



## VIEWPOINTS FOR THE DEVELOPMENT OF TEACHING CONTENTS IN THE FIELD OF INFORMATICS

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**Abstract:** Informatics education is in a special situation. The greatest and quickest changes in technology and content might be in this field. That is why it is a very important question what and how to teach on different education levels. What are the requirements of the European labour market? What trends can be recognized in the field of public education, vocational trainings and informatics BSCs? How can we give up-to-date and useable knowledge when everything continuously changes? That would be the only aim or instead of actual practical experience we should accentuate the theoretical knowledge, which could establish the further self-education.

**Key words:** education level, practical knowledge, theoretical knowledge, BSc, ECDL

### 1. Introduction

The world of Informatics education is in special situation. Let's see a simple example. Plausible to make a comparison from the world of mathematics, the closest branch of science to informatics. We can hardly find elements in mathematics curriculum, which would be the result of the last 20-30 years. Secondary school mathematics curriculum doesn't contain anything of the researching results in the last few decades and the vast majority of university mathematics also covers older knowledge.

At the same time the situation is just the opposite in the case of informatics, there is almost nothing in the curriculum, which has been the part of it for 20-30 years. We can experience that the empirical prediction known from electronics – that the number of transistors on integrated circuits doubles approximately every year (1965, Gordon Moore, Moore-law) – is true for informatics and within it for education contents as well.

### 2. Educational levels

European labour market requires most people to speak languages and being aware of the world of informatics to some extent, but on the other hand the need for informatics professionals is increasing gradually.

Applications skills are necessary to fill almost every position today (ECDL), so that it's importance has extensively appreciated, and its tuition appears on every educational level today, from kindergarten to university.

Competence levels were introduced as standard definitions of knowledge levels, which partly correspond to educational levels as well. [1, 2] (Hereinafter we will concentrate only on secondary school and university out of educational levels.)

Because of the skills required from an ordinary employee, people have had the false impression, that informatics knowledge is nothing more, than the professional acquirement of applications skills. Becoming acquainted with the continuously changing, developing softwares give a regular challenge to the ordinary user; however, it is obvious that an extremely talented student does not find this enough challenging, so they may not choose these disciplines as their career. The field of informatics

is not that attractive among students today as it used to be, so it is getting more difficult to educate sufficient number and level of professionals.

More and more educational specialists have realized that – similarly to other subjects - field-related theoretical knowledge would be necessary to be taught in informatics. Programming and computer science knowledge could make the surrounded technologized world clearer for students; it would help the understanding of certain principles. On the other hand it could orient better the talented ones towards informatics. [3]

In German speaking areas, professor Hromkovic, Juraj with his team aimed to integrate the basics of computer science to the school curriculum in order to solve the above problems. [3, 4]

It was proposed in the United Kingdom in 2012, that new ways have to be found in the area of informatics education, which serves students' personality and professional development much better in the future. [5]

In Finland, Professor Ralp-John Back experienced in connection with first year college students, that they can hardly understand and learn formalism without former knowledge. He has introduced the structured derivation method to secondary school mathematics curriculum as an experiment, which he was also promoting here in Hungary. [6]

In Hungary the NAT (National Base Curricula, 2003) contains besides a lot of other things, the info technology as a developing area, in which there are the bases of making algorithms and data modelling..[7]

The above examples all suggest that - beside the now prevailing, quite practice-focused European trends (which seem to turn over now) – general informatics attainments, giving wide range of knowledge, would be needed yet on secondary school level.[3, 4, 5, 6]

In Hungary the separate informatics subject and the well-educated informatics teachers may guarantee both the education of high level applications skills and high level theoretical knowledge. Meanwhile the work with the propagation of digital literacy progresses very successfully in Hungary, which was awarded at the second time by ECDL Foundation in 2012. [8]

The applications skills required on the European labor markets strengthen the education of employees being able to handle informatics devices, but does not help to achieve other aims, neither the professionals education, nor the strengthening of general thinking capabilities; the recognition of principles.

