

## MEASURING COMPUTER SCIENCE KNOWLEDGE LEVEL OF HUNGARIAN STUDENTS SPECIALIZED IN INFORMATICS WITH ROMANIAN STUDENTS ATTENDING A SCIENCE COURSE OR A MATHEMATICS-INFORMATICS COURSE

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### ABSTRACT

An analysis of Information Technology knowledge of Hungarian and Romanian students was made with the help of a self developed web based Informatics Test. The goal of this research is an analysis of the Computer Science knowledge level of Hungarian and Romanian students attending a Science course or a Mathematics-Informatics course. Analysed was how effectively can students from different grades answer questions dealing with different subjects. After having evaluated the test results correctness of the original presumption emerged. Significance level was 5% through the analysis. It was found significant divergence in knowledge of Hungarian students and Romanian students attending a science course (Profil Real) and a Mathematics-Informatics course. Romanian students attending a science course and a Mathematics-Informatics course scored higher in programming than their Hungarian counterparts specialized in Informatics in the 11<sup>th</sup> grade. After the calculating values of the partial correlation we have got same results by subjects too.

After the evaluation a final conclusion can be made: Romanian students of the Real Profile have the same or more practice in programming than Hungarian students specialized in Informatics, though the latter have the same or higher Computer Science knowledge level. Unfortunately, Hungarian teachers concentrate on word processing and spreadsheet calculation and teach programming just for the students specialized in Informatics, although algorithm thinking would be important for every student before finishing secondary school.

Keywords - measuring, information technology, knowledge, level, hungarian, romanian, students

### I. INTRODUCTION

Some research was done comparing the Schoolsystems (Döbert et al, 2002) and the role of Information and Communication Technology in the education of some European countries (Hüsing and Korte, 2006; Dagienè and Mittermeier, 2006; SFIB, 2004).

We can see all students have different level of computer usage abilities by same Information Technology Education in a country (Isman, Celikli, 2009) and we can find more differentiation by countries.

The goal of this research is an analysis of the IT skills and programming knowledge of Hungarian and Romanian students attending a Science course or a Mathematics-Informatics course.

The National Basic Curriculum of Hungary describes the curriculum grade by grade, subject by subject to teachers.

Information Technology education in Romania bears a close resemblance to the one in Hungary from the point of view of the material discussed. Theoretical knowledge, word processing, spreadsheet calculation, database management and programming are parts of the curriculum in both countries.

Though topics are the same but the number of CS classes are different. This research is analysing whether differences in the IT skills of students depend on the number classes they are taught in or not.

In order to be able to compare the students' IT skills in the different countries a detailed analysis was needed. Various curriculums in the different grades had to be checked, as well as the number of weekly Informatics classes and whether Informatics was a compulsory or an optional subject. Still, this is not enough to carry out the examination. Further, the students' knowledge had to be checked in various grades of the different countries. To be able to make comparisons between these students, a uniform questionnaire had to be devised in which questions regarding the different subject matters of Information Technology had to be asked. Only after having sent out these questionnaires to students of the different countries could the survey be carried out on the basis of their answers.

First, let us have a look at how many Informatics classes are held in the respective countries (Table I). Information Technology is only an elective course in the last two years of the secondary school in Hungary.

TABLE I. Number of Information Technology Classes in Different Grades

Country	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.
Hungary	1	1	1	1	2	2	2	2	2	2	3*	3*
Romania	0	0	0	0	0/1	0/1	0/1	0/1	1-2; 3-4; 6-7**	1-2; 3-4; 6-7**	1-2; 3-4; 6-7**	1-2; 3-4; 6-7**

\* selectable

\*\* depends on specialization

In Romanian schools the bulk of students get their first experience in Information Technology in the 9<sup>th</sup> grade. It also happens that students' study Informatics in one class a week for one or two years in the 5<sup>th</sup>-8<sup>th</sup> grades of certain schools, but this is rare and the curriculum also depends on the teacher to a great extent.

In Hungary students start to learn Information Technology earlier, so my starting hypothesis' were based on this knowledge before making a comparison.

The first starting hypothesis was that Hungarian students specialized in Informatics have higher Computer Science literacy and programming knowledge than Romanian counterparts attending a science course.

The second starting hypothesis was that Hungarian students specialized in Informatics have the same Computer Science literacy and programming knowledge as Romanian students specialized in Mathematics-Informatics because they spend more time on this subject.

## II. INFORMATION TECHNOLOGY EDUCATION IN HUNGARY

IT education is based on a national curriculum in Hungary (Ministry, E. H, 2003). According to the National Basic Curriculum (NBC) of Hungary the use of IT is to be demonstrated in the first four school grades since 2003 (e.g. search on the Internet, painting with computers etc.) and is taught in 1 class weekly. According to the Information Technology curriculum the following subjects are taught from the 5<sup>th</sup> grade to the 12<sup>th</sup> grade at the schools of Hungary in 2 classes weekly:

- Word processing
- Spreadsheet calculation
- Presentation
- Algorithm and programming
- Database management

Generally the Microsoft Office packet is taught and it can be seen that teaching Word processing takes 4 years in Hungary (Table II.). Basic algorithms or rather programming appears in Information Technology sooner, but recursion, list and tree data structures are only selectable part of the curriculum. Database management begins in the 9<sup>th</sup> grade. In grades 11-12 CS is just selectable. At basic level it is taught 2 hours weekly, on a higher level 3 hours weekly and a final exam can be taken.

