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IMPROVEMENT OF THE UNIVERSITY PROGRAMME ON THE BASE OF MODULARITY

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Abstract

The curriculum "Computer Systems" of RTU faculty's of Computer Science and Information Technology is developed on the basis of classical teaching principles. The curriculum is accredited for 6 years till 2013 on academic bachelor, professional school after bachelor's degree, master and doctoral levels.

Despite of the current positive state RTU Institute of Applied Computer Systems (IACS) taking advantages provided by European Social Fund in Latvia is implementing a set of projects directed towards improvement of the educational curriculum "Computer Systems" and the quality of studies. Total amount of the implemented projects is 486800 Latvian lats for the period from October, 2005 till August, 2008. The necessity of revision of learning process, its content and objectives is determined by the following factors: Latvian Republic accession to the European Union; explosion of industry; a new standard of Informatics for secondary education in Latvia.

The aim of the paper is to introduce readers to practical exploitation of opportunities provided by ESF in the improvement of IACS's learning process, competitiveness of IACS's graduates and valuable inclusion of Latvian Republic into the common EU scientific and educational area.

Keywords:

Curriculum, computer systems, course profile, module.

Introduction

Nowadays we can observe an evolution from the industrial age to the information age that causes the rise of information society. Information society requires not only abilities to use information technology and process information, but also abilities to learn new knowledge and to get new skills. These changes cause emerging of so called "knowledge work" (Drucker, 1973), i.e., a new type of intelligent work. The essence of knowledge work is turning information into knowledge through the interpretation of available non-standardized information for purposes of problem solving and decision making. The great challenge for universities is how to organize teaching and learning process and to decide which curricula may promote graduates to be the knowledge workers. Naturally, academics, researchers and practical workers are involved in intensive discussions on this issue. Examples of publications (Cohen, 2005; Hardaway et.al., 2005; Kowalik, 2006; Patterson, 2006) and the following activities (E-learning, 2005; TENCompetence, 2007; ViVERA, 2007) are only few that refer to this problem.

Starting with early 90-ies when Latvia regained independence, the country has made significant steps towards the development of information society (Grundspenkis, 2006). Sweeping changes have happened in all society, GDP is steadily growing and the number of university students is increasing very quickly. From the other side, economical situation in the country, in particular, exceptionally high demand of labour market for skilled computer science and information technology specialists has caused the extremely high number of students being enrolled yearly in the corresponding study progammes. In addition, the necessity to earn one's living forces students to start working very early (even being the freshmen). As a consequence, new forms of education, for example, project-oriented teaching, group work, hybrid courses where only part of the lectures are traditional face-to-face ones, while others are internet supported or recorded, start to be more and more important. Implementation of the basic principles of distance learning–"any time, any place and any pace" is the problem of the day.

In these circumstances, universities should be flexible to adapt to the requirements of the changing

environment as well as to rapidly changing ideas, methods, methodologies and tools of computer science and information technology. Knowledge content included in curricula must follow all changes without considerable delay (Grundspenkis et.al., 2004). This is the main reason why universities continuously should modify their curricula and reconsider teaching and learning styles and modes. This is a worldwide tendency.

Historical background

At the early 90-ies when Latvia regained independence, sweeping changes concerned also education, i.e., reconstruction of the whole education process was started. Strictly predetermined curricula were replaced step by step by more flexible ones containing obligatory (compulsory) courses and electives. As a result, more possibilities appeared for students to choose courses of their own interest. Serious reconstruction of engineering studies was carried out also at the Faculty of Computer Science and Information Technology (CS&IT) of RTU. This process was based on the survey of a great number of curricula used in USA, Canada and different European countries. The main conclusion was that the experience of other universities is very significant for the development of core requirements, but to get the curricula which will be accreditable and recognized at the international level and at the same time be adaptable to local conditions requires new principles. The model curriculum paradigm was chosen as the working hypothesis. The development of the first curriculum, which later was called "Computer Systems", was based on two relevant documents, namely, the "Computing Curriculum 1991" (Computing, 1991) and "Model Curriculum and Guidelines for Undergraduate Degree Program in Information Systems" (IS'97 in brief) (Davis, 1997). In result, a model curriculum suitable for RTU was developed (Grundspenkis, 1998). The concept of learning units was used to make the model curriculum as flexible as possible taking into account constraints put on the curriculum by rules of Ministry of Education and Science and RTU Senate. The model was grounded on a fundamental body of computer science, information systems and information technology knowledge.