It could be a break-out point for Hungary, if it acquired leading role in the field of informatics, which is one of the most dynamically developing industries in the world. This aim can be brought to achievable nearness for Hungary by appropriate informatics education As of this writing has not been decided, if the educational contents and number of lessons belonging to the field – according to the current educational reforms, which formerly shocked teachers' society - will change[9]

The state of affairs is absolutely clear in the area of higher education, the primary aim is obviously to educate employees being able to handle informatics devices. Even institutes financed by private sector see great (business) potential in taking up this field. [1, 2]. One can give countless examples for this, but the closest one to us might be the private university; Aquincum Institute of Technology (AIT) Budapest, which aims to provide world-class education in a given specialization. (<http://www.ait-budapest.com>) What kind of requirements have companies defined toward informatics graduates In the „Research about Hungarian labor force preparedness in IT” done for the MEFIT (Hungarian EU Development Management Board) one can read that multinational companies mostly expect professionals with a couple of years of experience, already specialized in some areas, while other companies prefer young employees with wider range of knowledge, in some cases without professional experience.

### 3. Educational Content

In case of higher education the works belonging to informatics majors and other areas of science have to be decoupled. Today's scientific life is unimaginable without utilizing the possibilities of informatics, so computer work is naturally integrated to the disciplines of majors. Internet penetration and the propagation of home computer environment in Hungary is slightly below the European average, so in order to solve this, several subjects have been introduced under the name of basics of informatics. Of course, professional disciplines include the needed informatics knowledge in different majors. In England there are trainings whose name already show the close connection between different professions and informatics eg. ICT and Law, ICT and Business. [10].

#### In the field of informatics the BSC courses are divided into three main groups:

- the trainings which contain mainly the base of theoretical computing science Bachelor of Computer Science (BCompSc) or the Bachelor of Computing (BComp).
- the trainings which contain mainly practical oriented subjects e.g. Bachelor of Science in Information Technology (BSc IT), Bachelor of Computer Applications (BCA), Bachelor of Information Technology (BSc IT) and Bachelor of Applied Science (Information Technology) (BAppSc(IT)).
- the trainings which contain subjects in business informatics e.g. Bachelor of Business Information Systems (BBIS), or Bachelor of Commerce (BCom,)

BSc of Computer Science (BSc.Comp.) trainings usually discuss the following topics:

programming methods, programming paradigms, algorithms, data structure, logic, computer science, computer architecture, mathematics, linear algebra, calculus, probability theory, combinatorics, discrete mathematics, differential calculus. The following topics can also be included in the courses: computer theory, databases, computer networks, real-time programming, compilers, distributed systems, artificial intelligence and human-computer interaction.

BSc of Information Technology (BSc.IT) trainings usually include the following disciplines: programming languages, operating systems, algorithms, optimization, computer networks, database management systems, relational database systems, software engineering, computer graphics, distributed systems, web-developing, data-mining, artificial intelligence, multimedia, e-commerce, law and ethic of computers and network, software testing, digital electronics.

The typical disciplines of BSc.IT and BSc.Comp trainings are shown in Table 1.

**Table 1.** Comparison of BSc.IT and BSc.Com

BSc.Comp		BSc.IT
programming paradigms	algorithms	programming languages
logic	operating systems	graphics
computer science	data-bases	multimedia
compilers	computer networks	e-commerce
computer architectures	distributed systems	law and ethic
mathematics	artificial intelligence	electronics
		testing
		data mining

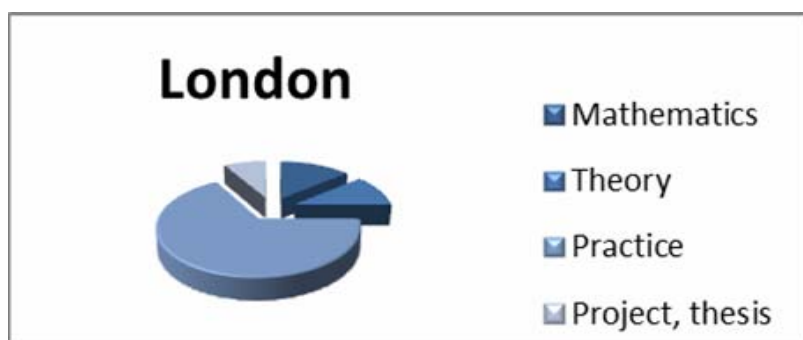
Let's look some BSc trainings closer. Firstly let's see the general informatics BSc program of London University. Computing and Information Systems (CIS) training looks like the most similar to our national Programming Informatics BSc. reachable by the link [13].

