

JOINT MASTER'S CURRICULUM IN SOFTWARE ENGINEERING

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ABSTRACT

Developing a joint curriculum across different institutions is a unique and novel initiative to harmonize university education in Europe, sharing the efforts of curriculum development (hence reducing their cost), and to improve the quality of education. Our project covers seven partner institutions from five countries – four in the role of beneficiary partners and three have an advisory role. This paper outlines the principles adopted in the creation and development of an MSc in Software Engineering that is compliant with the Bologna agreement.

Keywords: Curriculum development, master's studies, software engineering, cooperative development, Bologna declaration.

1. INTRODUCTION

The development of a joint software engineering masters programme that complies with the Bologna declaration [3] is a challenging task. This paper outlines the philosophy and some of the principles and experiences of designing such a programme. The project [2] is EU-funded under the Tempus programme which aims at the academic development of non-EU countries [1]. Participants of the project are: Humboldt University Berlin (Germany); University of Novi Sad (Serbia); DeMontfort University, Leicester(UK); Deusto University, Bilbao (Spain); University of Belgrade (Serbia); University of Niš (Serbia); University Sts. Cyril and Methodius (FYR Macedonia). There are also two individual experts from Romania and Bulgaria.

'Joint' is fundamental to the curriculum and initially implemented by our beneficiary partners in South Eastern Europe. By "joint" we take the view that the degree would be common to all participating institutions, with possibilities to share facilities, instructors, and students. As joint studies are still in their infancy within the EU, the central principle of Bologna declaration is to facilitate and foster closer collaboration in (higher) education within the union.

The subject area of the proposed masters is Software Engineering, where Europe is in need to gain a competitive edge. The role of the other project partners (from European Union) is

to give advice for the definition of the curriculum, provide knowledge transfer, and support the quality assurance of the curriculum.

In particular, our goals are:

- establishing basic principles of the MSc studies in software engineering according to the Bologna declaration and to current EU practices. Those studies must be designed to fulfill labor market needs and requirements for international students mobility;
- creating the joint MSc curriculum in such a way that every institution can adopt it with respect to regional needs and its own tradition;
- establishing international recognition and educational quality control.

2. 'JOINT' CURRICULUM: IDEA, ADVANTAGES, AND PROBLEMS

As we have articulated earlier, 'joint' is fundamental to our thinking. We started from the principle that 'joint' should be seen and realised in all of the project life cycles. In particular:

- joint principles of the goals and of the structure of the curriculum;
- joint agreement and acceptance of module list;
- distributed development of teaching materials across universities;
- exchange of teachers/instructors amongst the institutions;
- students mobility across the partners;
- common principles of quality assurance;
- coordination of all development activities.

A central objective of the project is the harmonization of curricula across institutions and countries. The advantages of this harmonization are many and it includes the reduction of efforts in the process of curriculum development and its delivery; increase of knowledge transfer level between European partners; improvement of quality of education; increase of mobility of employment within the EU nations, hence increasing prosperity and quality of life.

One of the challenges in the development of the curriculum is its acceptance by the various institutions. We have therefore started from the position that the overriding principle is flexibility. This is to satisfy the needs of the different educational environments. For example, there are differences in students' pre-knowledge and in teachers' special strengths and in particular traditions at the respective institution.

3. PROJECT OUTCOMES

The following results have been achieved by the project consortium:

- definition of the curriculum goals and structure: learning outcomes, number of semesters, number of modules, ECTS credits;
- list of all modules to be offered in the curriculum which is divided to induction layer modules, core modules, optional modules, final project;
- module templates for each of the module: the requirements specification of a module (aims, learning outcomes, syllabus content, prerequisites, assessment);
- teaching materials for several modules of the proposed module list: presentation material, lecture notes for the teachers, exercises, supporting literature;
- delivery of the first two semester with teachers and students mobility.

4. CURRICULUM GOALS AND STRUCTURE

The mission of our joint curriculum has been defined as follows:

The MSc curriculum in software engineering is committed to excellence in European-wide software education and training of engineers to deliver high quality and trustworthy software systems that meet the local industrial needs.

Based on that mission, more detailed learning outcomes have been derived from acknowledged experience and principles of software education and training. To check the curriculum against the needs of European software industry, the curriculum specification has been positively reviewed by ESI (European Software Institute).