TABLE II. The subjects of CS by grades in Hungary

Subject	Grade							
	5.	6.	7.	8.	9.	10.	11.	12.
Word processing		✓	✓	✓	✓			
Spreadsheet calculation				✓	✓			
Presentation						✓		
Algorithm and programming			✓	✓	✓			
Database management					✓			

## III. INFORMATION TECHNOLOGY EDUCATION IN ROMANIA

The Romanian school system differs from the Hungarian one since the students take a country-wide ability test at the end of the 8<sup>th</sup> grade (Eurydice, 2008). Admittance into the secondary school they have opted is based on their scores. Those who would like enroll into a Mathematics-Informatics course of the chosen secondary school have to score higher in this country-wide test. In Romanian schools the bulk of the students have their first experience in Information Technology in the 9<sup>th</sup> grade. It also happens that students study Informatics in one class a week for

one or two years in the 5<sup>th</sup>-8<sup>th</sup> grades in certain schools, but this is rare and the curriculum depends heavily on the teacher.

Syllabuses usually involve simply the use of Office tools. Algorithms and database management are not taught. It is a nation-wide phenomenon that Information Technology is taught from the 9<sup>th</sup> grade in Romania but the curriculum prescribes the subject matters covered and also determines the weekly number of Informatics classes. If admitted to a social science course, there are one or two Informatics classes a week in the first two years of secondary school education. Students in the 9<sup>th</sup> grade are taught managing the operating system, word processing, e-mailing, using the Internet and preparing a simple homepage. Students in the 10<sup>th</sup> grade learn preparing presentations, spreadsheet calculation and database management so programming is still not mentioned.

Those who are admitted to a natural sciences course are taught Information Technology in 3-4 classes a week in secondary school; this number can be raised to 6-7 classes a week if you study in a Mathematics-Informatics course and have chosen to learn Informatics intensively.

Students admitted to a natural sciences course learn word processing, spreadsheet calculation and preparing presentations at a similar pace as students of social sciences courses but the higher weekly number of classes allows to deal with some other topics as well. The main task is to get to know the basic algorithms and the use of one-dimensional arrays in the 9<sup>th</sup> grade. To find and arrange various algorithms are parts of the curriculum in the 10<sup>th</sup> grade. Students in the 11<sup>th</sup> grade get acquainted with two-dimensional arrays, functions, procedures, stacks, lists, row data structures, binary trees and backtracking algorithms. In the 12<sup>th</sup> grade the focus is put on database management: preparation of databases, tables, relations, reports, queries and forms (Ministerul, E., 2009).

#### IV. COMPARISON TOOLS

It is possible to compare the Hungarian and Romanian Information Technology education examining the students' knowledge. Since it is quite difficult to send out questionnaires physically to the various schools and the order of the questions can not be changed in that case, and also because students sitting close to each other in the classroom can see the other's answers, so the most effective solution seemed to be a web-based Informatics test.

Some research was done making test to standardize the IT education in Switzerland (Bucher and Wirthensohn, 2004) and Austria (Micheuz, 2005).

Questions of various difficulties were formed in the main topics of Information Technology. The topics chosen were part of Informatics education in almost every country: theoretical knowledge, word processing, spreadsheet calculation, database management and programming. There can be significant deviations in the curricula of some countries; therefore the test was expanded with questions on cryptographical knowledge as well as formal languages and automats since in certain German provinces these are also part of the Information Technology curriculum (note: the test is appropriate to compare the IT education of other countries too.) (Kiss, 2008).

The database structure for the test had to be planned in a suitable way so that the data could be obtained later on. The personal data of the students filling in the test were put in a separate table as well as their answers to the questions. When filling in the test the students first had to give their actual grade and some other data. If students gave the username of their teacher then the teacher also could see how they succeeded and would get a feedback on their progress. *Grade* was important because he/she would get a question sheet depending on the grade given. Students could mark topics not taught to them (except basic information technology and office packages). If they marked one, the system would not ask questions dealing with the topic but saved it with the answer „I have never learned that”. With this option students got fewer questions and answers would flow in at a quicker pace. Next, students could begin to fill in the test.

Every test question has 6 possible answers, only one of which is correct, 3 of them bad, and the 5th choice is: „I have never learned that”, the 6th: „I have forgotten it”. The answers „I have never learned that” and „I have forgotten it” show which part of the curriculum the students have not learned in that grade and if they could remember it or not. Every question has two time limits given in seconds. The first is the minimum time to read, understand and answer the question, the second is the maximum answering time. The software saves the total time used by the student. These time limits are not seen or known by the students. These are used during the evaluation so a correct answer is accepted only if it arrives in the available time interval. Teachers can register on this site too if they are willing to give some of their data. The system is protected by registration code, and registered teachers can log in with their username and password. If a student filling in the test gives the username of the teacher too than the teacher can later see his/her answers and the results. Some reports can be generated

helping the work of the teacher. It is recorded whether the students have given them the right to inspect. It is also indicated if they have marked a question as not learned or if the topic of the question is familiar to them but they have forgotten the right answer.

The evaluation of the answers is only possible after processing the saved data. The first step is to check whether the students of the given country have learned the given topic. If they have not, the comparison with the data of the students of other countries is impossible to make.

If the students knew the topic because they had learned it, it had to be checked if the time spent answering the questions was within the limits given. If so, the answer could be accepted as right.

The mean and the standard deviation of the right answers had to be calculated in the various grades and countries and make comparisons with the help of statistical means. In order to be able to do this, enough students filling in the test were needed in each grade. When comparing the IT skills of students in two countries, the Independent Samples T-test was taken.

#### V. NUMBER OF PARTICIPIANTS

The knowledge of the Hungarian students specialized in Information Technology and that of the Romanian students attending a science course and a Mathematics- Informatics course are worth comparing only in the last two years of secondary school because the number of students filling in the test reaches the required amount there (Table III.).

TABLE III. The number of participants per grades and countries

Grades	Hungarian	Romanian	
	Informatics course	sciences course	Mathematics-Informatics course
5	0	0	0
6	0	0	0
7	0	0	0
8	0	0	0
9	0	0	0
10	0	0	0
11	69	94	212
12	91	87	158

After the examination it turns out what knowledge the students can acquire in the intensive Informatics training in the different countries and it is also revealed that the students of which country know more of the various topics.