The achievement of BSc is to complete 12 units. Accurately this means that they have to fulfil 11 units from courses and a project work which is worth 1 unit. The exact unit denominations can be read on the link above so we won't detail them as they are not exciting separately. The comparison of contents are more interesting, the contrast of mathematics and informatics, practice and theory.

There are three levels determined by the training, which may match to the three year long system. On each level they have to accomplish 4 units. On level 1 there are one mathematics and three informatics units. All of these are practical and grounding subjects. On level 2 each of the four units are connected to the knowledges of started courses on level 1 or some branches of them on advanced level - the aim is to get mastery in them. For example the Java for beginners continues on graphical, web environments. Level 3 is already the level of specialization. After one starter and one advanced level, the level of special knowledges is to come. Representative areas can be the field of network security or data compression. On level 3 one selected field mean only half unit, so the student chooses 6 of them and the project work gives the forth.

If we want to give the rate of above mentioned areas, we should use a common measurement; credits. We get the following results: Mathematical subjects: 15 credits, Informatical theory: 10 credits, Informatical practice: 140 credits. Naturally there can be a 1-2 credit difference caused by the fault of sampling, but it will be adequate for indicate the proportions. Four units mean 60 credits of a year.

We can say this at the first sight, we have counted all the elements of level 3 to the credits of practical informatics, but it's certainly not proper, because data compression surely contains mathematical knowledges as well. Though knowing that because of the fault of sampling, there can be 1-2 credits of fault, the following modification - which is shown in Figure 2 - would better fit to reality



**Figure 2.** London, CIS BSc rate of content: Mathematical subjects: 25 credits, Informatical theory: 20 credits, Informatical practice: 120 credits, Project work: 15 credits

As part of all the credits (180), the credits which show special personal knowledge gives 60 credits (the selectable subjects, project work, thesis, minor subjects if any)

A better known institute is Cambridge University Computer Science of which structure of BSc program's is very similar to the formerly mentioned London University program. The accurate description can be read in this link [14].

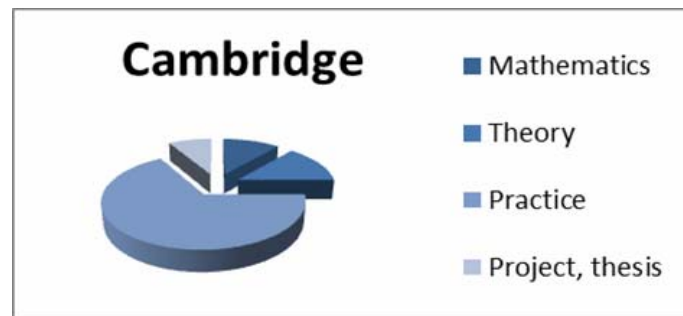
The Computer Science training of the Cambridge University is divided into three parts. The part 1, the first year is to ground the knowledge, during the second year they deepen their knowledge and the third year is for specilization. One year is devided into four units (their terminology is „paper” for it).

During the first year, students have to select at least two units of informatics and at least one unit of mathematical groundwork. This means exactly that one can learn three unit of informatics plus one unit of mathematics or two units of informatics and two units of mathematics.

During the second year each of the four units are from the field of informatics and only one of them are theoretical one. During the third year - the year of specialization - they should choose three units and their thesis gives the fourth one. In this last year they can choose three from the following themes: bioinformatics, digital signal processing, advanced artificial intelligence, advanced graphics, specification and verification of hardware and software, semantics etc..

The formerly shown division modified only a little bit: Mathematical subjects: 20 credits; Informatical theory: 25 credits; Informatical practice: 120 credits; Thesis: 15 credits.

Out of all the (180) credits, credits that show special personal knowledge: 75 (the elective subjects, project work, thesis, minor subjects if any). The above division is shown on Figure 3.



**Figure 3.** BSc Cambridge , rate of content

Let us see a similar example from Germany, the Informatics Bsc of Martin-Luther Universitate (Martin-Luther-Universitat Halle Wittenberg /Informatik BSC). The accurate description can be read in this link [15].

