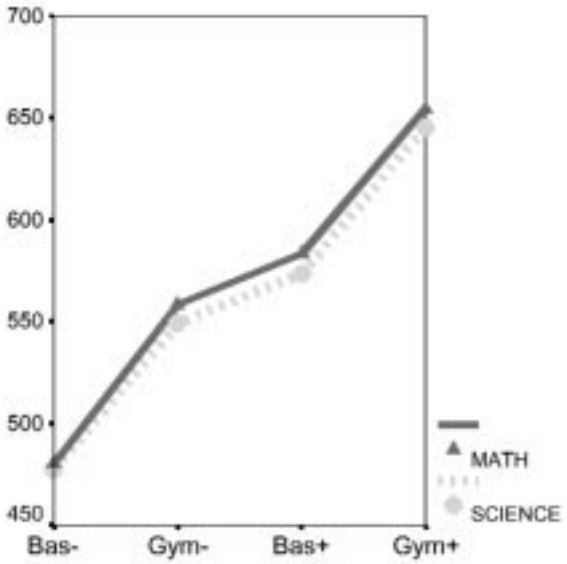
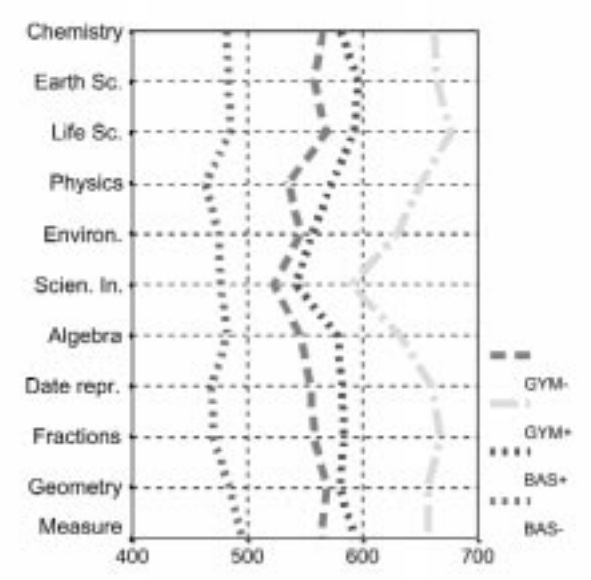


Figure 11: Performance of the students in the clusters at Gymnasium and Basic schools



The first group we called **Gym+**; these students attend Gymnasium and are the best students according to the TIMSS testing. They performed in all mathematics and science areas excellently. The second group of students attends Basic schools and we called them **Bas+**. They performed excellently at Basic school, but lower than Gym+. The third group of students we called **Gym-**. They performed lower than Bas+.

The fourth group of students we called **Bas-**. They are from the Basic schools and their performance is the lowest of all.

Differences between Basic schools and Gymnasium are very important. They help the Ministry of Education realize that both types of school have their specific role in the educational system.

Table 7: Cross tabulation – Clusters and some questions from students questionnaire

		CLUSTER			
		Bas-	Gym-	Bas+	Gym+
		Row %	Row %	Row %	Row %
MAX EDU OF PARENTS	primary	65,4%	3,0%	27,8%	3,7%
	secondary	35,0%	21,4%	30,7%	12,9%
	university	9,2%	30,7%	19,0%	41,1%
GEN\HIGHEST EDUC LEVEL\SELF	<some secondary sc>	90,5%	,0%	9,5%	,0%
	<finish secondary sc>	63,4%	6,4%	29,1%	1,1%
	<some vocational education>	40,4%	14,7%	41,6%	3,4%
	<some university>	20,9%	28,9%	34,5%	15,8%
	<finish university>	11,5%	31,1%	22,6%	34,8%
GEN\OUTSIDE SCHL\PLAY COMPUTER GAMES	no time	31,1%	22,9%	24,9%	21,1%
	less than 1 hour	17,3%	31,0%	21,9%	29,8%
	1-2 hours	15,6%	24,8%	26,9%	32,7%
	3-5 hours	21,6%	25,5%	29,8%	23,1%
	more than 5 hours	23,5%	21,7%	35,7%	19,1%
GEN\OUTSIDE SCHL\PLAY WITH FRIENDS	no time	17,8%	31,5%	21,7%	29,0%
	less than 1 hour	19,7%	24,7%	20,6%	34,9%
	1-2 hours	19,3%	27,8%	24,4%	28,5%
	3-5 hours	30,8%	22,8%	30,1%	16,3%
	more than 5 hours	45,2%	20,3%	24,7%	9,7%
GEN\OUTSIDE SCHL\DOING JOBS AT HOME	no time	18,2%	30,3%	18,0%	33,5%
	less than 1 hour	17,3%	27,2%	23,4%	32,2%
	1-2 hours	28,3%	23,8%	27,2%	20,6%
	3-5 hours	41,2%	21,4%	28,6%	8,8%
	more than 5 hours	63,5%	15,1%	14,5%	7,0%
MAT\OUTSIDE SCHL\STUDYING MATH	no time	15,4%	23,6%	18,3%	42,7%
	less than 1 hour	22,9%	24,3%	26,4%	26,3%
	1-2 hours	34,9%	28,2%	22,9%	14,0%
	3-5 hours	40,3%	42,0%	17,7%	,0%
	more than 5 hours	86,2%	,0%	13,8%	,0%