The whole curriculum covers three semesters: The first semester includes core modules compulsory for the students. The second semester offers a list of elective modules from which students can select. Finally, in the third semester, a project has to be conducted. Each semester lasts 15 weeks with a total value of 30 ECTS credits (1 ETCS = 20 hours of total student's workload).

In case students do not fulfil the entry requirements, an additional induction layer is offered for the beginners.

5. MODULE LISTS

Figure 1 provides an overview of the module lists connected with the different semesters. These modules cover a broad area of software engineering fields. The intention is that the consortium elaborates teaching materials for all of these modules. On the other hand, the particular institution is free to select a subset of these modules to be offered to its students. In that way, the needs of different educational environments can be better satisfied.

Induction layer	1st Semester: Core modules	2nd Semester: Elective modules	3rd Semester: Project
<ul style="list-style-type: none"> ● Introduction to software engineering ● Principles of programming, coding and testing ● Project management ● System modeling and design 	<ul style="list-style-type: none"> ● Research methods ● Requirements engineering ● Architecture, design, and patterns ● Software testing ● System integration ● Information system development process 	<ul style="list-style-type: none"> ● Software evolution ● Component-based development ● Formal methods engineering ● Software engineering for critical systems ● Privacy, ethics, and social responsibilities ● Applied system thinking ● Business modelling ● E-business ● Business process re-engineering ● Service quality management ● Software engineering for database systems ● Advanced topics in software engineering 	<ul style="list-style-type: none"> ● Project, e.g. <ul style="list-style-type: none"> - Electronic Patient Records - Electronic purse - Flight Control Systems - ...
<div style="border: 1px solid black; padding: 5px; transform: rotate(-15deg); display: inline-block;"> 1 ECTS = 20 hours of total student's workload </div>	30 ECTS 15 weeks	30 ECTS 15 weeks	30 ECTS 15 weeks

Figure 1. Overview of the module lists

6. MODULE TEMPLATES

Having defined the structure of the curriculum and the respective module lists, each of the modules had to be described by a corresponding requirements specification which we call module template.

A module template defines the

- aims

- learning outcomes
- syllabus
- prerequisite
- recommended assessment

of that module.

As an example, figure 2 provides the module template of the core module 'Research methods'. These module templates form the basis for the next step, the development of teaching materials. Teaching material developers have to implement the information provided by module templates.

<p>RESEARCH METHODS (SE-C-01)</p> <p>AIMS: The module will introduce and develop the concepts, organisational structure and deliverables of a research project using qualitative and quantitative methods. To extend to a postgraduate level, the student's appreciation and understanding of how to organise, to plan and 'execute' a technical research project.</p> <p>LEARNING OUTCOMES: Upon successful completion of this module, the student will be able to:</p> <ul style="list-style-type: none">• prepare, plan and monitor a research project using tools and skills needed for critical evaluation and analyses of project results;• formulate, plan and communicate a research project;• select and appreciate the appropriate search methods for collection of information;• demonstrate knowledge and experience on procedures and methods for structuring, gathering and handling of information and data in a technological environment. <p>SYLLABUS CONTENT:</p> <ul style="list-style-type: none">• Project approaches: project management, quality management.• Communication skills: presentation skills, literature search & patents, technical report writing.• Methods for research: problem analyses and problem solving techniques; methods for structuring a problem; qualitative methods for system/process analyses and performance assessment; quantitative methods for data gathering and data analyses; experiment design and collection of data, performance analyses, variance analyses, statistical quality control, statistical process control; plagiarism and referencing; health and safety aspects of research <p>PREREQUISITES: None</p> <p>RECOMMENDED ASSESSMENT: course work</p>
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Figure 2. Module template example

7. TEACHING MATERIALS

The first stages – definition of curriculum goals and structure, of the module lists, and of the module templates – were more or less a joint activity of the whole consortium.

Teaching material development can be considered more as an individual activity. Each of the modules had been assigned to a single module developer (in some cases, two staff members have been involved). Thus, a distributed development of teaching materials by consortium partners took place.

During that activity, several visits of beneficiary partners took place at the advisory partners as teacher retraining to provide expertise.

