Development of an environmental and resources engineering learning

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INTRODUCTION

The environmental engineering higher education and lifelong learning program development are discussed in this paper with reference to the European Union's TEMPUS (Trans European Mobility Programme for University Studies) action, which supports the modernisation of higher education in the Partner Countries of Eastern Europe, Central Asia, the Western Balkans and the Mediterranean region, mainly through university cooperation projects [1][2].

Modernization of curricula in academic disciplines is one of the TEMPUS priority themes. DEREL (Development of Environment and Resources Engineering) is a TEMPUS project [3][4], leaded by the University of Firenze (UNIFI), Italy, in the period 10/2010 – 06/2014. The DEREL Consortium consists of 11 Universities (4 EU and 7 Partner Countries (PC)), and 7 non-academic institutions. The project introduced a new, up-to-date, second cycle degree in Environment and Resources Engineering at DEREL PC Universities: Ss Cyril and Methodius University in Skopje – UKIM (FYR of Macedonia), University of Novi Sad - UNS (Serbia) and Polytechnic University of Tirana – PUT (Albania), based on the European Credit Transfer System – ECTS [5], and in accordance with the Bologna Process [6], following the conditions for setting up a Double Second Cycle Degree. The project also implemented a sustainable regional network aimed to offer lifelong learning seminars for environment and resources engineering education and training of interested stakeholders, and to organize workshops focused on strengthening the links in the knowledge triangle: environment education-innovation-research. The three agreements between UNIFI with UKIM, UNS, and PUT for establishment of shared educational paths in the environmental programs, aimed at awarding double degree titles between UNIFI and DEREL PC Universities, are one of the significant concluding objectives of the project.

The DEREL project is extension of the previosly successfully finished TEMPUS Joint European Project_19028_2004, entitled as DEREC – Development of Environmental and Resources Engineering Curriculum [7][8], which was aimed to achieve the following objectives: (i) to develop a new three-years undergraduate curriculum in Environmental Engineering at the "Ss. Cyril and Methodius" University in Skopje, FYR Macedonia, based on the European Credit Transfer System and in accordance with the Bologna Declaration; (ii) to fulfil the necessary conditions for offering a Double

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Degree in Environmental Engineering which is to be implemented on the basis of an agreement between the University "Ss. Cyril and Methodius", Skopje and the University of Firenze.

The DEREL second cycle degree and lifelong learning courses were prepared on the basis of the following investigations and documents: (i) surveys of the PC environmental needs analysis, identifying the specific problems and needs on which the DEREL project should focus; (ii) expertise of the DEREL academic staff; (iii) questionnaires filled in by relevant industry and non-governmental organizations. The analysis of the environmental capacity needs of the DEREL Partner Countries (Serbia, Albania and FYR of Macedonia) showed that there is a clear necessity to introduce into the higher education systems, in these three countries, one modern, interdisciplinary integral second cycle curriculum in environmental and natural resources engineering, as well as a set of corresponding lifelong learning courses. The reference ECTS ranges for the DEREL second cycle curriculum, as well as the minimum number of ECTS for the access to the second cycle degree course, given as competence areas and disciplines, are discussed in this paper. The main DEREL project findings useful to the engineering education community are also presented.

1 TEMPUS DEREL PROJECT EXPERIENCE

Curricula harmonization and lifelong learning programme development in higher education are among the focused aspects of the TEMPUS action, since 1990 [1]. Higher education includes teaching, research and social services activities of universities, and refers to a level of education provided by universities, colleges, institutes of technology awarding academic degrees or professional certifications [2].

The TEMPUS JP_511001_2010, titled as DEREL – Development of Environment Engineering Learning, was financed by the European Commission in a period October 15th, 2010 – June 14th, 2014, and had as general objective the improvement of higher education and lifelong learning systems in the fields of environment and resources engineering for a sustainable development [3][4]. The DEREL project implementation contributes to the reform of contents, teaching methodologies and the structure of the Second Cycle environment and resources engineering studies, in universities from three Western Balkans Partner Countries: Albania (AL), FYR of Macedonia (MK) and Serbia (RS). One specific main objective of the project was, in fact, the development of new up-to-date, second cycle degree curricula in Environment and Resources Engineering at the three PC universities: Ss. Cyril and Methodius University in Skopje (MK), University of Novi Sad (RS), and Polytechnic University of Tirana (AL). The DEREL academic staff developed the second cycle degree curricula in Environment and Resources Engineering taking into account all positive results and achieved objectives of TEMPUS Joint Project DEREC. The DEREL studies have started in the academic year 2012/2013 and, in accordance with the Bologna Process, are based on the European Credit Transfer System. The curricula development has the further specific and important purpose of following the criteria and conditions for setting up a Double Second Cycle Degree.