It is worth to point out that from the very beginning the "Computer Systems" curriculum was realized as a 3+3 curriculum, i.e. 3 years of bachelor studies plus 3 years of master studies. In the early 90-ies it was the only computer science and information technology curriculum of such kind (all other universities kept 4+2 schema). In the middle of 90-ies the "Computer Systems" curriculum was harmonized with two other curricula ("Automation and Computer Engineering" and "Information Technology") which were taught at the Faculty of CS&IT. The idea was that the first and the second year students have the same courses (except electives) while the third year students have specific courses for each of the three study programmes. The faculty follows this principle till nowadays.

At the end of 90-ies the academic studies at the RTU were changed to 3+2+3, i.e. 3 year bachelor, 2 year master, and 3 year doctoral studies. Concurrently the professional studies were started. First, the three years long first level professional study (college) programme was launched at the very end of 90-ies. In the year 2004 "Computer Systems" professional bachelor and professional master study programmes were licenced and offered to students.

Evaluation of the existing curriculum

The evaluation of the "Computer Systems" academic study programme was done in the year 2001 when the programme was submitted for accreditation. The international evaluation commission included three professors, one from each country–Sweden, Estonia and Lithuania. The commission suggested full accreditation (for six years) of the programme. The accreditation board at the Ministry of Education and Science of Latvia certified the suggestion of the International evaluation commission. At the moment the "Computer Systems" academic study programme is repeatedly accredited till the year 2013.

During the years of realization of "Computer Systems" study programme the academic staff got experience how to run the teaching and learning process, and minor changes have been done each year. There are two main sources of motivation for changes: student questionnaires and requirements of employers. In general students are satisfied with content of courses and the whole study process. Employers also are satisfied about knowledge level and skills obtained by students. At the same time several drawbacks of the "Computer Systems" have been fixed. The most important ones are the following: insufficient amount of practical work in laboratories and individually, small projects, as a rule, worked out in one course, and lack of group work. Suggestions and requirements received from both parties are discussed at the departments and reflected in self-evaluation reports of the "Computer Systems" study programme, which are completed each year.

Theoretically both these activities should provide continuous improvement of the study programme. Unfortunately, in practice it is not a case because experienced professors are overloaded, have not real motivation and are not able to view the programme as a system, i.e. as a whole. Those are the reasons why

the programme board made a decision to apply for the projects funded by the European Social Fund (ESF), which are targeted towards the improvement of the study programmes in natural science and engineering. It should be mentioned that such factors as rapid development of software and information technology industry in Latvia, new standard of Informatics subject for secondary schools and the development of profession standards by professional organizations also triggered this decision.

Conceptual framework for curriculum improvement

Three interrelated projects with the total amount of more than 0,7 million euro have been implemented to improve the "Computer Systems" study programme, curriculum and syllabus. Two of mentioned projects are related to master programme for academic studies - one concerns basic courses which are taught during the first and second year, second one includes the third year bachelor courses and master level courses. Third project is related to professional bachelor and professional master study programmes.

At the starting point of projects' implementation the following goals were formulated: improvements should lead to project-oriented teaching, courses should be widely supported by e-learning environments and tools, and at least for a subset of courses hybrid educational mode should be realized in practice.

To reach these goals, the methodological framework was outlined. The basic concept of the framework is two-dimensional modularity of the study programme. The horizontal dimension corresponds to the decomposition of the study programme into subsets of courses which have related topics and are taught concurrently. The vertical dimension corresponds to the decomposition of the study programme into subsets of courses which have related topics and are taught in different semesters or different study levels, for example, at bachelor and master level. As it was mentioned before experienced professors are overloaded and are not able to view the programme as a system, i.e. as a whole. Visualised course representation gives more understanding on overall course number and specialisation, and analyse curriculum systematically, thus helping to determine knowledge that interconnects different courses and analyse possible changes (Vinogradova, 2005).

Starting point for module definition was the investigation of the existing "Computer Systems" academic study programme and profession standards of a software engineer and a system analyst where general and specific knowledge and skills are defined. This activity resulted in form of so called "course profiles" which are filled up by experts of the corresponding courses. The essence of the course profile is identification of input/output knowledge. In fact, it is an extended course description with clear focus on prerequisite knowledge and strict formulation of outcomes, i.e. knowledge and skills obtained after finishing the course. In addition the course profile contains expert's opinion about the module in which the course should be included, as well as the statement about the current situation where such indicators as "right semester", "correct volume", "conflict courses", "student training level", "teaching materials" and "improvement proposals" are fixed. The gathered information allowed to define modules included 2-4 courses both of vertical and horizontal dimensions of modularity. Figure 1 shows a schematic representation of the two-dimensional modularity concept for the computer science specific courses of the two of "Computer Systems" study programmes. While courses taught in one semester that represent horizontal dimension of modularity are grouped horizontally, courses grouped in one module (i.e. vertical dimension) are coloured.