#### VI. COMPARING THE INFORMATICS KNOWLEDGE OF HUNGARIAN AND ROMANIAN STUDENTS - SURVEY RESULTS

The web-test on Informatics was filled in by altogether 1002 students from 22 Romanian cities. The comparison between the Hungarian students receiving basic Information Technology education and the Romanian students attending a social science course can only be made in the 10<sup>th</sup> and 12<sup>th</sup> grades. The survey could not be carried out up to the 8<sup>th</sup> grade since teaching Informatics is only compulsory from the 9<sup>th</sup> grade in Romania; students do not learn Informatics in a uniform system and it depends on the teacher what is taught. In Hungary, students can learn more Informatics weekly in the last two years of secondary school if they choose it as an optional subject. In Romania students learn more Information Technology if they are specialized in natural science, and if attending a Mathematics-Informatics course then they have even more classes a week. So the comparison should be limited to the students learning Informatics in the last two years of secondary school.

##### A. Survey results of the Hungarian students specialized in Informatics and the Romanian students attending a science course in the second part of secondary school on the basis of topics

###### 1) Result by subjects

The following table shows the results by countries and by subject (Table VI.). The mean shows how many questions could the students answer, the next column the ratio in percentage, and the last one the standard deviations.

TABLE IV. The mean and the standard deviation of right answers by Hungarian students specialized in Informatics and Romanian students attending a science course in the second part of secondary school on the basis of topics

Grade	Subject	Nationality of students	Mean	percent of the correct answers	Std. Deviation
11.	Theoretical knowledge	Hungarian	13,43	29,21%	7,61
		Romanian	8,33	18,12%	3,26
11.	Word processing	Hungarian	5,48	39,13%	3,30
		Romanian	3,00	21,43%	2,04
11.	Spreadsheet calculation	Hungarian	3,85	20,24%	1,97
		Romanian	2,50	13,16%	1,57
11.	Database management	Hungarian	3,09	17,15%	2,67
		Romanian	1,42	7,87%	1,38
11.	SQL	Hungarian	0,45	5,62%	1,55
		Romanian	0,00	0,00%	0,00
11.	Programming	Hungarian	7,09	27,26%	4,67
		Romanian	5,42	20,83%	1,68
11.	OOP	Hungarian	0,16	1,99%	0,66
		Romanian	0,00	0,00%	0,00
12.	Theoretical knowledge	Hungarian	16,81	36,55%	6,86
		Romanian	11,64	25,30%	5,14
12.	Word processing	Hungarian	5,75	41,05%	2,35
		Romanian	4,27	30,52%	2,00
12.	Spreadsheet calculation	Hungarian	4,59	24,18%	3,53
		Romanian	2,91	15,31%	2,12
12.	Database management	Hungarian	2,68	14,90%	2,92
		Romanian	4,09	22,73%	2,07
12.	SQL	Hungarian	1,22	15,25%	2,32
		Romanian	3,00	37,50%	2,65
12.	Programming	Hungarian	5,60	21,56%	3,96
		Romanian	6,36	24,48%	1,50
12.	OOP	Hungarian	0,23	2,88%	0,70
		Romanian	1,64	20,45%	1,57

Looking at the data in the table you can see that Hungarian students achieve better results in the field of theoretical knowledge, word processing, spreadsheet calculation, database management and programming in the 11<sup>th</sup> grade. They learn some SQL while the Romanian students do not. We have previously noticed that Hungarian students did not learn programming in the basic Information Technology education. They could answer right just 27% of the questions as a result of the first year spent in a specialized Informatics class. Object-oriented programming is missing from the education in both countries.

In the 12<sup>th</sup> grade the Hungarian students were still ahead in theoretical knowledge, word processing and spreadsheet calculation but Romanian students caught up in the field of database management. This is the grade where Romanian students get acquainted with this topic. Based on their scores you can say they learn more of SQL and show more proficiency in programming; the Hungarian students do not perform better any more. There is one essential difference between the educational programs of the two countries: Romanian students attending a science course learn the basics of object-oriented programming in the last year of secondary school while their Hungarian peers do not, not even in specialized Informatics classes.

2) *Correlation between the subjects by Hungarian students specialized in Informatics and Romanian students attending a science course*

A partial correlation calculation was done regarding the subjects in order to do a deeper analysis of the results by countries and grades (Falus-Ollé, 2008).

TABLE V. Correlation between the subject by Hungarian students specialized in Informatics in grade 11<sup>th</sup>

Subjects	Control Variables	Theoretical knowledge	Word processing	Spreadsheet calculation	Database management	Programming
Theoretical knowledge	Correlation	1,00	<b>0,68</b>	<b>0,71</b>	0,29	<b>0,79</b>
	Sig. (2-tailed)		0,00	0,00	0,02	0,00
Word processing	Correlation	<b>0,68</b>	1,00	<b>0,67</b>	0,34	<b>0,57</b>
	Sig. (2-tailed)	0,00		0,00	0,01	0,00
Spreadsheet calculation	Correlation	<b>0,71</b>	<b>0,67</b>	1,00	0,36	<b>0,74</b>
	Sig. (2-tailed)	0,00	0,00		0,02	0,00
Database management	Correlation	0,29	0,34	0,36	1,00	0,24
	Sig. (2-tailed)	0,02	0,01	0,01		0,39
Programming	Correlation	<b>0,79</b>	<b>0,57</b>	<b>0,74</b>	0,24	1,00
	Sig. (2-tailed)	0,00	0,00	0,00	0,39	

According to the table the results by Hungarian students in the 11<sup>th</sup> grade show positive calculated values of correlation between the subjects (Table V.). The calculated values show middle strong connection between theoretical knowledge and word processing, spreadsheet calculation and programming, between word processing and spreadsheet calculation, between spreadsheet calculation and programming. The strong of correlation is middle between word processing and programming. The calculated values show weak connection between theoretical knowledge and database management, between word processing and database management, between database management and programming. We can recognise same results with earlier analysing, the Hungarian students specialized in informatics learn more theoretical knowledge, word processing, spreadsheet calculation and programming but is not in this grade enough time to learn deep database management. We cannot see connection between database management and programming. I have not analysed the object oriented programming and SQL subject, because the number of successful answers was very low. We can in this point declare the Hungarian students specialized in informatics learn in 11<sup>th</sup> grade programming and learned earlier in basic course theoretical knowledge, word processing and spreadsheet calculation.