The implemented TEMPUS project DEREL, based on the Bologna Declaration, has contributed to the reform of contents, teaching methodologies and the structure of the University studies in Environmental Engineering at the Partner Countries (PC) Universities involved (FYR of Macedonia, Serbia and Albania). Taking into account the environmental policy established and led by the corresponding Ministries in the Partner Countries, in addition to their intentions to follow the guidelines of European Union in terms of higher education and environmental policy, the necessity to develop of new interdisciplinary first and second cycle curricula, as well as lifelong learning programme, in environmental and resources engineering, was underlined.

The DEREL project also leads to the development and implementation of a sustainable regional DEREL network in which all DEREL Universities participate, aimed at: (i) Developing lifelong learning seminars at the DEREL Partner Countries for continuous environment and resources engineering education and training of interested stakeholders (i.e. public services, enterprises, non-governmental organizations); (ii) organizing and working out workshops focused on strengthening the links in the knowledge triangle: environmental education-innovation-research, with participation of postgraduate students, public services, enterprises, and non-governmental organizations as well as in cooperation with all stakeholders interested in environment and resources engineering issues.

The main outcomes of the TEMPUS DEREL project are described in the following with a brief description of the guide elements as well as the effects and the positive consequences.

Three new up-to-date, second cycle degree curricula in Environment and Resources Engineering are developed and accreditated at three Partner Countries universities in Serbia, Albania and FYR of Macedonia. The new curricula, properly and specifically designed have been enhanced by the three agreements between UNIFI with UKIM, UNS, and PUT which establish shared educational paths in the environmental programs, aimed at awarding double degree titles between UNIFI and DEREL PC Universities, as significant concluding objectives of the project.

A Lifelong training program in environmental and resources engineering was also developed, with a set of 30 lifelong learning courses. These courses established strong foundations for development and implementation of a sustainable regional DEREL network, for education and training in the field of environmental and resources engineering, which is crucial for the further development of a cooperation and partnership with public services, enterprises, NGO's and all other interested stakeholders.

DEREL Second Cycle courses and lifelong learning courses were prepared on the basis of the surveys of the PC environmental needs analysis, expertise of the DEREL academic staff and questionnaires filled in by relevant industry and non-governmental organizations. Development strategies of Partner Countries, local regulation and national environmental action plans were also taken into account. DEREL project gave high priority on development of partnership with industries increasing the knowledge triangle education-innovation-research. Particularly, enterprises and non academic partners were actively participating in the six lifelong learning seminars and the three workshops organized in the framework of the DEREL project. Students and other interested stakeholders were actively involved in the project giving a feedback through filling in corresponding questionnaires.

Among the consequences of the project are the establishment of a DEREL network aimed to provide future scientific and research cooperation and achievement of sustainability of the DEREL project results. Partner Countries Universities acquired modern equipment for education and research in the environmental and resouces engineering area. PC staff training and retraining at EU Universities was completed through four seminars of one week of training. The cooperation network has reinforced also by the nine international students' who performed three months of mobility. Seven students from PC Universities spent their mobility periods at UNIFI and two were from UNIFI to Ss Cyril and Methodius University.

Educational materials for all twenty DEREL Second Cycle courses and thirty lifelong learning courses were worked out and printed both in paper and electronic versions. Adaptation of the DEREL curricula courses for web-based access was also performed using the corresponding online learning equipment. Blended learning courses methodology for the DEREL courses was developed.

Numerous activities for dissemination of the DEREL project results were performed, with distribution of large number of dissemination materials about the DEREL curriculum, DEREL studies, lifelong training program developed, etc..

