

THE CONCEPT TO MEASURE AND COMPARE STUDENTS KNOWLEDGE LEVEL IN COMPUTER SCIENCE IN GERMANY AND IN HUNGARY

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While education is based on a national basic curriculum in Hungary, Germany's 16 regions each with its own Ministry of Education determine curricula independently resulting in difficulties for school switching students. Standards of computer science education varying in different regions is discussed along with efforts to unify the curricula. Differences in CS education of the two countries are pointed out. In order to make the two education system comparable a web-based on-line questionnaire was prepared by the author. Students are to fill in from all regions and in all grades in both Germany and Hungary. The questionnaire and evaluation methods are discussed together with first results.

Keywords: computer science education, comparison method in education

Germany is a Federal Republic with 16 members. Each member has its own Ministry of Education and an own School system with own curricula. Therefore differences in computer science education are significant in different regions (Kiss, 2007a). Computer science is obligatory in Bavaria and in Saxony but not even selectable in Hessen and Schleswig-Holstein. In some region the curriculum consists of just the office packet, in Mecklenburg-Vorpommern students learn the newest methods in Cryptography too, in Bavaria word processors are taught from object oriented viewpoint in the 5th grade. Except Lower Saxony the basic knowledge of information technology (Informationstechnologische Grundlagen; ITG) is introduced in all schooltypes from grade 5-10: somewhere as an independent subject, somewhere as part of natural science generally taught in 1-2 hour per weeks. Efforts are made to make computer science obligatory in all regions teaching it along uniform standards.

Computer Science Education in Germany and in Hungary

Basic knowledge of information technology (ITG)

The German subject „Basic knowledge of information technology” doesn't exist in Hungary. According to the National Basic Curriculum (NBC) of Hungary the use of computer science is to be demonstrated in the first four school grades since 2003 (e.g. search on the Internet, painting with computers etc.). In Germany this begins in the Basic knowledge of

information technology from the 5th grade, but there are differences in the different regions. In most cases this is taught as part of natural science, but in Bavaria, Berlin and in Saxony Anhalt it is an independent subject. Table 1 shows the weekly CS grades taught in the various school types of the German regions.

There are three different schooltypes: lower secondary school (Hauptschule), intermediate secondary school (Realschule) and high school (Gymnasium). The counterpart of the German lower secondary and intermediate secondary school is the primary school in Hungary. In Germany after the lower secondary school students may decide to study in vocational school where they can absolve the final exam too (table 1.).

Table 1. Basic knowledge of information technology in the German regions

| Region | Lower sec. school | | | | | | Intermediate sec. | | | | | | High school | | | | | |
|-------------------------------------|-------------------|---|---|---|---|----|-------------------|---|---|---|---|----|-------------|---|---|---|---|----|
| | 5 | 6 | 7 | 8 | 9 | 10 | 5 | 6 | 7 | 8 | 9 | 10 | 5 | 6 | 7 | 8 | 9 | 10 |
| Baden-Württemberg | | | | | | | | | | | | | | | | | | |
| Bavaria | | | | | | | | | | | | | 56 | | | | | |
| Berlin | 28 | | | | | | 28 | | | | | | 28 | | | | | |
| Brandenburg | | | | | | | 80 | | | | | | 80 | | | | | |
| Bremen | | | | | | | | | | | | | | | | | | |
| Hamburg | 24 | | | | | | | | | | | | | | | | | |
| Hessen | Min. 16 | | | | | | Min. 16 | | | | | | | | | | | |
| Mecklenburg Western Pomerania | | | | | | | | | | | | | | | | | | |
| Lower Saxony | | | | | | | | | | | | | | | | | | |
| Nord Rhine Westphalen | 60 | | | | | | 60 | | | | | | 60 | | | | | |
| Rhineland- Palatinate | | | | | | | | | | | | | | | | | | |
| Saarland | | | | | | | 24 | | | | | | 40 | | | | | |
| Saxony | | | | | | | 26 | | | | | | 26 | | | | | |
| Saxony-Anhalt | | | | | | | 30 | | | | | | 28 | | | | | |
| Schleswig- Holstein | | | | | | | | | | | | | | | | | | |
| Thuringen | | | | | | | 84 | | | | | | 84 | | | | | |

One can see the number of grades is region specific and it's on the teacher to decide how long time he/she takes to teach basic knowledge of information technology integrated in natural science in some regions.