TABLE VI. Correlation between the subject by Hungarian students specialized in Informatics in grade 12<sup>th</sup>

Subjects	Control Variables	Theoretical knowledge	Word processing	Spreadsheet calculation	Database management	SQL	Programming
Theoretical knowledge	Correlation	1,00	<b>0,48</b>	0,23	0,38	0,18	0,28
	Sig. (2-tailed)		0,00	0,03	0,00	0,09	0,01
Word processing	Correlation	<b>0,48</b>	1,00	0,04	0,30	0,05	0,26
	Sig. (2-tailed)	0,00		0,74	0,00	0,63	0,01
Spreadsheet calculation	Correlation	0,23	0,04	1,00	0,26	0,14	0,22
	Sig. (2-tailed)	0,03	0,74		0,01	0,19	0,04
Database management	Correlation	0,38	0,30	0,26	1,00	0,34	<b>0,66</b>
	Sig. (2-tailed)	0,00	0,00	0,01		0,00	0,00
SQL	Correlation	0,18	0,05	0,14	0,34	1,00	0,21
	Sig. (2-tailed)	0,09	0,63	0,19	0,00		0,04
Programming	Correlation	0,28	0,26	0,22	<b>0,66</b>	0,21	1,00
	Sig. (2-tailed)	0,01	0,01	0,04	0,00	0,04	

In the table we can see the calculated values and the strength of the correlation between the subjects (Table VI.). The calculated values show middle connection between theoretical knowledge and word processing. The strong of correlation is middle between database management and programming. It means the correlation is stronger by



these two subjects than one year earlier. The teachers have more time to teach database management in last grade in secondary school.

TABLE VII. Correlation between the subject by Romanian students attending a science course in grade 11<sup>th</sup>

Subjects	Control Variables	Theoretical knowledge	Word processing	Spreadsheet calculation	Database management	SQL	Programming
Theoretical knowledge	Correlation	1,00	<b>0,48</b>	0,23	<b>0,60</b>	-0,05	0,12
	Sig. (2-tailed)		0,01	0,24	0,00	0,80	0,56
Word processing	Correlation	<b>0,48</b>	1,00	<b>0,40</b>	<b>0,45</b>	-0,13	0,03
	Sig. (2-tailed)	0,01		0,04	0,02	0,51	0,90
Spreadsheet calculation	Correlation	0,23	<b>0,40</b>	1,00	0,15	0,12	-0,16
	Sig. (2-tailed)	0,24	0,04		0,45	0,56	0,42
Database management	Correlation	<b>0,60</b>	<b>0,45</b>	0,15	1,00	0,07	0,17
	Sig. (2-tailed)	0,00	0,02	0,45		0,74	0,40
SQL	Correlation	-0,05	-0,13	0,12	0,07	1,00	-0,12
	Sig. (2-tailed)	0,80	0,51	0,56	0,74		0,56
Programming	Correlation	0,12	0,03	-0,16	0,17	-0,12	1,00
	Sig. (2-tailed)	0,56	0,90	0,42	0,40	0,56	

According to the table the results by Romanian students attending a science course in the 11<sup>th</sup> grade show mostly positive calculated values of correlation between the subjects (Table VII.). The calculated values show middle strong connection between theoretical knowledge and database management. The strong of correlation is middle between theoretical knowledge and word processing, between database management and word processing. It means Romanian students attending a science course in the 11<sup>th</sup> have more chance to learn database management than Hungarian their peers.

TABLE VIII. Correlation between the subject by Romanian students attending a science course in grade 12<sup>th</sup>

Subjects	Control Variables	Theoretical knowledge	Word processing	Spreadsheet calculation	Database management	SQL	Programming	OOP
Theoretical knowledge	Correlation	1,00	0,28	<b>0,45</b>	<b>0,44</b>	0,34	<b>0,44</b>	0,10
	Sig. (2-tailed)		0,24	0,05	0,00	0,14	0,05	0,69
Word processing	Correlation	0,28	1,00	0,19	<b>0,38</b>	0,38	<b>0,61</b>	0,26
	Sig. (2-tailed)	0,24		0,43	0,10	0,09	0,00	0,27
Spreadsheet calculation	Correlation	<b>0,45</b>	0,19	1,00	<b>0,46</b>	0,42	0,16	0,14
	Sig. (2-tailed)	0,05	0,43		0,05	0,07	0,50	0,55
Database management	Correlation	<b>0,44</b>	<b>0,38</b>	<b>0,46</b>	1,00	<b>0,46</b>	0,33	<b>0,54</b>
	Sig. (2-tailed)	0,00	0,10	0,05		0,04	0,15	0,01
SQL	Correlation	0,34	0,38	0,42	<b>0,46</b>	1,00	0,21	<b>0,63</b>
	Sig. (2-tailed)	0,14	0,09	0,07	0,04		0,37	0,00
Programming	Correlation	<b>0,44</b>	<b>0,61</b>	0,16	0,33	0,21	1,00	0,04
	Sig. (2-tailed)	0,05	0,00	0,50	0,15	0,37		0,85
Object Oriented Programming	Correlation	0,10	0,26	0,14	<b>0,54</b>	<b>0,63</b>	0,04	1,00
	Sig. (2-tailed)	0,69	0,27	0,55	0,01	0,00	0,85	

In the table we can see the calculated values and the strength of the correlation between the subjects (Table VIII.). The calculated values show by Romanian students attending a science course in the 12<sup>th</sup> grade middle strong correlation between programming and word processing, between Object Oriented Programming and SQL, database management. The strong of correlation is middle between theoretical knowledge and database management, spreadsheet calculation and programming, between word processing and database management, between spreadsheet calculation and database management. It means the Romanian students attending a science course in the 12<sup>th</sup> learn more subjects than their Hungarian peers, the Romanian teachers concentrate on more subjects than Hungarian teachers.