As far as the assessment is concerned an external quality assessment of the DEREL project was ensured through the contribution of external evaluators, who monitored the whole process of project realization, and have prepared corresponding reports, which significantly increased the quality of the project results. Furthermore three Self-Assessment Reports for the DEREL curricula at the PC Universities were prepared in order to be applied at the ENAEE (European Network for Accreditation of Engineering Education) for awarding the EUR-ACE® accreditation label.

2 APPROACH AND METHODOLOGY

The curriculum and lifelong training program which were developed in DEREL project are based on the definition of study paths, aimed to establish specific competences for dealing with the complexity of environment and anthropogenic activities interactions, to analyse and evaluate the effects of these interactions, to understand the physical phenomena, to predict the consequences and to plan control, protection and mitigation interventions. Also environmental risks assessment, i.e. floods, droughts, earthquakes, wind, fire, and pollution, as well as a suitable exploitation of natural resources, i.e. water, air and soil, were included in the curricula development since they are the aspects that most influence

the process of sustainable development of a modern society. In the same field, research activity aims at developing new methods and technologies, in order to reduce the environmental impact of human activities and protect the environment, and to deal with the sustainability of development. This includes, for example, water and soil protection expertizes, waste treatment technologies, built environment assessment, mitigation and adaptation to climate change effects.

2.1 The "Environmental Engineering" curricula

The minimum requirements of the Italian Ministry of Education, University and Research, as well as the internal requirements of the School of Engineering – University of Firenze and of the Degree Course Council, has been considered as landmarks for the minimum reference ECTS range of the first cycle degree course on "Environmental Engineering", as presented in *Table 1*:

Table 1. Minimum reference ECTS according to the Italian Minister Decree (DM270/2004) and ECTS range of the 1st cycle degree course on "*Environmental Engineering*" at the School of Engineering – University of Firenze.

EDUCATIONAL DISCIPLINES		*Minimum reference ECTS*	*ECTS range*
Basic knowledge activities:		36	39-72
	Mathematics, Informatics and Statistics		*21-39*
	Chemistry & Physics		*18-33*
Characteristic skills:		45	57-90
	Civil Engineering		*24-36*
	Environment and Territory Engineering		*24-36*
	Security, Civil, Environmental and Territory Protection		*9-18*
Integrative activities		18	18-42
Student autonomous activities		12	12-12
Foreign language assessment			3-3
Final exam			6-6
Others (Stage, etc.)			1-24

In the frame of the DEREL project, the contracting and coordinating institution, the University of Firenze, School of Engineering, has presented the general requirements, i.e. minimum ECTS of the Italian Ministry of University and Research and local conditions of the School of Engineering and the Degree Course Council, to be met in order to fulfil the necessary conditions for offering a Double Second Cycle Degree Title. This constitutes the first main objective of the DEREL project, and it is implemented on the basis of a specific agreement between the University of Firenze and the involved PC Universities, the Ss. Cyril and Methodius University, Skopje, the University of Novi Sad, and the Polytechnic University of Tirana, signed by Rectors of these universities.

Following the minimum requirements above and in general with reference to the second cycle degree courses running at all the EU consortium members universities involved in the project, the draft general frame of DEREL curriculum, e.g. the reference ECTS ranges dedicated to the characteristic skills for environmental engineering, to the integrative knowledge activities, to the student autonomous activities, to the stage activities, as well as to the thesis and final exam, have been also defined, as presented in*Table 2*.

Table 2. Reference ECTS ranges for the DEREL Second Cycle curriculum

Educational disciplines & activities		Minimum number of ECTS	Maximum number of ECTS
Characteristic Skills for Environmental Engineering		45	66
Integrative Knowledge Activities		24	54
Student Autonomous Activities		8	18
Final Exam		10	18
Further educational activities	Foreign Language	0	3
	Computer Science Skills	0	3
	Stage	0	15
	Vocational guidance	0	3
Stage activities		3	

The conditions for the admission to the postgraduate level are also defined. In particular, to be enrolled to the postgraduate curriculum on "Environment Engineering", the students must have acquired 90 ECTS (out of 180 ECTS) during the 1st cycle course, as in *Table 3.*

Table 3. Minimum number of ECTS for the access to the Second Cycle Degree Course, given as competence areas and disciplines