Computer science in high school

In Germany computer science is taught in some form in all regions. Difference show up in being obligatory or not. In the best part of regions there is a chance to learn it in higher level which means 4-5 hours per week while in basic level it is just 2-3 hours per week. This chance is at hand in the 11-13th grades. Some regions make studying CS obligatory for those who want to absolve a final exam in 10th grade. Final exam from computer science can be taken in all regions but in Baden-Württemberg and Saxony-Anhalt the exam is just verbal.

In Hungary CS is just selectable in the 11-12 grades. On basic level it is taught in 2 hours per week, on a higher level in 3 hours per week (table 2.). A final exam can be taken as in Germany (Kiss, 2007b).

Table 2. Computer science in high school

| Grade | 10 | 11 | 12 | 13 |
|-------------------------------|----------------|----------------------------------|----------------------------------|----|
| Baden-Württemberg | 2 hours | 2 hours | | |
| Bavaria | 2 hours | 3 hours | | |
| Berlin | OS, 3 hours | Basic, 3 hours / higher, 5 hours | | |
| Brandenburg | OS, 3 hours | Basic, 3 hours / higher, 5 hours | | |
| Bremen | OS, 2-3 hours | Basic, 3 hours / higher, 5 hours | | |
| Hamburg | OS, 2 hours | Basic, 3 hours / higher, 5 hours | | |
| Hessen | Basic, 3 hours | Basic, 3 hours / higher, 5 hours | | |
| Mecklenburg Western Pomerania | 2 hours | Obl. 2 hours / higher 4 hours | | |
| Lower Saxony | | 3 hours | | |
| Nord RhineWestphalen | | Basic, 3 hours | Basic, 3 hours / higher, 5 hours | |
| Rhineland-Palatinate | | Basis, 3 hours / higher, 5 hours | | |
| Saarland | 2 hours | Basis, 3 hours / higher, 5 hours | | |
| Saxony | | 2 hours | | |
| Saxony-Anhalt | | OS, 2 hours | | |
| Schleswig-Holstein | | 2-3 hours | Basis, 2-3 hours | |
| Thuringen | 2 hours | Basis, 3 hours / higher, 6 hours | | |
| Hungary | 2 hours | Basis, 2 hours / higher, 3 hours | | |

The Curriculum of Computer Science in the High Schools of Germany and Hungary

The Computer Science curriculum in the high schools of Hungary consists of:

Word processing
Spreadsheet calculation
Presentation
Algorithm and programming
Database management

First let's see the differences between the high school curricula of the two countries. In Hungary generally the Microsoft Office packet is taught, while in Germany the Open Office and other freeware softwares. The reason is of financial kind: the goal is to spare the price of expensive softwares which otherwise should be bought by the parents.

Word processing

Table 3 shows when word processing is entering the curriculum in the German regions and in Hungary, respectively. In some regions this isn't part of the Computer Science curriculum, because it is taught within the literature subject.