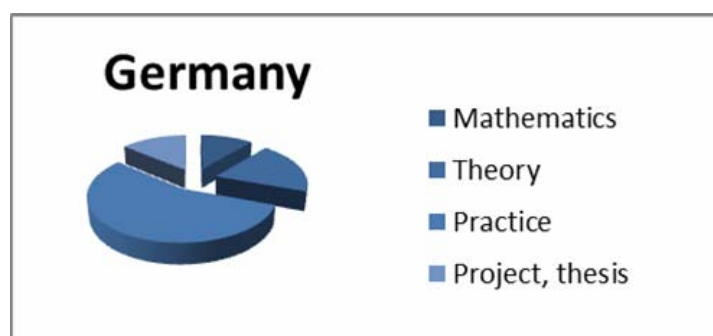
The structure of the training is similar to the English ones, the duration of the course is three years long. During the first year there are the groundwork subjects, and then follow the mandatory subjects which deepen the first year's studies. The last year is for specialization which means bioinformatics, business calculation or mathematics. Here they have to take part in a project work and write a thesis.

The credit values of mathematical subjects can be read from the training's description. To decide the rate of theory and practice we should see the subjects closer. We reckoned among the theoretical subjects the Operating systems, Modelling, Automates and Computer Science, Stochastics, Computer Architecture.

The division of content is the following: Mathematical subjects: 20; Informatical theory: 35; Informatical practice: 100; Project work, thesis: 25.

As part of the all credits (180), the credits which show special personal knowledge gives 40 credits (the selectable subjects, project work, thesis, minor subjects if there are any)

The guessed rate of subjects is shown on Figure 4.



**Figure 4.** BSc Germany, rate of content

The next training we will examine is the Computer Science Bsc training of Tampere University of Finland. The syllabus can be read following the next link [16].

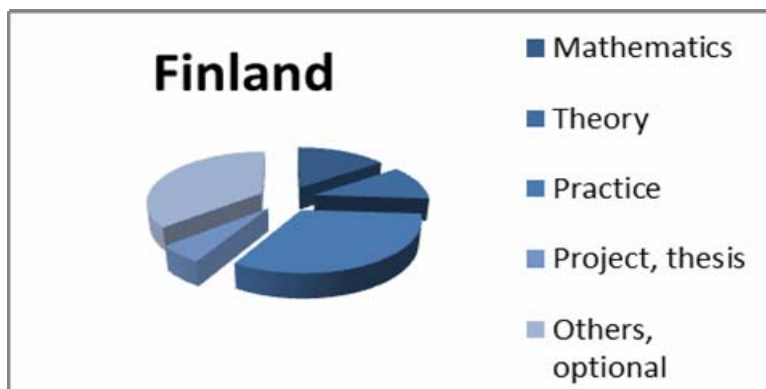
The training is three years long there as well, but there is a great difference in the structure of it comparing to the above-mentioned ones. They place great emphasis on developing Swedish, English

and general communication skills and they expect learning of a minor subject as well. It is featuring to have a wide range of selectable subjects too.

We reckoned among the theoretical subjects the Logic, Formal Languages and part of Programming Paradigmas.

Categorizing the subjects the guessed rates are the followings, which are shown on Figure 5: Mathematics: 27 credits (previously we didn't connected Logic and Formal Languages to Mathematics); Informatical theory: 20 credits; Informatical practice: 68 credits; Others: 19 credits (English communication skills etc.); Selectable subjects: 46 credits.

As part of all the credits (180), the credits which show special personal knowledge gives 46 credits (the selectable subjects, project work, thesis, minor subjects if any)



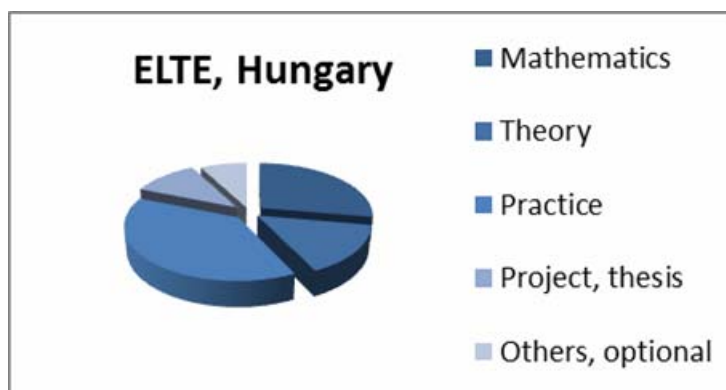
**Figure 5.** *Tampere Finland, Computer Science BSc*

At last (but not least) we examine the division of the Programming Informatics BSc of Eötvös Loránd University from Hungary. The credit values are from 2008, B Software specialization. The exact informations can be read on this link [17].