### 3) Analysis of the means by subjects

The next step in the analysis was to inspect whether the means by subject would differ if using the Independent samples test. The null hypothesis was that no significant difference would exist between the means of all subjects by countries. Because of having two independent samples it was possible to use the T-test to decide whether the hypothesis was true or not (Table IX.). If the analysis of the results (*Levene test*) showed the variance of the two groups different ( $p < 0,05$ ) (Levene, 1960), in this case the means could be compared with *Welch's t test* ( $p < 0,05$ ) (Welch, 1947), else the means could be compared with *T-test* ( $p < 0,05$ ) (Nahalka, 1993).

TABLE IX. Independent sample test of Hungarian students specialized in Informatics and Romanian students attending a science course in the second part of secondary school on the basis of topics

Grade	Subject	Levene's test for Equality of variances		T-test for equality of means		means are different
		F	Sig.	t	Sig. (2-tailed)	
11.	Theoretical knowledge	3,89	0,05	2,28	0,03	yes
11.	Word processing	3,33	0,07	2,51	0,01	yes
11.	Spreadsheet calculation	0,04	0,84	2,08	0,05	yes
11.	Database management	8,29	0,01	2,11	0,00	yes
11.	SQL	4,26	0,04	1,00	0,02	yes
11.	Programming	7,74	0,01	1,22	0,03	yes
11.	OOP	3,04	0,08	0,84	0,40	no
12.	Theoretical knowledge	0,63	0,43	2,42	0,02	yes
12.	Word processing	0,23	0,63	1,99	0,05	yes
12.	Spreadsheet calculation	4,08	0,04	1,57	0,03	yes
12.	Database management	1,00	0,32	-1,55	0,12	no
12.	SQL	1,01	0,32	-2,37	0,02	yes
12.	Programming	5,45	0,02	-0,63	0,23	no
12.	OOP	18,58	0,00	-5,31	0,01	yes

Having finished the statistical analysis you can see there are no differences in object-oriented programming between Hungarian and Romanian students in the 11<sup>th</sup> grade; they do not learn this topic at all. Hungarian students have better IT skills and programming knowledge in this grade.

In the 12<sup>th</sup> grade the Hungarian students do not obtain higher scores in database management and programming anymore; there are no differences between the means of correct answers, the Romanian students caught up with their Hungarian counterparts, but there are significant differences between the means of good answers concerning the other fields of Information Technology. That means Hungarian students have better IT skills but not deeper programming knowledge in this grade.

#### B. Survey results of the Hungarian students specialized in Informatics and the Romanian students attending a Mathematics-Informatics course in the second part of secondary school on the basis of topics

##### 1) Result by subjects

The following table shows the results by countries and by subject (Table X.). The mean shows how many questions could the students answer, the next column shows the ratio in percentage and the last one the standard deviations.



TABLE X. The mean and the standard deviation of right answers by Hungarian students specialized in Informatics and Romanian students attending a Mathematics-Informatics course in the second part of secondary school on the basis of topics

Grade	Subject	Nationality of students	Mean	percent of the correct answers	Std. Deviation
11.	Theoretical knowledge	Hungarian	13,43	29,21%	7,61
		Romanian	12,41	26,97%	4,01
11.	Word processing	Hungarian	5,48	39,13%	3,30
		Romanian	3,85	27,51%	2,20
11.	Spreadsheet calculation	Hungarian	3,85	20,24%	1,97
		Romanian	3,41	17,93%	2,15
11.	Database management	Hungarian	3,09	17,15%	2,67
		Romanian	3,26	18,11%	2,60
11.	SQL	Hungarian	0,45	5,62%	1,55
		Romanian	0,59	7,41%	1,28
11.	Programming	Hungarian	7,09	27,26%	4,67
		Romanian	10,70	41,17%	2,66
11.	OOP	Hungarian	0,16	1,99%	0,66
		Romanian	0,00	0,00%	0,00
12.	Theoretical knowledge	Hungarian	16,81	36,55%	6,86
		Romanian	15,30	33,26%	4,92
12.	Word processing	Hungarian	5,75	41,05%	2,35
		Romanian	5,70	40,71%	2,27
12.	Spreadsheet calculation	Hungarian	4,59	24,18%	3,53
		Romanian	5,20	27,37%	2,63
12.	Database management	Hungarian	2,68	14,90%	2,92
		Romanian	5,75	31,94%	3,11
12.	SQL	Hungarian	1,22	15,25%	2,32
		Romanian	4,05	50,63%	3,33
12.	Programming	Hungarian	5,60	21,56%	3,96
		Romanian	13,05	50,19%	2,98
12.	OOP	Hungarian	0,23	2,88%	0,70
		Romanian	1,05	13,13%	1,54

In the 11<sup>th</sup> grade Hungarian students attending an Informatics course performed better in theoretical knowledge, word processing, spreadsheet calculation, database management and programming than Romanian students attending a science course. On the basis of the data in the table this advantage remains only in the field of word processing if compared with the scores of the Romanian students attending a Mathematics-Informatics course; word processing is noticeably more emphasized in Hungary. The topic of SQL is only mentioned in both countries. Romanian students had higher scores in programming. They have not learned object-oriented programming in this grade yet.