Table 3. Word processing

| Region | Grade | | | | | | | | | |
|-----------------------------------|-------|---|---|---|---|----|----|----|----|--|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| Baden-Württemberg [1] | | | | | | | | | | |
| Bavaria [2] | | | | | | | | | | |
| Berlin [3] | | | | | | | | | | |
| Brandenburg [4] | | | | | | | | | | |
| Bremen [5] | | | | | | | | | | |
| Hamburg [6] | | | | | | | | | | |
| Hessen [7] | | | | | | | | | | |
| Mecklenburg Western Pomenaria [8] | | | | | | | | | | |
| Lower Saxony [9] | | | | | | | | | | |
| Nord RhineWestphalen [10] | | | | | | | | | | |
| Rhineland-Palatinate [11] | | | | | | | | | | |
| Saarland [12] | | | | | | | | | | |
| Saxony [13] | | | | | | | | | | |
| Saxony-Anhalt [14] | | | | | | | | | | |
| Schleswig-Holstein [15] | | | | | | | | | | |
| Thuringen [16] | | | | | | | | | | |
| Hungary [17] | | | | | | | | | | |

It can be seen that teaching this subject draws 4 years in Hungary while only 1-2 years in Germany. Computer Science education begins somewhat later (in the 11-12 grade) in Lower Saxony but in this two years a lot of other knowledge is taught too.

Spreadsheet calculation

Spreadsheet calculation is missing from the curriculum of Computer Science in 5 regions (table 4) while word processing is missing in just 2 regions. The reason is similar to those above: spreadsheet calculation is integrated in the Math subject. This situation has advantages and disadvantages as well.

The advantage is that in Computer Science education it leaves more time to teach other subject matters. The disadvantage is that most teachers have no degree in Computer Science.

Table 4. Spreadsheet calculation

| Region | Grade | | | | | | | | | |
|-------------------------------|-------|---|---|---|---|----|----|----|----|--|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| Baden-Württemberg | | | | | | | | | | |
| Bavaria | | | | | | | | | | |
| Berlin | | | | | | | | | | |
| Brandenburg | | | | | | | | | | |
| Bremen | | | | | | | | | | |
| Hamburg | | | | | | | | | | |
| Hessen | | | | | | | | | | |
| Mecklenburg Western Pomenaria | | | | | | | | | | |
| Lower Saxony | | | | | | | | | | |
| Nord RhineWestphalen | | | | | | | | | | |
| Rhineland-Palatinate | | | | | | | | | | |
| Saarland | | | | | | | | | | |
| Saxony | | | | | | | | | | |
| Saxony-Anhalt | | | | | | | | | | |
| Schleswig-Holstein | | | | | | | | | | |
| Thuringen | | | | | | | | | | |
| Hungary | | | | | | | | | | |

Presentation

Presentation classes are missing in regions (table 5) where word processing or the spreadsheet calculation are not. The reason is not as clear as in the earlier case. In some regions it is missing completely from the education while sometimes we find it as part of the art subject. If it is taught at all, then generally much earlier than in Hungary.

Table 5. Presentation

| Region | Grade | | | | | | | | | |
|-------------------------------|-------|---|---|---|---|----|----|----|----|--|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| Baden-Württemberg | | | | | | | | | | |
| Bavaria | | | | | | | | | | |
| Berlin | | | | | | | | | | |
| Brandenburg | | | | | | | | | | |
| Bremen | | | | | | | | | | |
| Hamburg | | | | | | | | | | |
| Hessen | | | | | | | | | | |
| Mecklenburg Western Pomenaria | | | | | | | | | | |
| Lower Saxony | | | | | | | | | | |
| Nord RhineWestphalen | | | | | | | | | | |
| Rhineland-Palatinate | | | | | | | | | | |
| Saarland | | | | | | | | | | |
| Saxony | | | | | | | | | | |
| Saxony-Anhalt | | | | | | | | | | |
| Schleswig-Holstein | | | | | | | | | | |
| Thuringen | | | | | | | | | | |
| Hungary | | | | | | | | | | |

Algorithm and programming

Basic algorithms or rather programming appears in Computer Science sooner in Hungary (table 6.). But then as opposite to the used methods in Hungary, teaching the subject is approached from object oriented aspects in most of the regions in Germany. In some provinces JAVA is taught too, while in other regions algorithms are taught together with DELPHI. In Bavaria even word processing is taught from object oriented aspect in grade 6. In provinces where programming is taught more than two years, students learn more than in Hungary, because recursion, list and tree data structure are part of curriculum, while in Hungary they are just selectable. Another advantage of the German CS education is group work. The students in high school learn to work together: 2-3 persons work on bigger projects learning the advantage and disadvantage of project work too, what they will utilize in their later work in the area of Computer Science.

