

Environmental Process Control Engineering: Interdisciplinary Approach for an International Master's Course Curriculum

A. Capodaglio¹, R. Vilanova², R. Katebi³ and J. Vehi⁴

¹ (Dept. of Hydraulic & Environmental Eng., University of Pavia, Italy)

² (Esc. Tècn. Sup. d'Eng., Univ. Autònoma of Barcelona, Spain)

³ (Dept. of Electronic and Electrical Eng., Ind. Contr. Centre, Univ. of Strathclyde, UK)

⁴ (Electronics, Informatics and Automatics. Inst. d'Informàtica i Aplicacions, Univ. of Girona)

Abstract - This communication's aim is to present an International experience in new Curriculum Development from the perspective of the new challenges for Higher Education in Europe, and with an interdisciplinary approach to content design.

Key-Words: Environmental Engineering, Process Control, Master's Degree, joint degree, interdisciplinarity

1 Introduction

Higher education plays a central role in the development of modern societies as it enhances social, cultural and economic development. At European level, education in general and higher education in particular are not subjects of a "common European policy": competence for the content and the organisation of studies remains at national level, however, some European actions have been implemented that are specifically designed to add a European dimension to education, and to help to develop quality education. The Curriculum described in this paper is strictly linked to two of these Actions. Environmental problems are nowadays at the forefront of the list to be addressed in order to improve economic competitiveness and improvement of quality of life, not only for European citizens, but for at this point the entire world population. The scale of environmental problems ranges in fact from local to global, and often local solutions at a small scale may contribute in time to improvements at the global scale as well. Air quality and water quality are just two sectors where small distributed improvements at the local scale (local pollution emissions reductions, either by the introduction of new technologies or optimization of the existing ones) are necessary to significantly contribute to the solution of global problems. The need to tackle environmental problems at a global

level, therefore, is an established fact at this point. In addition, EU environmental regulations establish common goals that will need collaborative efforts for achievement. Multidisciplinary expertise as well as deep knowledge of different realities in different countries are part of this European dimension of the problem.

The Curricular programme herein described aims to emphasize this European-view of the problem in the specific Environmental Engineering & Sciences area, where new professionals should work towards local solutions bearing in mind global policies.

Keeping in mind the depicted future for the High Education Area in Europe, it is important to have the opportunity to learn from existing experiences: it is in this sense that this paper reports some important facts and rationales regarding both the development and the management of a Curriculum Development project, as well as the innovative features with respect to the curriculum's contents. Even though there exists a useful compendium on issues to be taken into account when facing a joint master's programme definition [1], this experience born out of an interdisciplinary consortium may provide interesting distinctive features and special added value for both the curriculum and Engineering education.

2 Background: Training Young Researchers

The WWT & SYSENG (WasteWater Treatment plant and SYStem ENgineering) network was a Research Training Network project running from 2001 to 2005 funded under the Marie Curie programme [2-4]. The network itself, devoted to the training of young researchers (PhD students and PostDocs) consisted of seven partners in leading universities across Europe carrying out a number of sub-projects within the application of system engineering methods and technologies in control and management of urban wastewater systems. One major objective of this research network and other research activities by the partners was to train engineers and researchers who could use and apply system engineering theory and technology to analyze, control, monitor and manage the complex environmental processes such as wastewater treatment control, flood management, drinking water networks, and air pollution problems. A short description of each sub-project developed by the network is given below.

- 1) *Integrated modelling of the urban wastewater system (Imperial College London, UK).*
- 2) *Integrated model based control design for the urban wastewater system (U. of Strathclyde, UK)*
- 3) *Control strategy development and evaluation (Lund University, Sweden).*
- 4) *WWTP operation with versatile control strategies (Universitat Autònoma de Barcelona, Spain)*
- 5) *Integrated control in combined sewage systems (Technical University of Crete, Greece)*
- 6) *Integrated modelling of hazardous chemicals in the urban wastewater system (Technical University of Denmark)*
- 7) *GIS-based modelling of water quality at the basin scale (University of Pavia, Italy)*
- 8) *Modelling of wastewater treatment plants (University of Pavia, Italy)*

After observing the success of the concluded project, some of the former partners (UAB, UPV, USTRATH) considered that introducing this type of curriculum at a Master's Level would definitely be an enhancement in the curricular graduate offer in the environmental

area and ultimately serve to increase the competitiveness of the sector's industry.