In subsequent tables we use sign schemes for the presentation. The sign scheme uses the table of adjusted residuals and replaces the values in following way:

Abs (z)≥3,29 then +++ respective – – – .p≤0.001.

Abs (z)≥2,58 then ++ respective – –. p≤0.01.

Abs (z)≥1,96 then + respective –. p≤0.05.

Table 8: Urban CLUSTER Crosstabulation*

			CLUSTER				
			Bas –	*Gym –*	*Bas +*	*Gym +*	*Total*
Count	Urban	City	794	456	850	386	2486
		Country	595	21	393	2	1011
	Total		1389	477	1243	388	3497
Adjusted Residual	Urban	City	–14,7	12,7	–2,6	13,1	
		Country	14,7	–12,7	2,6	–13,1	
Adjusted Residual	Urban	City	– – –	+ + +	– –	+ + +	
Sign Scheme		Country	+ + +	– – –	+ +	– – –	

*Table 9: Cluster * Max Edu of Parents*

Adjusted Residual

		MAX EDU OF PARENTS		
		primary	*secondary*	*university*
CLUSTER	Bas –	+ + +	+ + +	– – –
	Gym –	– – –	– – –	+ + +
	Bas +	o	o	o
	Gym +	– –	– –	+ + +

Chi- square (6)= 513 sig.=0.000 Cramer's V = 0.39

We then tested to see if the education of the parents would discriminate students in the clusters.

We observe from Tables 7 and 9 that students at Gym schools (Clusters Gym+, Gym–) have at least one parent with university education. The parents of students at Bas schools (Clusters Bas+, Bas-) have mostly secondary and lower education. A highly significant percentage of parents of students from cluster Bas- did not reach university.

*Table 10: Cluster * Gen/Highest Educ Level/Self*
Adjusted Residual

		GEN/HIGHEST EDUC LEVEL/SELF				
		<some secondary sc>	*<finish secondary sc>*	*<some vocational education>*	*<some university>*	*<finish university>*
CLUSTER	Bas –	+ + +	+ + +	+ + +	o	– – –
	Gym –	–	– – –	– – –	o	+ + +
	Bas +	– – –	– – –	+ +	o	+ + +
	Gym +	–	– – –	– – –	o	+ + +

Chi- square (12)= 785 sig.=0.000 Cramer's V = 0.49

Next, we looked at the educational aspirations of students from the different clusters:

The aspiration of the students clearly differs among the clusters, as we can observe in Tables 7 and 10. The students from the Bas- cluster (lowest performance in TIMSS testing) aspire to finish some kind of secondary education. It is very interesting that all students at Gym schools aspire to finish university, as their parents did. When we compare the parent education – Table 9 - and student aspirations we find that there is a significant parallel between the parents' education and child's educational aspirations.

Considering the questions on the student questionnaire that refer to outside school free time activities, we find some which discriminate the students in the clusters.

The following activities do not discriminate students in the clusters: Have extra lessons in Math, Have extra lessons in Science, Club participation, Work at paid job, Watch TV or videos, Playing sports, Reading a book (Table 11).

*Table 11: Cluster * Gen/Outside SCHL/Reading a book*
Adjusted Residual

		GEN/OUTSIDE SCHL/READING A BOOK				
		no time	*less than 1 hour*	*1-2 hours*	*3-5 hours*	*more than 5 hours*
CLUSTER	Bas –	o	o	o	–	o
	Gym –	o	o	o	o	o
	Bas +	o	o	o	o	o
	Gym +	o	o	o	–	–

Chi- square (12)= 21 sig.=0.052 Cramer's V = 0.05

Reading a book, as a free time activity, does not show any significant difference among the clusters. On the other hand following activities do discriminate students in the clusters: Studying Math - Table 12, Doing Jobs at home – Table 13, Play with friends – Table 14, Play computer games – Table 15.

