

Environmental engineering curricula development

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INTRODUCTION

The environmental engineering education is 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].

Environmental Engineers are technicians and professionals with specific competences on the sustainability of human presence on the territory. Among the challenges of this specific kind of engineer are: a) the emissions and sinks of greenhouse gases; b) the energy and water linkage; c) the resilience to disasters of natural and technological origin, as recently stated by the Sciences Academies [3]. National science academies of 15 countries, including the UK, the US, China, Germany, Russia and India, signed the joint "G-Science" Statements [3], calling on world leaders at annual G8 Summits to focus on three "global dilemmas": growing demands for water and energy, natural disasters and measuring carbon dioxide. The scientists recommended that governments should "engage the international research community in developing systematic, innovative solutions" to these pressing problems.

Already in 1992, the Governments, at the United Nations Conference on Environment and Development (UNCED), informally known as the "Earth Summit", in Rio de Janeiro, were called to rethink economic development and to find ways to arrest the destruction of irreplaceable natural resources and pollution of the planet.

More recently, in 2012, at the United Nations Conference on Sustainable Development "Rio+20", held in Rio de Janeiro [4], the Governments confirmed and updated the need to redirect international and national plans and policies to ensure that all economic decisions fully took into account any environmental impact. The definition of the pathways to a sustainable future, i.e. a future with more jobs, clean energy, greater security and a decent standard of living for all, was among the objectives of the conference. "Rio+20" constituted an unprecedented opportunity to build "The Future We Want", as it was aiming for political consensus on a global plan which balances and integrates economic and social development and environmental protection. Thus, in an economic and social sustainable developed word, the environmental protection is becoming a more and more relevant subject, both at European and global level. Environmental policy is object of discussions, in different conferences and prime ministers summits, and constitutes a priority of policy in an increasing number of countries. The necessity to develop new, modern, integral interdisciplinary undergraduate curricula in environmental engineering within the Higher Education System has its starting point from the conditions described above.

Particularly, two "Environmental Engineering" curricula, carried out within two TEMPUS projects [5],[6], are presented in this paper. Both the 1st and 2nd cycle curricula, developed through these projects, are based on the European Credit Transfer System [7] and are in accordance with the Bologna Process [8].

The first TEMPUS Joint European Project, carried out in the period 2005-2008, by the University of Firenze in cooperation with the Ss Cyril and Methodius University in Skopje, FYR of Macedonia, was entitled DEREC – Development of Environmental and Resources Engineering Curriculum [5]. Within DEREC a new three-years 1st cycle curriculum in Environmental and Resources Engineering was opened at the University Ss Cyril and Methodius, Skopje, and the necessary conditions for offering a Double Degree, on the basis of an agreement between the Ss. Cyril and Methodius University and the University of Firenze, were fulfilled.

The second TEMPUS Joint Project, called DEREL – Development of Environment and Resources Engineering Learning, is active since October 2010 [6]. The DEREL project, as a continuation of DEREC, is aimed to introduce new, up-to-date, 2nd cycle curricula in Environment and Resources Engineering at the Ss Cyril and Methodius University in Skopje, FYR of Macedonia, University of Novi Sad, Serbia and Polytechnic University of Tirana, Albania, following the criteria and conditions for setting up a 2nd Cycle Double Degree. The new 2nd Cycle Degree Course, i.e. DEREL curricula, have been activated in the current academic year 2012/2013.

1 CURRICULA DEVELOPMENT WITHIN THE TEMPUS PROJECTS

Since 1990 curricula harmonization and lifelong learning programme development in higher education are among the focused aspects of the TEMPUS – Trans European Mobility Programme for University Studies action [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 implemented projects, both 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 PC, in addition to their intentions to follow the guidelines of European Union in terms of

higher education as well as environmental policy, the necessity of development of a new multidisciplinary and interdisciplinary 1st and 2nd cycle curricula in "Environmental Engineering" was stressed. Given, in fact, the background situation in the PC, the introduction of new curricula in environmental engineering has also been relevant towards the discussion of important topics of the engineering education field.

1.1 The TEMPUS Joint European Project DEREC

The TEMPUS JEP_19028_2004, entitled DEREC – Development of Environmental and Resources Engineering Curriculum [5],[9],[10] was aimed to achieve the following objectives: (i) to develop a new three-years 1st cycle curriculum in Environmental and Resources Engineering at the Ss. Cyril and Methodius University in Skopje, FYR Macedonia, based on the European Credit Transfer System [7] and in accordance with the Bologna Declaration [8]; (ii) to fulfil the necessary conditions for offering a Double Degree in "Environmental Engineering" which is to be implemented on the basis of an agreement between the Ss. Cyril and Methodius University and the University of Firenze. In order to create an adequate support towards the fulfilment of the relevant objectives to the realisation of a coherent European Higher Education Area and the achievement of expected outcomes, a Consortium has been created. The Consortium was composed by six Universities, the Macedonian Ministry of Education and Science, and two individual experts, from Bulgaria and from Germany. Two Universities were from FYR Macedonia: Ss. Cyril and Methodius University in Skopje, Grant Coordinator Institution, and South-East European University, of Tetovo. Four Universities were from European Union: the University of Firenze, Grantholder Institution, Aristotle University of Thessaloniki, Greece, Ruhr University Bochum, Germany, and Vienna University of Technology, Austria.