The next step of the framework is to define matrix of relations for comparison of information given in matrix with recommendations of the (Computing, 2001).

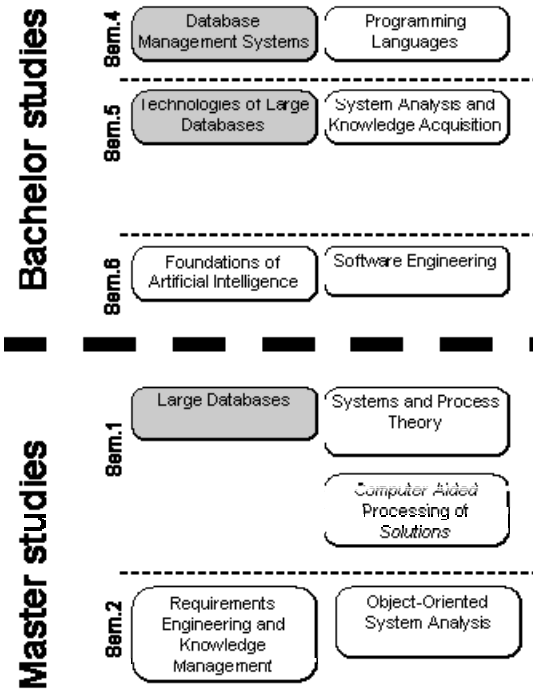

Fig. 1. Two-dimensional modularity of the curriculuim

Representation in Figure 1 gives the professor information on overall place of the course in the curriculum, but all possible links discovered during analysis of the course profiles can not fit this picture. "Course profiles" contain information about general

and specific knowledge and skills provided by the course, as well as input/output knowledge. The latest enriches curriculum system with different types of links between courses and modules.

Because courses in modules are interconnected by default, more interesting are links between modules presented at Figure 2.

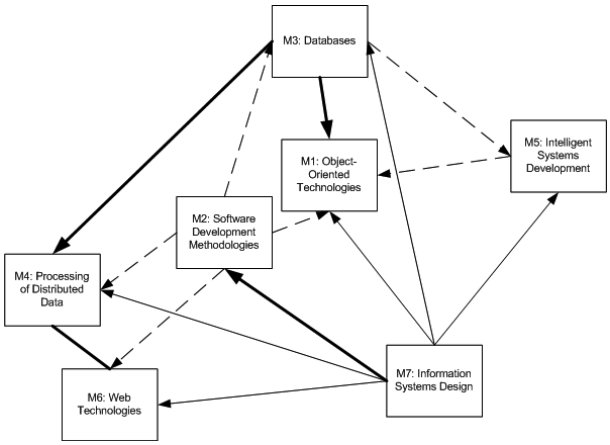

Fig. 2. Example of the curriculum module links

At the moment three types of links are identified based on the link descriptions given by the professors. Simple arrows denote that knowledge from one module contributes to the overall understanding of the knowledge of a connected module. Solid arrows denote tight connection: either part of the course or a whole course should be taught before a connected course. The last type of links represents interconnected concepts that can be taught in both modules. This type of module connection can change over time because the connected concepts can move from one course to another.

Analysis of the curriculum in the context of European Educational Space

Within the project the analysis of curricula in the field of computer science within the European Educational Space has been made. Two main researches were conducted:

- an identification of possible curricula providing academic mobility of higher education students;
- a comparison of the curriculum of master study "Computer Systems" taught at Riga Technical University with the similar curricula of other countries of European Union on the level of subjects and their groups.

The full list of institutions of higher education of European Union was obtained by using information from the following sources:

- Web sites of institutions responsible for higher education in each country;
- a portal on learning opportunities throughout the European Space (Portal, 2007);
- an international education directory of colleges and universities (International Education, 2007);
- a Web site of higher education in Europe from Graduateshotline.com (Higher Education, 2007);
- a directory Colleges.com (College, 2007).
- The following criteria were used when selecting curricula:
- information about a curriculum is in English on the Web site of a corresponding institution of higher education;
- information about a curriculum includes titles of study subjects, credit points for each subject, as well as semesters, when the subject is taught (only for the identification of mobility opportunities);
- the level of a curriculum is the academic master study (the same as the level of the curriculum "Computer Systems");
- the title of a curriculum contains some of the following possible words: Computer Science, Computer Systems, Software Engineering, Software Development, Information Systems, Information Technology, Computing;
- the offered curriculum is not a distance learning programme;
- the degree that students obtain after the completion of a curriculum is Master of Science.