In the 12<sup>th</sup> grade the Hungarian advantage in the field of word processing disappears, Romanian students achieved the same scores. They even produced better results in the field of database management, SQL and programming than their Hungarian peers and their results are similar to those of the students attending a science course since object-oriented programming appears in this grade.

2) *Correlation between the subjects by Romanian students attending a Mathematics-Informatics course*

We have seen earlier the partial correlation by Hungarian students specialized in Informatics and Romanian students attending a science course. The following tables show the calculated values of correlation by Romanian students attending Mathematics-Informatics course it helps to do a deeper analysis of the results by countries and grades.

 TABLE XI. Correlation between the subject by Romanian students attending a Mathematics-Informatics course in grade 11<sup>th</sup>

Subjects	Control Variables	Theoretical knowledge	Word processing	Spreadsheet calculation	Database management	Programming
Theoretical knowledge	Correlation	1	0,16	-0,23	0,19	0,12
	Sig. (2-tailed)		0,62	0,47	0,56	0,72
Word processing	Correlation	0,16	1	<b>0,57</b>	0,16	-0,27
	Sig. (2-tailed)	0,62		0,05	0,61	0,94
Spreadsheet calculation	Correlation	-0,23	<b>0,57</b>	1	-0,23	-0,09
	Sig. (2-tailed)	0,47	0,05		0,47	0,79
Database management	Correlation	0,19	0,16	-0,23	1	0,12
	Sig. (2-tailed)	0,56	0,61	0,47		0,72
Programming	Correlation	0,12	-0,27	-0,09	0,79	1
	Sig. (2-tailed)	0,72	0,94	0,79	0,12	

According to the table the results by Romanian students attending a Mathematics-Informatics course in the 11<sup>th</sup> grade show mostly positive calculated values of correlation between the subjects (Table XI.). The calculated values show middle strong connection between spreadsheet calculation word processing.

 TABLE XII. Correlation between the subject by Romanian students attending a Mathematics-Informatics course in grade 12<sup>th</sup>

Subjects	Control Variables	Theoretical knowledge	Word processing	Spreadsheet calculation	Database management	SQL	Programming	OOP
Theoretical knowledge	Correlation	1,00	0,47	<b>0,62</b>	<b>0,70</b>	0,55	0,01	0,50
	Sig. (2-tailed)		0,14	0,04	0,02	0,08	0,78	0,12
Word processing	Correlation	0,47	1,00	0,10	0,38	0,51	0,01	0,38
	Sig. (2-tailed)	0,14		0,77	0,25	0,11	0,78	0,25
Spreadsheet calculation	Correlation	<b>0,62</b>	0,10	1,00	<b>0,80</b>	<b>0,71</b>	-0,05	0,38
	Sig. (2-tailed)	0,04	0,77		0,00	0,01	0,88	0,25
Database management	Correlation	<b>0,70</b>	0,38	<b>0,80</b>	1,00	<b>0,79</b>	-0,14	<b>0,72</b>
	Sig. (2-tailed)	0,02	0,25	0,00		0,00	0,68	0,01
SQL	Correlation	0,55	0,51	<b>0,71</b>	<b>0,79</b>	1,00	-0,40	0,46
	Sig. (2-tailed)	0,08	0,11	0,01	0,00		0,21	0,16
Programming	Correlation	0,01	0,01	-0,05	-0,14	-0,40	1,00	-0,11
	Sig. (2-tailed)	0,78	0,78	0,88	0,68	0,21		0,75
Object Oriented Programming	Correlation	0,50	0,38	0,38	<b>0,72</b>	0,46	-0,11	1,00
	Sig. (2-tailed)	0,12	0,25	0,25	0,01	0,16	0,75	

According to the table the results by Romanian students attending a science course in the 11<sup>th</sup> grade show mostly positive calculated values of correlation between the subjects (Table XII.). If we make a comparison with the results by 11<sup>th</sup> grade we can recognize more middle and middle strong correlation values between the subjects. The calculated values show middle strong connection between database management and spreadsheet calculation, SQL. The strong of correlation is middle between theoretical knowledge and database management, spreadsheet calculation, between spreadsheet calculation and SQL, between database management and Object Oriented Programming. It means Romanian students attending a Mathematics-Informatics course in the 12<sup>th</sup> could learn

more in topic database management, SQL, Object Oriented Programming, spreadsheet calculation and SQL than Hungarian their peers.

### 3) Analysis of the means by subjects

The next step in the analysis was to inspect whether the means by subject would differ if using the Independent samples test (Table VII.).

TABLE XIII. Independent sample test of Hungarian students specialized in Informatics and Romanian students attending a Mathematics-Informatics course in the second part of secondary school on the basis of topics

Grade	Subject	Levene's test for Equality of variances		T-test for equality of means		means are different
		F	Sig.	t	Sig. (2-tailed)	
11.	Theoretical knowledge	4,99	0,03	0,67	0,39	no
11.	Word processing	3,20	0,08	2,36	0,02	yes
11.	Spreadsheet calculation	0,93	0,34	0,77	0,44	no
11.	Database management	0,01	0,91	-0,29	0,77	no
11.	SQL	0,21	0,65	-0,43	0,67	no
11.	Programming	6,30	0,01	-3,79	0,00	yes
12.	Theoretical knowledge	1,58	0,21	0,93	0,26	no
12.	Word processing	0,05	0,82	0,08	0,93	no
12.	Spreadsheet calculation	2,86	0,09	-0,75	0,45	no
12.	Database management	0,45	0,50	-4,20	0,00	yes
12.	SQL	10,76	0,00	-4,53	0,00	yes
12.	Programming	0,67	0,42	-7,92	0,00	yes
12.	OOP	31,42	0,00	-3,67	0,03	yes

Looking at the table containing the statistical data you can see that the analysis carried out on the basis of percentile data has proved to be correct.

In the 11<sup>th</sup> grade Romanian students achieved better results in programming, while their Hungarian peers were better in word processing but they have the same knowledge in the other fields.