Subjects connected to mathematics are The Base of Mathematics, Calculus, Numerical methods, Discrete Mathematics, Linear Algebra, in total 50 credits. Informatical theory (Logic, Formal Languages, Distributed Systems, Compilers, Programming Methods I. II.) has 27 credits. Information Technologies (Algorithms, Artificial Intelligence, Base of Programming, Base of Computers, Operating systems, Programming Languages, Databases) has 69 credits. The thesis: 20 credits; Selectable: 9 credits; Others: 5 credits.

As part of all the credits (180), the credits which show special personal knowledge gives 29 credits (the selectable subjects, project work, thesis, minor subjects if any)

The above mentioned data are shown on Figure 6.



**Figure 6.** *ELTE, Programming Informatics BSc*

The comparison of Bsc programmes are shown on Figure 7.

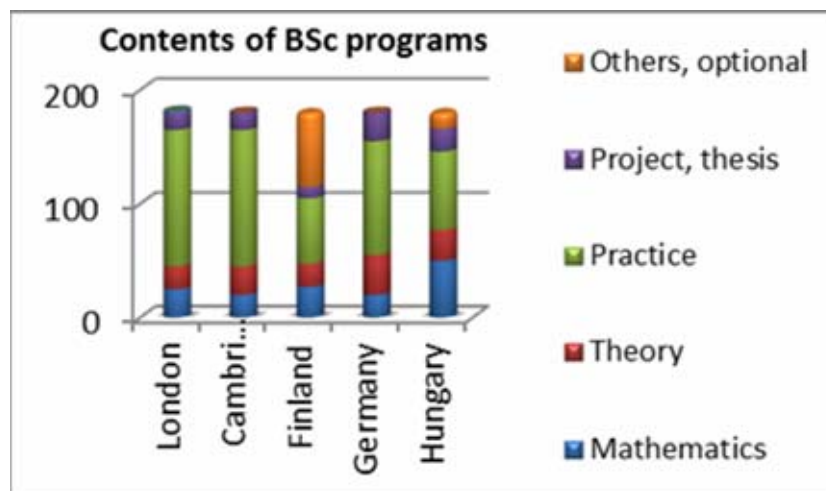


Figure 7. The content of examined BSc programs

#### 4. Viewpoints of developing informatics teaching contents

One question to be answered obviously appears. Is it appropriate that the proportion of mathematical-theoretical subjects show so big variability in different trainings? (There is no notable difference between Cambridge and London University.)

We have mentioned at the beginning of the article that the actual current informatical appliances change and alternate like Moore-law. Does the deeper theoretical knowledge serve better the opportunity of future development?

In the field of programming languages, technologies the program of London University focuses on Java language, so students can deepen their knowledge in it. Other institutes teach three programming languages instead. Which is the better method? Do we have to learn one thing deeper or it is better to know various things.

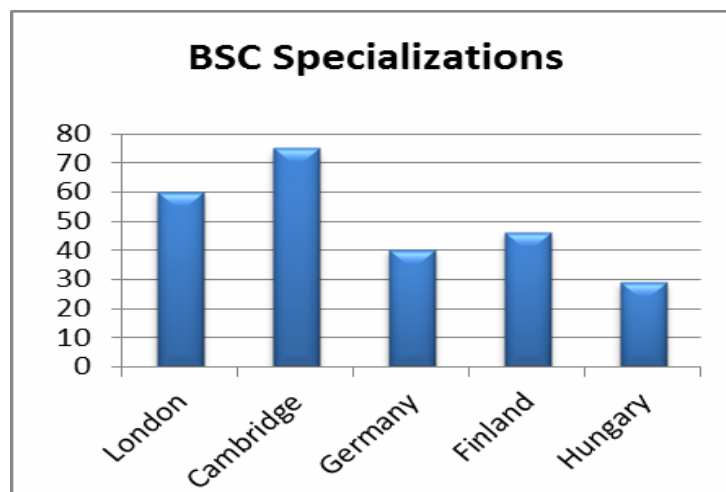
Another – not so obviously seen – difference is the appearance of specialization. Practically it means the third years selectable courses and the spread of them. In these group of courses mainly there are current fields of informatics as bioinformatics, digital signs, advanced graphics, decision supporting systems. etc.