Competence Area	Reference Scientific Disciplines	Minimum ECTS
Mathematics, Computer Science and Statistics	Algebra. Geometry. Mathematics. Statistics and Mathematical Probability. Mathematical Physics. Statistics for experimental and technology research	33
Physics and Chemistry, Safety, Civil, Environment and Territory Protection	General and Inorganic Chemistry. Fundamentals of Chemistry and Technology. Experimental Physics. Matter Physics. Electrotechnics.	21
Structural Engineering and Soil Mechanics	Soil Mechanics. Structural Mechanics. Structural Engineering.	12
Environmental and Territory Engineering	Applied Geology. Applied Geophysics. Hydraulics. Fluid mechanics. Hydraulic and maritime structures and hydrology. Environmental and sanitary engineering. Topography and Cartography.	24
TOTAL		90

If the minimum of 90 ECTS is not satisfied by less than 30 CFU, the Enrolment Evaluation Committee proposes students a preliminary access path, including undergraduate study course exams, which have to be passed by perspective students, before official enrolment in the second cycle degree course on "Environment Engineering".

2.2 The DEREL lifelong learning program

The DEREL lifelong learning program was developed in the framework of the DEREL project, with participation of all 11 DEREL universities. The program has 30 lifelong courses from the following 6 scientific areas: management of water resources, wastewater management, solid waste management, geoenvironment technologies, renewable energy technologies and natural hazards. DEREL lifelong learning courses were presented on 6 seminars and 3 workshops organized in a period April 2013 – April 2014, in 3 DEREL Partner Countries – Albania, FYR of Macedonia and Serbia, with active participation of large number of interested stakeholders from environmental ministries and agencies in the DEREL Partner Countries, non-governmental organizations, environmental industry, water supply companies, solid waste management companies, graduate and postgraduate students, etc.

The six DEREL lifelong learning seminars and three workshops enabled creation of sustainable linkages in the DEREL consortium: (i) building up of a DEREL network by joining together the DEREL Consortium and participants from the seminars and workshops; (ii) continuous knowledge transfer between DEREL EU and PC Universities; (ii) increasing of direct linkages of the DEREL network with large industrial partners and Small and Medium Enterprises (SMEs); (iii) Creating and networking a database of governmental, non-governmental and industry partners.

3 DEREL PROJECT OBJECTIVES

3.1 The curricula development

The educational program of the Second Cycle Environmental Engineer is organized in two years. In the first year the students study in-depth modelling skills (in the mathematic and numerical field, and systems engineering); the ability of analysis and economic evaluation in relation to plants and works to be included in the territory are enhanced by; training especially in the fields of hydraulics, geology and engineering environmental health, are completed. The second year is dedicated to develop expertise in the various operational areas of Environmental Engineering: Land Protection, Plant, Quality of the Environment and Energy; Environmental Risk Management. After successful completion of the second cycle Final Exam (Postgraduate Diploma Work) the student is awarded with the title Master of Science in Environmental and Resources Engineering.

3.2 The educational objectives

The main educational objectives of the DEREL curricula, as well as the DEREL lifelong learning program, are as follows:

- To foster the acquisition and implementation of broad research and analytical skills related to environmental and resources engineering.
- To respond to the changing impact of environmental engineering solutions in a global and social context.
- To produce graduates equipped to pursue careers in industry, the public sector and non-governmental organisations.
- To be employed and promoted, after graduating, as environmental engineers in consulting, industry, government, and academia or in related professions.
- To Maintain state-of-the-art knowledge through lifelong learning and continuing education.
- To Provide lifelong learning program in environmental and resources engineering, in order to offer to any interested stakeholder a set of modern environmental training courses which update and upgrade their specific competences about the sustainability of human presence on the territory.
- To support the engineering profession through participation in professional societies, civic groups, and educational institutions.

The DEREL graduates are able to adequately answer the demand of technical innovative competences in the environmental and resources engineering and have specific synthetic capacity to solve problems in the environmental field. They are high level professionals, with advanced knowledge in the modern environmental and resources engineering. DEREL graduates have analytical and numerical modeling capabilities to apply advanced mastery of methods and technical and scientific knowledge in the environment and resources protection and control. The education of the DEREL graduates is also designed for the long life learning and the specialization on defined sectors or scientifically advanced for the third level of the educational path.