The LEGO Mindstorm kit which is very useful in learning programming is used from the lower level (grade 5-6) to university in almost all of the provinces (Kiss, 2006).

Table 6. Algorithm and programming

| Region | Grade | | | | | | | | | |
|-------------------------------|-------|---|---|---|---|----|----|----|----|--|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | |
| Baden-Württemberg | | | | | | | | | | |
| Bavaria | | | | | | | | | | |
| Berlin | | | | | | | | | | |
| Brandenburg | | | | | | | | | | |
| Bremen | | | | | | | | | | |
| Hamburg | | | | | | | | | | |
| Hessen | | | | | | | | | | |
| Mecklenburg Western Pomerania | | | | | | | | | | |
| Lower Saxony | | | | | | | | | | |
| Nord Rhine Westphalen | | | | | | | | | | |
| Rhineland-Palatinate | | | | | | | | | | |
| Saarland | | | | | | | | | | |
| Saxony | | | | | | | | | | |
| Saxony-Anhalt | | | | | | | | | | |
| Schleswig-Holstein | | | | | | | | | | |
| Thuringen | | | | | | | | | | |
| Hungary | | | | | | | | | | |

Database management

Database management is a subject taught in most regions for two years while in Hungary just one year (table 7.). This means that not just database management, but also SQL commands are taught. This part of the Computer Science curriculum begins in the 9th grade like in Hungary.

Table 7. Database management

| Region | Grade | | | | | | | | |
|-------------------------------|-------|---|---|---|---|----|----|----|----|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Baden-Württemberg | | | | | | | | | |
| Bavaria | | | | | | | | | |
| Berlin | | | | | | | | | |
| Brandenburg | | | | | | | | | |
| Bremen | | | | | | | | | |
| Hamburg | | | | | | | | | |
| Hessen | | | | | | | | | |
| Mecklenburg Western Pomenaria | | | | | | | | | |
| Lower Saxony | | | | | | | | | |
| Nord Rhine Westphalen | | | | | | | | | |
| Rhineland-Palatinate | | | | | | | | | |
| Saarland | | | | | | | | | |
| Saxony | | | | | | | | | |
| Saxony-Anhalt | | | | | | | | | |
| Schleswig-Holstein | | | | | | | | | |
| Thuringen | | | | | | | | | |
| Hungary | | | | | | | | | |

Other fields of Computer Science not taught in Hungary

Two fields are to be mentioned here which are taught only in the German high schools though not in all regions.

Formal languages and automats

Teaching a formal language and automats or rather the Turing machine is a subject typically part of higher education in Hungary but in some regions of Germany this areas are parts of the Computer Science curriculum in high school (table 8). Because of the difficulty of this subjects they appear first in the 11th grade or after. The knowledge of these subjects plays an important role later in Computer Science or in Mechatronics (Kiss, 2007c).

Table 8. Formal languages and automats

| Region | Grade | | | | | | | | |
|-------------------------------|-------|---|---|---|---|----|----|----|----|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Baden-Württemberg | | | | | | | | | |
| Bavaria | | | | | | | | | |
| Berlin | | | | | | | | | |
| Brandenburg | | | | | | | | | |
| Bremen | | | | | | | | | |
| Hamburg | | | | | | | | | |
| Hessen | | | | | | | | | |
| Mecklenburg Western Pomenaria | | | | | | | | | |
| Lower Saxony | | | | | | | | | |
| Nord Rhine Westphalen | | | | | | | | | |
| Rhineland-Palatinate | | | | | | | | | |
| Saarland | | | | | | | | | |
| Saxony | | | | | | | | | |
| Saxony-Anhalt | | | | | | | | | |
| Schleswig-Holstein | | | | | | | | | |
| Thuringen | | | | | | | | | |
| Hungary | | | | | | | | | |