Taking into account the listed criteria 29 curricula in 25 institutions of higher education from 15 countries of European Union were identified for the research of providing academic mobility of higher education students (Table 1). One part of the found institutions are the partners of Riga Technical University in Erasmus programme (Erasmus, 2007); others were examined from the perspective of potential partners.

The research results show that it is very difficult to provide mobility of higher education students because there are essential differences among curricula. Mainly only credit points of one subject can be transferred for the greater part of students studying at foreign institutions of higher education. Moreover, usually these credit points are provided by subjects of a free choice or such subjects as Software Engineering, Artificial Intelligence and Databases. The greatest number of credit points which can be transferred is 2 or 3 credits, however in this case it is necessary to consider such factors as the specialization chosen by the student at the foreign institution and subjects passed by the student in his/her local institution.

In the second research much more institutions and curricula were found because there was not necessary to know a semester when subjects are taught. Totally

55 curricula in 43 institutions of higher education from 18 countries of European Union were identified (Table 1). The focus of the research was concentrated on obligatory study subjects. The analysis of curricula at the level of subjects shows that there is an enormous diversity both in the titles and in content of subjects. Totally 262 different titles of subjects were identified. The most often offered subjects are presented in Table 2. Thirty three subjects are found in two curricula, and others only in one of curricula.

Table 1. Distribution of curricula and institutions by countries

	First research		Second research	
Country	**Number of curricula**	**Number of institutions**	**Number of curricula**	**Number of institutions**
United Kingdom	8	6	17	11
Belgium	1	1	3	3
Czech Republic	1	1	1	1
Denmark	1	1	2	2
Greece	1	1	4	3
Estonia	-	-	3	2
Ireland	3	2	3	2
Lithuania	1	1	1	1
Italy	-	-	4	3
Cyprus	2	2	2	2
Luxembourg	1	1	1	1
Malta	1	1	1	1
Netherlands	-	-	2	1
Portugal	1	1	1	1
Romania	3	2	3	2
Slovak Republic	1	1	1	1
Germany	2	2	2	2
Sweden	2	2	4	4
Totally	29	25	55	43

The results of the research allow to reveal general tendencies. The main attention is granted to software engineering, including object-oriented approach, project management, artificial intelligence (intelligent and distributed systems, data mining, etc.), databases, information systems, computer networks, compilers and research methods. All of the mentioned subjects excluding compilers are incorporated in the curriculum "Computer Systems". Moreover, the credits either are identical with the average number of credit points of other curricula in European Union, for example, in Artificial Intelligence, Modern Databases, Information Systems, Research Methods, or are higher, for example, as for Object-oriented Approach.

Table 2. Distribution of subjects by curricula

Country	Number of curricula
Software Engineering	13
Scientific Research Methods	11
Software Project Management	10
Modern Software Development Methods	9
Object-oriented Approach	8
Intelligent Systems	7
Compilers	7
Distributed Computational Systems	6
Information Systems Analysis and Design	5
Computer Networks	5
Modern Databases	4
Databases	4
Artificial Intelligence	3
Data Mining	3
Formal Methods	3
Human-Computer Interface	3
Operating Systems	3
Programming Languages	3
Computer Security	3

Conclusions and future work

Improvement of the already existing curriculum of "Computer Systems" is time and work consuming task which can be carried out only by experienced and well motivated experts–members of academic staff. The paper describes some of the steps within the developed framework which is based on the concept of two-dimensional modularity. The horizontal dimension corresponds to the decomposition of the study programme into subsets of courses which have related topics and are taught concurrently. The vertical dimension corresponds to the decomposition of the study programme into subsets of courses which have related topics and are taught in different semesters or different study levels. Matrix of relations between modules has been developed and the list of interrelated topics constructed.

Analysis of curricula in the field of computer science within European Educational Space allow to conclude that rregardless of the fact that there is a big diversity among curricula in the field of computer science the curriculum "Computer Systems" at Riga Technical University falls within European Educational Space because it includes the most popular subjects. However, in order to provide good opportunities for students' mobility it is necessary to align programmes of study within European Educational Space.

It is worth to stress that in the current economical situation in Latvia such resource-intensive and expensive project directed towards improvement of a university's study programme may be carried out only with the ESF support.

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