??Inasmuch as a big proportion of the programmers become a professional developer for mobil or web platform, do we have to build these fields to their mandatory studies and if so the question is how? We could see several solutions for this question in our examples. The Java subject of London University (on web also), the ASP.NET subject of ELTE gives knowledge in this field as well, but in other universities there are subjects for web or mobile developing only as elective ones (Finland). The appeared differences are not adjudgeable unambiguously.

The role and dynamic appearance of specialization shows that students get their Bsc diploma as a professionalist of a field of informatics. The data are shown on Figure 8.

There is a good example in the offer of University of Central Lancashire, which contains 21 different BSc diplomas in the field of informatics, e.g Computing, Computer network technology, Web and Multimedia.





**Figure 8.** Rate of specializations

We can get more information following the next link [19]:

The specialization in MSc trainings are unambiguously characterized by specialization. There are several fields of informatics where one can get an MSc diploma, usually the great number of elective subjects are representative. In England there are MSc trainings which can be finished in one year. All of the 180 credits can be gathered during two semesters plus working in a summer project. For example the Computer Science MSc of Birmingham University is open for students without informatics BSc diploma as well. They do have to take some mandatory subjects, but more than half of them can be selected. Students with an Informatics BSc diploma can collect all of their credits from elective subjects in both of the semesters: eg. System Development, Natural Computation, Mathematical Foundations, Artificial Intelligence.

More details can be read by following the link [20].

In Abo University in Finland one can get an MSc Informatics diploma in four areas : Computer Science, Electronic and Mobile Commerce, Embedded Computing and Software Engineering. The training is two years long, consisting of 120 credits. Let's see the Computer Science diploma. Freely selectable 95 credits from subjects from the fields of Software Theory, Software Systems, Computational Systems Biology, High Performance Computing.

The MSc diploma of ELTE can be obtained on the following areas of informatics: Modelling, Software technology, Information Systems. The training is two years long and consists of 120 credits here as well. Compulsory subjects together are worth 26 credits, all of the other credits are given by elective subjects and the thesis. There is a big similarity in the structure of Finnish Computer Science MSc and national Softwaretechnology MSc. The other MSc trainings of Abo University characteristically concentrate on special parts of informatical areas: (Embedded Computing, Mobile Commerce). Similar specializations can be noticed in the MSc training of ELTE: Information Systems MSc (database).

We haven't given detailed information for Informatics MSc, but we can say that specialization is the essential difference, which is the most obtrusive. We can see that the specialization started in the third year of BSc is completed there. In Figure 9. it is shown that more than three quarter of credits can be selected from the offered subjects.





**Figure 9.** *MSc specializations*

Naturally, it is important too - from the point of view of specialization – how big is the offer of the elective subjects.

Our last remarks are in connection with specialization again. We are over the basing period, do we have to resort earlier prepared environments, systems and if so then how much of them? This question leads to far, that's why we illustrate it only with a specific example. Developing native graphical applications do we use Win32 API or MFC, a visual developing tool.

Should we use devices for vizualization in planning or analyzing applications or not? Do we require the usage of code generation devices or we have to focus on conventional code writing. Which of them will be more useful for the students, from which one can learn programming better?

It is a similar question to the former one – maybe it is a bit more general – is CMS a user system, do we have to concentrate on it or we have to focus on developing such systems.

We have counted a lot of questions which are important and determine basicly the content and the outcomes of the trainings by our opinions.

It is not easy to take position even on that question whether the proportion of practical subjects have to be surely the same as it is suggested by most of the trainings.

### 3. Conclusion

We can see regarding the educational dilemmas that in one hand there is a strong demand for the modernization of education, while on the other hand there is no standard answer for this, which might not be that big problem. Finding the appropriate proportion of practical skills ready to use and theoretical knowledge supporting the future progresses on different educational levels appears as key issue Regarding the higher education, company- and user demands are better observable in the practical focused degrees like the curriculum of Cambridge- and London University, but neither are theoretical focused universities unprecedented It can be stated that both the level of specialization and the dominance of the practical proportion of the degree focuses on the immediate enrolment (although in some cases the overdone of specialization may worsen it) in contrast to the long term solutions. We think that this decision has to be made by the given education institutions, taking the local demands and possibilities into consideration. Independently of the strategic objective of the different institutions, outstanding professional knowledge can only be achieved by obtaining lots of experiences. Paraphrasing the famous words of Euclid we can state that there is no royal road to have perfect knowledge of programming” –programming, programming and programming, what we can advise to everyone!

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