Teaching materials consist of several parts:

- Presentation materials
- Supporting literature for lecturers
- Lecture notes explaining the way in which the material (e.g. a slide content) should be delivered to the students
- Materials for theoretical and practical exercises (assignments, solutions, tools ...)
- Supporting literature for students.

8. QUALITY ASSURANCE STRATEGY

For the sake of quality of the whole curriculum and its parts, a quality team has been formed. The members of this quality team and their individual tasks can be found in Figure 3.

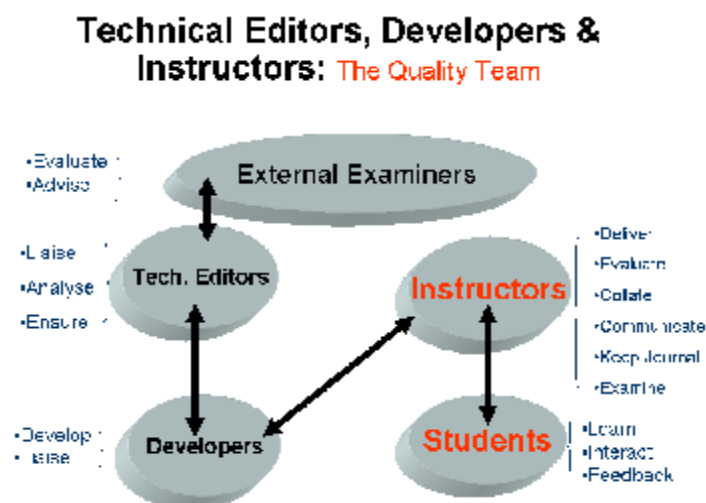


Figure 3. Quality team and its tasks

The external examiner is responsible of the assessments of students performance, i.e. he/she will be active during the examination process.

In our project, we introduced a number of technical editors. They are responsible for a couple of modules, in particular of the quality of teaching materials provided by the module developers.

9. REVIEW OF THE CURRICULUM DEVELOPMENT PROCESS

The whole project went to a sequence of phases starting at the end of 2004. These phases covered [7]:

- Definition of the curriculum goals; analysis of the situation at partner universities; analysis of the special requirements of the local software industry;
- Based on that, definition of the structure and the contents of the curriculum;
- Development of teaching materials;
- Delivery of the curriculum.

During this process, the consortium had to cope with several challenges.

A: National educational environments:

While on one hand there was an urgent need of well-educated software engineers in South Eastern Europe, during the whole development time we were confronted with instable educational environments in these countries. National university reforms in Serbia and FYR Macedonia took place – however, without definite clear decisions. Thus, even the length of the proposed curriculum which should be the same throughout the participating institutions was subject to insecurity.

B: Differences between partner institutions:

The curriculum has been developed for four different faculties with different traditions in education and research where two of them are part of engineering faculties and two of them part of faculties of natural sciences. Correspondingly, their ideas of the curriculum contents were different from each other. One of the issues was the role of theoretical foundation in master studies which had been traditionally underestimated by engineering faculties.

C: Flexibility:

The described diversities in national and institutional environments could only be handled by a flexible construction of the curriculum. Rather than to prescribe identical structures of the curriculum throughout all institutions, a curriculum framework has been developed. Based on the pool of teaching materials developed for the proposed module list (cf. Figure 1), the single institution has the freedom to select appropriate ones, in particular from the elective modules. In that way, the traditions and the capacity of a particular faculty could be taken into consideration in a convenient way.

D: Teaching material development:

The development of teaching materials from scratch is a time-consuming activity. Although there were existing teaching materials of EU partners, only some of them were completely sufficient to serve the needs of the joint studies. Thus, a larger amount of new materials had to be produced. Main emphasis had to be placed on reusability: Existing teaching materials normally were not reusable since a lot of add-on information was only in the minds of the module developers. Thus, teaching materials had to be enriched by lecture notes to enable their application by a lecturer that has not developed the materials. Lecture notes consist of teaching tips (methodological information) as well as additional technical information.

10. EXPERIENCE FROM THE FIRST DELIVERY OF THE CURRICULUM

The curriculum has started in February 2007.

The first delivery has been implemented with teachers mobility as well as with students mobility.