Cryptography and data protection

Cryptography and the data protection are taught in Hungary similarly to formal languages and automats at the universities. In Germany it is taught in 7 regions in the high school (table 9). The topic is especially important today being useful to show the students how easy is to break short or easy passwords especially when using the Internet where safe passwords are a must. In the table below it can be seen in which regions are taught the newest methods of cryptography. The grades are certainly varying with the regions.

Table 9. Cryptography and data protection

| Region | Grade | | | | | | | | |
|-------------------------------|-------|---|---|---|---|----|----|----|----|
| | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 |
| Hamburg | | | | | | | | | |
| Mecklenburg Western Pomenaria | | | | | | | | | |
| Lower Saxony | | | | | | | | | |
| Rhineland-Palatinate | | | | | | | | | |
| Saarland | | | | | | | | | |
| Saxony-Anhalt | | | | | | | | | |
| Thuringen | | | | | | | | | |

The basic idea and standpoint for making a comparison

The basic idea is to prepare a web-based on-line questionnaire with several test questions for students from all regions and all grades in Germany and in Hungary. The answers will help to show how the two education systems differ from each other. In order to reach the best results the author used unified questions of computer science based on the national/regional curricula of Hungary and Germany.

Why was the web-based method chosen? This method was superior because in paper form the students would have got the questions in the same order and they could have answered them just in lesson time. The web-based format meant they could face the questions in a different order so they cannot help each other. A further benefit of a web-based questionnaire is that students can complete the test at home too, not only in school where time is limited. Moreover it is more convenient for the teachers and lecturers because the test does not shorten the duration of the lesson. Preparing the test in a one-hour class would probably not give enough time because the large amount of questions. This is due to the unification of the two countries' different curricula of computer science. In order to find the best results the appropriate questions have to be tailor-made for every theme and for every grade. The questions are composed to suit the grade and the level of the different education systems. For instance, because of these differences, German students in grade 6 face the same questions as Hungarian students in grade 8.

The test

First of all students have to give details about their actual grade and other qualifying data. (Figure 1.)

Figure 1. Students details

Computer Science Test for Students

Name:

Sex*:

Username of teacher:

Province*:

Schooltype*:

Grade*:

Special training?*:

Check the Theme that **have never learned**:

- Programming
- Object Oriented Programming
- Database management
- SQL
- Cryptology
- Formal language and Automats

The respondent's name is not required, which provides anonymity, however gender is important so that it is known how many girls and boys have completed the test. In cases where a student gives the username of his/her teacher, the teacher can see how the students performed on the test and can control the students' work. A further requirement is to choose the province, this data helps us to find out the underlying perspective of the study, namely, to compare the regions. The following question asks for the

type of school, potential answers are secondary school, high school or university. The grade is important, because this will decide what kind of question sheet the student will get that suits the level of his or her grade. The same questions are put in a different order so that the students writing the same test in the same time and in the same room aren't able to help each other.

The numbers of questions in grades are:

1. 5th Grade: 11 questions
2. 6th Grade: 26 questions
3. 7th Grade: 70 questions
4. 8th Grade: 113 questions
5. 9th Grade: 136 questions
6. 10th Grade: 137 questions
7. 11th Grade: 151 questions

The first impression when considering the numbers of questions in the higher levels is that there may be too many but the average solving time in the following table (Table 10.) shows this is fear is not realised.