3.3 The Double Degree

The University of Firenze (UNIFI), as grantholder of the DEREL project, and the DEREL Partner Countries Universities – Ss Cyril and Methodius University in Skopje, University of Novi Sad and Polytechnic University of Tirana, are in a procedure of signing an Agreement for the establishment of shared educational paths in study courses “environment and territory protection engineering” of the second cycle degree class of the University of Firenze on one side and the corresponding curricula at

the PC Universities, on the other side, aimed at awarding the double degree titles of UNIFI and PC Universities.

For the mutual recognition of degree titles between the Environmental Engineering curriculum at the University of Firenze and the curricula designed in the PC, a certain conditions have been fulfilled in order to ensure the following: (i) the exchange students to obtain at the partner university at least 30 ECTS, previously approved by the Degree Council of the home university, on the basis of a learning agreement which considers also the remaining credits that the students will acquire in the home university; (ii) to make the first year in the two curricula similar enough to allow equivalence; (iii) to make the second year in the curricula significantly compatible in order to allow student exchange in the respect of the Italian regulation and obtain the equivalence, for the selected students involved in the international mobility activities.

4 DEREL PROJECT FINDINGS

DEREL project findings useful to the engineering education community are underlined in the following. A clear necessity to introduce one modern, interdisciplinary integral postgraduate curriculum in environmental and natural resources engineering into the higher education systems of the three Partner Countries – Serbia, Albania and FYR of Macedonia, was revealed. The common learning outcomes posed the basis for the establishment of the agreements for shared educational paths in the environmental programs, aimed at awarding double degree titles between EU and Partner Countries.

International student's mobility from Partner Countries to EU Universities and vice versa, should be enhanced as much as possible, giving the opportunity to the students, irrespective of the country in which they are enrolled, an opportunity to enhance their Higher Education experience by exploring a different country and culture over short stay or exchange programmes. Particularly educational institutions should actively encourage students to broaden their horizons by creating the right environments and opportunities for young people to develop global competencies.

Lifelong training program in environmental and resources engineering is always necessary to be implemented, especially in the Partner Countries involved, since there is a constant advancement in technology and hence it is necessary to continue learning. In this framework, a priority should be put on development of partnerships of universities with the environmental industries and increasing the knowledge triangle environmental education-innovation-research. At the same time Development strategies of Partner Countries, local regulation and national environmental action plans must be taken into account in developing the environmental enginenering education. The regional cooperation in environmental engineering must be also on a high level, since the environmental problems do not recognize borders and always have at least regional impact.

Dissemination of the project results must be on-going activity that happens throughout the lifetime of a research project. Dissemination is very important since it is the main way through which the project communicates with the outside world.

Students and any other interested stakeholders shoud be actively involved in the project giving a feedback through filling in corresponding questionnaires.

Academic staff training and retraining is important step in development of modern postgraduate and lifelong learning courses.

Although the online learning can deliver basic skill instruction, procedural training and simulations to a wide and geographically dispersed audience, the value of on-the-job training, one- to-one coaching and a mentor cannot be denied either.

External quality assessment of the project activities shoud be ensured in order to get monitoring of the whole process of project realization and, if necessary, corrections and improvements. For this reason the EUR-ACE® model with its Framework Standards ensure that: (i) study programmes in engineering maintain defined educational standards; (ii) provide an appropriate "European label" to the graduates of the accredited educational programmes to complement the labels awarded by national accreditation agencies; (iii) facilitate trans-national recognition thanks to the common European label; (iv) facilitate mutual recognition agreements; (v) facilitate recognition by the competent authorities in accord with EU Directive 2005/36/EC.

SUMMARY

TEMPUS DEREL (Development of Environment and Resources Engineering Learning) project experience and objectives are presented in this paper. The main characterictics and guide elements of the second cycle environmental engineering curriculum, as well as the lifelong learning program, worked out in the framework of the DEREL project, are described. The approach and methodology implemented in the development of the DEREL courses are pointed out. DEREL project findings useful to the engineering education community are discussed.

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