Nine lecturers from seven universities (Leicester, Novi Sad, Skopje, Nis, Bilbao, Berlin, Budapest) presented lectures and seven assistants from three universities accompanied the exercises. Students from three universities – Novi Sad (Serbia), Skopje (FYR Macedonia), and Nis (Serbia) – took part in students mobility.

All these activities have been covered so far by funds of our EU Tempus project. Thus, there is the natural question how the sustainability can be reached after the end of the project. The answer might be manifold: Local lecturers are just becoming enabled to deliver modules by teacher retraining within the current project and by being involved in the module development and module delivery.

In the future, teacher mobility between the involved universities is necessary. To that end, there is the plan to make use of another source: the CEEPUS network. CEEPUS (Central European Exchange Program for University Studies – <http://ceepus.info>) is a well established organization supporting teachers and students mobility. Recently CEEPUS also supports implementation of joint studies.

By now, teachers mobility is favoured in future deliveries of the curriculum. Students mobility, as implemented so far in the joint studies (spring semester 2007), proved to be tedious for host institutions (lack of students dormitories; lack of institutional support for students mobility). In other words, students mobility for larger groups of students can only succeed over a longer period if additional staff takes care of it.

11. CONCLUSIONS

The first delivery of the joint curriculum has started in February 2007 with teachers mobility as well as students mobility at three universities of two countries.

Thus, the first delivery corresponds to the official definition of a joint degree [4,5,6]: “Programmes leading to the award of a double, multiple or joint degree are characteristically offered by a consortium of at least two partner universities from different countries and require student mobility as a mandatory part of the curriculum” [6].

The main experiences gained so far can be summarized as follows:

- A strict project organization is necessary to coordinate the cooperation between different project partners.
- Common principles of quality assurance are crucial in such a multi-lateral project: curriculum validation by a validation panel covering academics and industrialists; quality assurance of teaching materials by defining a strict process of their development and assessment; common principles of students’ selection and students’ assessment; coordination of the activities by a quality team.
- It is rather advantageous that experts of certain special fields are being responsible to work out the teaching materials in that field.

- The elaborated curriculum has been originally developed for the partner universities in South-Eastern Europe. Meanwhile, DeMontfort University Leicester decided to adopt the curriculum, too.

The next project phase will cover, among others, mutual recognition of the studies by partner institutions.

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მაგისტრანტთა სწავლების გეგმა სპეციალობით „პროგრამული უზრუნველყოფის დამუშავება“

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რეზიუმე

ერთიანი სასწავლო პროგრამების შემუშავება სხვადასხვა დაწესებულებებისათვის – უნიკალური და ახალი ინიციატივაა ევროპაში საუნივერსიტეტო განათლების შესათანხმებლად, ერთიანი ძალისხმევით პროგრამათა სრულყოფის (ღირებულების შემცირების თვალსაზრისით) და მათი ხარისხის ასამაღლებლად. ჩვენი პროექტი მოიცავს 5 ქვეყნის 7 უმაღლეს პარტნიორ სასწავლებელს, რომელთაგან 4 თანამონაწილის და 3 კონსულტანტის სტატუსითაა. ნაშრომში გამოკვეთილია ძირითადი პრინციპები, რომლებიც მიღებულ იქნა „მეცნიერებათა მაგისტრის“ სასწავლო კურიკულუმის შექმნისა და განვითარების მიზნით სპეციალობაში „პროგრამული უზრუნველყოფის ინჟინერია“, რომელიც შეესაბამება ბოლინიის შეთანხმებას.

**ПЛАН ОБУЧЕНИЯ МАГИСТРАНТОВ ПО СПЕЦИАЛЬНОСТИ
»РАЗРАБОТКА ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ«**

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Резюме

Разработка совместной программы поперек различных учреждений - уникальная и новая инициатива согласовать университетское образование в Европе, совместно используя усилия развития программы (следовательно уменьшающий их стоимость), и улучшать качество образования. Наш проект охватывает семь учреждений партнера от пяти стран - четыре в роли партнеров бенефициария, и три имеют консультативную роль. Эта работа выделяет принципы, принятые при создании и развитии программы магистра ("Master Science") по специальности "Разработка программного обеспечения" (Software Engineering), которая является в соответствии с Болонским Соглашением.