Table 10. The average solving time

| Grade | Time (min) |
|--------------|-------------------|
| 5 | 12 |
| 6 | 14 |
| 7 | 36 |
| 8 | 49 |
| 9 | 72 |
| 10 | 59 |
| 11 | 67 |
| 12 | 57 |

Special training means that the student has achieved a higher level in computer science. The themes covered in the test are as follows:

1. Basic computer science
2. Office packages
3. Programming
4. Object oriented programming
5. Database management
6. SQL
7. Cryptography
8. Formal languages and automats

Students can tick some of the themes (except for basic computer science and office packages, because these themes appear in both countries in every region), which they have never learned. In this case the system does not ask questions in connection with those topics but registers and saves them as the answer, "I've never come across that". With this system in place students get fewer questions and the examiner receives lots of answers quickly. After completing the first administration page students can begin the test.

Every test question has 6 possible answers; one of them is correct, 3 of them are false, the 5th possible choice is: "I've never come across that", the 6th one is: "I've forgotten it". The last two potential answers "I've never come across that" and "I've forgotten it" can provide the author with crucial

information as to whether the student has learned certain topics (of the national / regional curriculum) and whether he or she remembers them.

Every question has two time limits in seconds. The first one is the minimum time needed to read, understand and answer the question, the second limit is the maximum answering time. The software saves the total time used by the student, furthermore, time limits are not seen or known by the student.

During the evaluation process various statistical methods are used (F-test, t-test, statistical analysis of the post-test, only randomized experimental design etc). With the help of these tools the examiner can show the potential real differences between the two countries from grade to grade in the analysed topic. Furthermore, using the same answers, this test will provide the opportunity to compare the computer science education in various regions of Germany as well.

What does the test provide for teachers?

Teachers can register on the following site (Figure 2.). They have to give several details at registration. The first notable difference is the username with which they can log on. The system is protected by a registration code so as to ensure that only the teacher which filled in this form can use the system.

Figure2. Registration for teachers

Registration for teachers

Username*:

Password*:

Password again*:

Name*:

E-mail*:

Province*: - ▼

Schooltype*: - ▼

Schoolname*:

Registration code*:

*required fields

If the students give the username of their teacher, the teacher can see their results and how they performed in the test. Some reports are really useful in assisting the work of the teacher. The registered teachers can see:

1. The distribution of students in provinces
2. The distribution of students in various types of schools
3. The distribution of students in a Class in Secondary school

4. The distribution of students in a Class in High school
5. The distribution of students in a Class in University
6. The average time taken to complete the test in Secondary school
7. The average time taken to complete the test in High school
8. The average time taken to complete the test in Universities
9. The distribution of their students in Classes
10. The list of their students in Classes
11. The results of their students (including the "I've never come across that" answers too)
12. The results of their students (including just the answered questions)
13. The summarized results of their students by subject matters (including just the answered questions)

Summary

Comparison produces evidence that in the significant part of Germany's regions appears computer science with more hours per weeks than in Hungarian education. The German schools have more financial means to buy and use newest hardware and software. Computer laboratories are well equipped and numerous. Software used comes generally from the public domain. Characteristically computers are found and connected to the internet in every family.

In Hungary the SULINET program helped to narrow the initial gap but there is still significant difference in the everyday use of computers in the two countries. German students use efficiently the advantages given by computer devices after finishing their schools while most Hungarian students still have problems using word processors after their final exam.

After comparing Computer Science education in the two countries we can conclude that students learn CS longer in most regions of Germany than in Hungary and there are some topics which are not part of the curriculum in Hungary at all. Analyzing the data we found that though in some regions word processing and spreadsheet calculation isn't part of the Computer Science education, but they are taught in the frame of literature or math subjects leaving more time to learn other important areas in Computer Science.

Up to the present 1470 students have completed the test in Hungary. Most of them are from High schools. This suggests High School teachers used the test to validate their work.

Next, test questions will be translated to German so testing can start soon in Germany too. The Hungarian version is running on the computer of the author at Budapest Tech, the German counterpart will run in the University of Paderborn on the server of the Department of Computer Science.

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