In the 12<sup>th</sup> grade the Romanian students caught up with the Hungarians in the field of word processing and achieved better results in programming (at OOP too), database management and SQL. Romanian students attending a Mathematics-Informatics course students have the same IT skills and better programing knowledge at the end of the secondary grammar school than Hungarians specialized in Informatics.

Next, a deeper analysis of the different topics of programming follows.

#### *Comparing the Programming knowledge of Hungarian students specialized in Informatics with Romanian students attending a science course in the second part of secondary school*

Hungarian students do not learn programming in a basic Informatics course (Kiss, 2011a, Kiss, 2011b). This means only scores of those students can be analyzed who have chosen Informatics as an optional subject and learn Informatics in the last two years of secondary school (Kiss, 2010a). Earlier significant differences were found between the means of good answers in programming at the 11<sup>th</sup> grade (table). A deeper analysis of the different programming topics was needed to make a decision about the second hypothesis as it was in the case when knowledge by genders was discussed in Hungarian grammar schools (Kiss, 2010b) and higher education (Kiss, 2010c). It was found in another study that male teachers expressed greater knowledge about computers than female teachers. 23.8% of science teachers (Akdemir, Ocak, 2008).

The following table is a break-down by programming topics, showing what percent of students of this grade could answer correctly the questions put to them (Table VIII.).

Once again a Z-test (Korpás, 2002) was accomplished in order to know if the means by Programming topics were equal or not.

In the above case the null hypothesis was that no significant difference existed between the means by nationality. The monitoring was held on the  $p=5\%$  significance level. The critical value of Z-test was between -1,96 and 1,96 at  $p=5\%$  significance level. If the calculated value of Z-test was in this range, the null hypothesis could be kept. The next table shows the calculated values of Z-test and the decision on keeping or not the null hypothesis by nationality.

TABLE XIV. How many percent of students answered successfully the questions - grouping by Hungarian students specialized in Informatics and Romanian students attending a science course in the nationality in the 11th grade

Programming topic	Hungarian		Romanian		Value of Z-test	Decision
	%	Std. dev.	%	Std. dev.		
Flowchart	35,2%	0,48	14,3%	0,36	-1,18	The means are equal
Structogram	22,0%	0,42	4,8%	0,22	-0,52	The means are equal
FOR cycle	43,4%	0,50	35,7%	0,48	-2,74	The means are not equal
Repeat-Until cycle	19,2%	0,40	14,3%	0,35	-1,44	The means are equal
Do-While cycle	26,4%	0,44	9,5%	0,30	-0,93	The means are equal
Parameter passing	16,5%	0,37	28,6%	0,46	-2,49	The means are not equal
Sort algorithm	14,3%	0,37	26,2%	0,45	-2,36	The means are not equal
Array management	9,9%	0,30	4,8%	0,22	-0,70	The means are equal
Subroutine	42,9%	0,50	36,5%	0,49	-2,67	The means are not equal
Stack management	12,1%	0,33	23,8%	0,44	-2,23	The means are not equal
binary three knowledge	6,0%	0,24	7,1%	0,26	-1,09	The means are equal
list knowledge	19,2%	0,40	21,4%	0,42	-1,96	The means are equal
Recursion	15,0%	0,48	22,2%	0,42	-1,98	The means are not equal
binary search algorithm	11,0%	0,31	19,0%	0,40	-1,92	The means are equal
The Eight Queens Problem	25,0%	0,28	14,3%	0,36	-1,64	The means are equal

According to the table it can be asserted at  $p=5\%$  significance level that Hungarian students specialized in Informatics and Romanian students attending a science course are not on the same knowledge level regarding the different programming topics in the 11<sup>th</sup> grade (Table). Hungarian students answered the FOR cycle and subroutine questions more successfully, but, on the other hand, Romanian students had the same or even better knowledge in parameter passing, sort algorithm, stack management and recursion. Romanian students attending a science course in the 11<sup>th</sup> grade have more practice in Programming than Hungarian ones specialized in Informatics. To offset this disadvantage Hungarian teachers should start to teach programming already in the 7<sup>th</sup> grade (in accordance with the National Basic Curriculum).

*Comparing the Programming knowledge of Hungarian students specialized in Informatics with Romanian students attending a Mathematics-Informatics course in the second part of secondary school*

Earlier significant differences were found between the means of good answers regarding programming topics in the 11<sup>th</sup> grade as well as in the 12<sup>th</sup> grade (Table IX.). A further analysis is made to see the differences by programming topics.

The following table is a break-down by programming topics, showing what percent of students in the 11<sup>th</sup> grade could answer correctly the questions put to them.

TABLE XV. Percent of students answering successfully the questions - grouping by Hungarian students specialized in Informatics and Romanian students attending a Mathematics-Informatics course in the 11th grade

Programming topic	Hungarian		Romanian		Value of Z-test	Decision
	%	Std. dev.	%	Std. dev.		
Flowchart	35,2%	0,48	65,0%	0,49	-5,05	The means are not equal
Structogram	22,0%	0,42	10,0%	0,31	-1,01	The means are equal
FOR cycle	43,4%	0,50	85,0%	0,36	-8,55	The means are not equal
Repeat-Until cycle	19,2%	0,40	32,5%	0,47	-2,66	The means are not equal
Do-While cycle	26,4%	0,44	52,5%	0,51	-4,03	The means are not equal

Parameter passing	16,5%	0,37	60,0%	0,50	-4,93	The means are not equal
Sort algorithm	14,3%	0,37	20,0%	0,41	-1,88	The means are equal
Array management	9,9%	0,30	40,0%	0,50	-3,29	The means are not equal
Subroutine	42,9%	0,50	70,0%	0,46	-5,62	The means are not equal
Stack management	12,1%	0,33	25,0%	0,44	-2,26	The means are not equal
binary three knowledge	6,0%	0,24	10,0%	0,30	-1,32	The means are equal
list knowledge	19,2%	0,40	47,5%	0,51	-3,75	The means are not equal
Recursion	15,0%	0,48	35,0%	0,48	-2,80	The means are not equal
binary search algorithm	11,0%	0,31	55,0%	0,51	-4,52	The means are not equal
The Eight Queens Problem	25,0%	0,28	40,0%	0,50	-3,38	The means are not equal