*Table 12: Cluster * Mat/Outside SCHL/Studying Math*
Adjusted Residual

		*CLUSTER * MAT/OUTSIDE SCHL/STUDYING MATH*				
		no time	*less than 1 hour*	*1-2 hours*	*3-5 hours*	*more than 5 hours*
CLUSTER	Bas –	– – –	– – –	+ + +	+ +	+ +
	Gym –	o	o	o	o	o
	Bas +	o	+ + +	– – –	o	o
	Gym +	+ + +	o	– – –	– –	o

Chi- square (12)= 121 sig.=0.000 Cramer's V = 0.16

It is interesting to note that the students with the lowest performance from cluster Bas- have the impression of studying math for hours. In contrast, the clever students from cluster Gym+ state that they spend no time studying math. Table 12 shows indirect correspondence between performance and free time devoted to studying math.

*Table 13: Cluster * Gen/Outside SCHL/Doing Jobs at Home*
Adjusted Residual

		*CLUSTER * GEN/OUTSIDE SCHL/DOING JOBS AT HOME*				
		no time	*less than 1 hour*	*1-2 hours*	*3-5 hours*	*more than 5 hours*
CLUSTER	Bas –	o	– – –	+ +	+ + +	+ + +
	Gym –	o	+ + +	–	–	–
	Bas +	o	o	o	o	– – –
	Gym +	+	+ + +	– – –	– – –	– – –

Chi- square (12)= 210 sig.=0.000 Cramer's V = 0.23

Table 13, like Table 12, shows indirect correspondence between doing jobs at home and achievement cluster. Spending more time doing jobs at home lowers results in testing.

Table 14. Cluster Gen/Outside SCH/Friends
Adjusted Residual

		GEN/OUTSIDE SCHL/PLAY WITH FRIENDS				
		no time	*less than 1 hour*	*1-2 hours*	*3-5 hours*	*more than 5 hours*
CLUSTER	Bas –	o	– –	– – –	+ + +	+ + +
	Gym –	o	o	+ +	– –	– –
	Bas +	o	–	o	+	– –
	Gym +	o	+ + +	+ +	– – –	– – –

Chi- square (12)= 166 sig.=0.000 Cramer's V = 0.19

Table 14 (as in Tables 13,12) shows indirect correspondence between playing with friends and achievement cluster. More time spent playing with friends correlates to lower results in testing.

*Table 15: Cluster * Gen/Outside SCHL/Play Computer Games*
Adjusted Residual

		GEN/OUTSIDE SCHL/PLAY COMPUTER GAMES				
		no time	less than 1 hour	1-2 hours	3-5 hours	more than 5 hours
CLUSTER	Bas –	+ + +	– – –	– – –	o	o
	Gym –	– – –	+ + +	o	o	o
	Bas +	– –	o	+ + +	o	o
	Gym +	– – –	+ + +	+ + +	o	o

Chi- square (12)= 125 sig.=0.000 Cramer's V = 0.16

Table 15 shows almost direct correlation between playing computer games and achievement cluster. More time spent playing computer games (up to two hours) correlates with higher results in testing.

We examine previous tables along with Table 8, and see that most Gym schools are located in cities and Bas schools are mainly in the country. Our hypothesis is that the students from cluster Bas- live mainly in the country, where they have to help with housework, have time to play with friends, math seems very difficult, and they usually have no computer. But this hypothesis needs investigation and further research in relation to other questions in the questionnaire.

CONCLUSIONS

In our investigation of the questions we set to address, we can report the following findings:

- There are pedagogically highly significant differences in achievement between Bas and Gym students and their respective schools.
- There is high correlation between the achievement in math and science, especially in relation to the school (determination coefficient varies from 76% to 81%). This close correlation is characteristic for both types of schools.
- The highest pedagogically significant differences between the Basic and the Gym schools are in the areas of Geometry, Fractions, Chemistry and Life Science. Earth Science, Algebra and Scientific Inquiry do not differentiate between types of school. In Basic schools Algebra has the central position among the math content areas; for Gymnazium, Fractions and Number sense has the central position among the math content areas.
- Two factors can explain 76% of the performance of the students. The first factor we called "talent for mathematics". It is mainly absorbed in mathematics content areas. The second factor we called "talent for science". It is mainly absorbed in science content areas.
- The students can be grouped into four clusters, two clusters in each type of school. The students in each cluster are homogenous. In every area they perform either better or worse than the students in the other cluster at each type of school. Parental education and the aspirations of their children discriminate students in the clusters. Some free time activities – Doing jobs at home, Play with friends, Play with Computer, Studying Math - also discriminate students in the clusters.

Our finding that there exist significant differences in achievements at Basic schools and Gymnasiums are very important for the decision-makers at The Ministry of Education, especially in relation to the question of cutting funding account for the Gymnasium type of school. Our results also provide arguments for the governmental support of education. For educators the relations between the math and science areas are very important. Our analysis of the different backgrounds and behavior of the students in the clusters offers avenues for future research.

This study can serve as an important base for further analysis and comparisons. In larger perspective, it will be very useful to case this analysis when considering the trends in achievement from 1995, through 1999 to 2003.