1.2 The TEMPUS Joint Project DEREL

The TEMPUS JP_511001_2010 called DEREL – Development of Environment Engineering Learning, and financed by the European Commission for the three years period October 15th, 2010 – October 14th, 2013, as general objective has the improvement of higher education and lifelong learning systems in the fields of environment and resources engineering for a sustainable development [6],[11]. The DEREL project implementation contributes to the reform of contents, teaching methodologies and the structure of the 2nd cycle "Environment 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 is, in fact, the development of new up-to-date, 2nd cycle curricula in "Environmental 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 2nd cycle curricula in "Environment Engineering" taking into account all positive results and achieved objectives of TEMPUS Joint Project DEREC. The 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 2nd Cycle Degree in "Environmental Engineering".

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.

2 APPROACH AND METHODOLOGY

The education and training programmes which were developed in DEREC and DEREL TEMPUS projects 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 analyze 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 natural disasters 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 expertises, waste treatment technologies, built environment assessment, mitigation and adaptation to climate change effects.

2.1 The 1st cycle curriculum

The DEREC project implementation coincided with the revision of the educational offer at the School of Engineering of the University of Firenze. Particularly, 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, has been considered as landmarks also for the DEREC project (*Table 1*). The revision of the curriculum was also attended by representatives of the labour market. Suggestions and guidance have been taken into account in the design of the new study programme.

Table 1. Reference ECTS ranges of the DEREC 1st cycle curriculum on “Environmental Engineering”

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

2.2 The 2nd cycle curriculum

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 2nd Cycle Degree. This constitutes the first main objective of the DEREL project, and has to be 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.

Following the minimum requirements above and in general with reference to the 2nd 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 (*Table 2*).

Table 2. Reference ECTS ranges for the DEREL 2nd cycle curriculum on “Environmental Engineering”

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
<i>Stage activities</i>		3

The conditions for the admission to the 2nd cycle curriculum are also defined. In particular, to be enrolled to the 2nd cycle curriculum on “Environmental Engineering”, the students must have acquired 84 ECTS (out of 180 ECTS) during the 1st cycle curriculum (*Table 3*).

Table 3. Minimum number of ECTS for the access to the 2nd cycle degree course, given as competence areas and scientific 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.	18
TOTAL		84

If the minimum of 84 ECTS is not satisfied by less than 30 CFU, the Enrolment Evaluation Committee proposes students a preliminary access path, including 1st cycle study course exams, which have to be passed by perspective students, before official enrolment in the 2nd cycle degree course on “Environment Engineering”.

3 THE EDUCATIONAL OBJECTIVES AND CURRICULA DEVELOPMENT

3.1 The educational objectives

The main educational objectives of the DEREC and DEREL curricula are as follows:

- Provide training in environmental engineering, in order to produce graduates equipped with specific competences on the sustainability of human presence on the territory;
- Foster the acquisition and implementation of broad research and analytical skills related to environmental engineering;
- 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;
- After graduating, to be employed and promoted as environmental engineers in consulting, industry, government, and academia or employed and promoted in related professions;
- Maintain state-of-the-art knowledge through lifelong learning and continuing education;
- Advance and support the engineering profession through participation in professional societies, civic groups, and educational institutions;

The DEREC and DEREL graduates are able to adequately answer the demand of technical innovative competences in the environmental engineering and have specific synthetic capacity to solve problems in the environmental field.

The DEREC graduates have suitable scientific basic knowledge and an adequate preparation on technical and scientific methods and contents of engineering, while the DEREL graduates 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 graduate 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.