According to the table it can be said at  $p=5\%$  significance level that bigger part of Romanian students attending a Mathematics-Informatics course could give correct answers than Hungarian students specialized in Informatics, except the topics Structogram, Sort algorithm and binary tree knowledge where knowledge levels were about the same. This means that the programming skill of Romanian students was higher than that of their Hungarian counterparts. At this point it should be noticed once again that Hungarian students start to learn programming later, because a big part of teachers omit this subject from the Information Technology Education of secondary schools which is however against the regulations of the National Basic Curriculum (prescribing it from the 7<sup>th</sup> grade).

Now let's analyse the situation in the 12th grade too! The following table is a break-down by programming topics, showing what percent of students in the 12<sup>th</sup> grade could answer correctly the questions put to them (Table X.).

TABLE XVI. Percent of students answering successfully the questions - grouping by Hungarian students specialized in Informatics and Romanian students attending a Mathematics-Informatics course in the 12th grade

Programming topic	Hungarian		Romanian		Value of Z-test	Decision
	%	Std. dev.	%	Std. dev.		
Flowchart	35,2%	0,48	60,0%	0,50	-4,52	The means are not equal
Structogram	22,0%	0,42	15,0%	0,37	-1,40	The means are equal
FOR cycle	43,4%	0,50	65,0%	0,48	-5,14	The means are not equal
Repeat-Until cycle	19,2%	0,40	37,5%	0,49	-3,01	The means are not equal
Do-While cycle	26,4%	0,44	65,0%	0,48	-5,27	The means are not equal
Parameter passing	16,5%	0,37	55,0%	0,50	-4,44	The means are not equal
Sort algorithm	14,3%	0,37	37,5%	0,49	-3,08	The means are not equal
Array management	9,9%	0,30	40,0%	0,50	-3,29	The means are not equal
Subroutine	42,9%	0,50	78,3%	0,42	-6,93	The means are not equal
Stack management	12,1%	0,33	40,0%	0,50	-3,28	The means are not equal
binary three knowledge	6,0%	0,24	22,5%	0,42	-2,24	The means are not equal
list knowledge	19,2%	0,40	65,0%	0,48	-5,43	The means are not equal
Recursion	15,0%	0,48	40,0%	0,49	-3,15	The means are not equal
binary search algorithm	11,0%	0,31	50,0%	0,51	-4,08	The means are not equal
The Eight Queens Problem	25,0%	0,28	50,0%	0,51	-4,15	The means are not equal

According to the table Romanian students attending a Mathematics-Informatics course could answer the programming questions more successfully than Hungarian students specialized in Informatics in the 12<sup>th</sup> grade, except by Structograms, where their knowledge was the same. The programming skill of Romanian students was better than that of the Hungarian students before the final exam. Romanian students making their final exam of Information Technology and intending to go to the university or college can start their programming studies from a higher level and do not need to spend much time to acquire the basics of programming. On the contrary, Hungarian students have many problems with basic programming too, so they first have to fix this after entering university or college (generally in their first year) and they can be taught only after that on a higher level. Therefore, Hungarian teachers should make more efforts when teaching programming in the secondary grammar schools if their students choose Information Technology as a final exam subject or when they decide to teach this part of Information Technology earlier. Also, more classes in Information Technology could be helpful too. On

the other hand, university lecturers teaching programming should be aware of their students having problems with programming basics and find a way to make up for lost ground.

## VII. CONCLUSION

One of my starting hypotheses was that the Hungarian students specialized in Informatics would do better than their Romanian peers attending a science course.

This proved to be true in the 11<sup>th</sup> grade except for object oriented programming a subject left out of the education in both countries.

In the 12<sup>th</sup> grade Romanian students achieved better results in object oriented programming and SQL, and achieved the same result in programming and database management. Hungarian students performed better at theoretical knowledge, word processing and spreadsheet calculation in both grades. Here you can see the advantage of more weekly classes (3-4) taught in science courses of Information Technology Education in Romania. The students can make up for their handicap, and have same knowledge in programming and database management, and even more so in object oriented programming. Their Hungarian peers have higher Computer Science knowledge level at the end of the secondary grammar school.

Another starting hypothesis was that as for Computer Science literacy and programming knowledge Romanian students attending a science course and a Mathematics-Informatics course would reach the same scores than the Hungarian students specialized in Information Technology.

This assumption turned out to be partly correct in the 11<sup>th</sup> and 12<sup>th</sup> grade. Hungarian students received higher scores in word processing, while Romanians in programming. They achieved the same scores in the other topics of Information Technology in the 11<sup>th</sup> grade.

Romanian students attending a Mathematics-Informatics course have the same Computer Science knowledge level and better programing knowledge in the 12<sup>th</sup> grade than Hungarian students specialized in Informatics.

Here must be mentioned that while in Romania object-oriented programming has been discussed in these two courses, in Hungary students do not learn it, not even in a specialized Informatics course, though those who have to deal with programming cannot avoid getting to know this field thoroughly later on.

Now a final conclusion can be made: Romanian students of the Real Profile (i.e. the Sciences program) have the same or more practice in programming than Hungarian students specialized in Informatics, though the latter have the same or better Computer Science literacy. Unfortunately, Hungarian teachers concentrate on word processing and spreadsheet calculation and teach programming just for the students specialized in Informatics, although algorithm thinking would be important for every student before finishing secondary school. After the calculating values of the partial correlation we have got same results by subject.

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