3.2 The curricula development

The educational program of the 1st cycle degree course on “Environmental Engineering” is organized in three years. In the first year, basic scientific disciplines, such as mathematics, physics and chemistry, and engineering oriented basic principles, i.e. informatics and statistics, and English language, are taught. In the second year, characteristic civil and environmental engineering competences, such as fluid, solid and soil mechanics, as well as specific competences for physical phenomena identification, monitoring, description and analysis, are taught. In the third year the program is directly linked to specific learning objectives in the field of environmental protection and resources enhancement. It also provides a preparation aimed at acquiring technical competences to exploit the resources and ensure maximum compatibility with the environment. In addition, it allows students to use their expertise in a perspective of global environmental sustainable development. A

stage within public or private bodies, as well as internal university laboratory, is required in the third year and an amount of ECTS ranging from 3 up to 15 is devoted to the activities which can help the student entry the labor market. In this case the contribution from academic tutors and mainly external experts is foreseen and strongly necessary. In substitution of 6 up to 12 ECTS of stage, elective courses are foreseen to develop some specific environmental themes connected to the environmental conditions of the country, i.e. land degradation and conservation, air pollution control, management of natural resources, etc. After successful completion of the 1st cycle final exam (1st Cycle Diploma Work) the student is awarded with the title Bachelor in Science in "Environmental Engineering".

The 2nd cycle curriculum in "Environmental Engineering" is articulated 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 2nd cycle final exam (2nd cycle Diploma Work) the student is awarded with the title Master of Science in "Environmental Engineering".

3.3 The Double Degree

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) PC curricula to be compatible with the minimum amount of ECTS required by the School of Engineering at the University of Firenze; (ii) to make the two curricula similar enough to allow the equivalence; (iii) to make the last year of 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 SUMMARY AND ACKNOWLEDGMENTS

Two "Environmental Engineering" curricula, worked out through two TEMPUS projects, are presented: (i) the first one, carried out in the period 2005-2008, by the University of Firenze in cooperation with the Ss Cyril and Methodius University in Skopje, FYR of Macedonia, was entitled DEREC (Development of Environmental and Resources Engineering Curriculum; (ii) the second project, titled as DEREL (Development of Environment and Resources Engineering Learning), is active since October 2010, with the participation of 4 EU Universities (from Italy, Greece, Germany and Austria), 7 Partner Countries Universities (from FYR of Macedonia, Serbia and Albania), 1 PC Ministry, 4 PC National Agencies, 1 PC nongovernmental organization and 1 PC enterprise. Both the 1st and 2nd cycle curricula, developed through co-operation, exchange of know-how and expertise between partners, are based on the European Credit Transfer System and are in accordance with the Bologna Process.

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REFERENCES

- [1] McCabe R., Ruffio P., Heinämäki P. (2011), TEMPUS @ 20 - A retrospective of the TEMPUS programme over the past twenty years, 1990-2010, Luxembourg: Publications Office of the European Union, ISBN 978-92-9201-163-5, doi:10.2797/56786, © European Union.
- [2] European Commission (2010), The EU contribution to the European Higher Education Area, Luxembourg: Publication Office of the European union, ISBN 978-92-79-15103-3 DOI: 10.2766/63140.
- [3] National Academy of Sciences (2012), Science Academies Issue 'G-Science' Statements to Call World Leaders' Attention to How Science and Technology Can Help Solve Global Challenges. *News From the National Academies*, May 10, 2012.
- [4] United Nations (2012), Rio+20 and Beyond: moving forward to a sustainable future, Fact Sheet, <http://www.uncsd2012.org/>.
- [5] University of Firenze (Project Coordinator), (2005-2008), Development of Environmental and Resources Engineering Curriculum (DEREC), TEMPUS Joint European Project (CD_JEP 19028-2004).
- [6] University of Firenze (Project Coordinator), (2010-2013), Development of Environmental and Resources Engineering Learning (DEREL), TEMPUS IV Joint Project 511001-TEMPUS-1-2010-1-IT-TEMPUS-JPCR.
- [7] European Communities (2009), ECTS Users' Guide, Luxembourg: Office for Official Publications of the European Communities. ISBN: 978-92-79-09728-7 DOI: 10.2766/88064.
- [8] The European Higher Education Area, (1999), Joint Declaration of the European Ministers of Education. [Bologna Declaration] Convened in Bologna on the 19th of June 1999.
- [9] Caporali Enrica, (2009), How to design an Environmental and Resources Engineering Curriculum: The DEREC project experience. *Towards a new curriculum – The DEREC experience*, Enrica Caporali & Atanasko Tuneski editors, 9:18. Firenze University Press. ISBN: 978-88-8453-877-2.
- [10] Tuneski Atanasko (2009), TEMPUS DEREC project: expected outcomes, archived objectives and future perspectives. *Towards a new curriculum – The DEREC experience*, E. Caporali & A. Tuneski editors, 1:8. Firenze University Press. ISBN: 978-88-8453-877-2.
- [11] Caporali E., Tuneski A., Borri C., (2012), Development of an Environmental and Resources Engineering Education Framework. In: SEFI 40th Annual Conference: 23-26 September, Thessaloniki (GR). Editors: Aris Avdelas, CD paper 135, ISBN: 978-2-87352-005-2.