In this view, these same partners, plus the University of Girona as a new entry, submitted a preparatory Socrates Curriculum Development Project (approved September, 2006) on which they have been working assiduously since. As the result of numerous meetings at the different partner institutions with discussions to coordinate all relevant issues, the common joint programme and procedures presented in this paper was developed.

3 EPCE – Environmental Process Control Engineering

The project herein described involves a consortium of 4 Universities from three different European Countries (Spain, Italy and Scotland). These partners are representative of two historically diverse though potentially complementary engineering areas – in fact, not linked as often as desirable – such as Environmental Engineering and Automatic Process Control. The motivation for this new Curriculum arises from the increasing needs of what we can call *Environmental Sensibility* from practically every point of view of our society. Special attention characterizes the productive processes where actual consumption needs impose high production rates, therefore high resources consumption. Use of resources must be as efficient as possible and the implied processes present in the production chain have to take this into account. On the other hand, there are environmental problems whose solution usually needs the use of systems engineering concepts, techniques and methods.

From the previously described situation, and the *privileged* position with respect to it, due to the existence of an active Socrates CD project, the four European universities that joined in the EPCE (Environmental Process Control Engineering) consortium feel the responsibility and commitment to respond to these challenges. The consortium joins Mediterranean and Anglo-Saxon universities that are actively replying to diverse local or regional environmental problems, and brings together expertise that considers the needs in developing as well as in industrialised countries. The establishment of the Masters

course was driven by the following considerations:

- All partners realised that their counterparts maintain strengths in fields that they themselves currently do not offer or approach from a different angle, important synergies are therefore to be expected.
- Students at each partner university are looking for training abroad, without recognition problems and threat of delays. (This experience also applies for students from third country universities.)
- The intended study programme should deliver highly motivated professionals who are capable to treat the social and environmental problems from an interdisciplinary point of view.
- The programme should excel by real-world project experiences, and be based on state-of-the-art research and in strong demand on the international education market.

All these aspects made clear to the consortium the need for both the regional point of view for the water and wastewater as well as other environmental problems, and the Systems Engineering approach as an adequate methodology to tackle such large scale problem. Therefore it seemed a most logical step to combine local competencies by integrating them into this joint international Masters programme in response to the *need for an Engineering profile that realizes of the European dimension of the problem and has the adequate Systems Engineering methodological skills to successfully face the problem*. This interdisciplinary approach has been found as a lack in exiting master programmes related to environmental studies form one face or another. The introduction of Control Engineering solutions and approaches based on the Systems Engineering methodology provides such a global thinking framework that is needed in order to face the problems at a global scale. This fact introduces one of the major innovative points of the master: *this programme aims to emphasize the European view of the problem. New professionals should work towards local solutions bearing in mind global policies. The mastering of IT techniques and tools will provide students graduating from this programme a suitable framework to face the*

problem. Use of advanced Modelling and Simulation approaches will represent the basis for a methodology where solutions can be validated prior to their implementation.

In addition to the competencies acquired in traditional Master Courses in Environmental Engineering and Sciences, students will acquire competencies in the system decomposition approach, which has demonstrated considerable success in many industrial sectors, and extended competencies in modeling and simulation of environmental systems, risk analysis, and extended use of information (e.g. from environmental and process monitoring).

The curriculum is structured in such a way that encompasses the different factors promoted within the Bologna declaration and that are to define the new European Education Space for Higher Education. This can be summarized saying that, in addition to the technical content of the curriculum, topics like the following ones, among others, are taken into consideration: *ECTS* is adopted as the central concept on the curriculum structure and the basis for the credit allocation criteria; *Mobility* designed as an integral part of the curriculum; *Integration Actions* at the different partner institution to let the students know the corresponding local cultures; *Teaching and Learning* methods are programmed as a mixture of classical (frontal teaching) and modern (read e-learning and web based) methods, fostering discussion and leadership, encourage team-work. as well as communication skills.

The acquired competencies will include:

- A basic understanding and knowledge of environmental systems
- Cross-disciplinary thinking/knowledge in modelling, simulation, control, sensor technology, communication and information technology
- System engineering theoretical knowledge and methods
- European language proficiency
- Computer and information technology skills
- Understanding complex systems planning, co-ordinating and organising

- Learning and understanding European water/wastewater directives, rules and regulations
- Problem-solving ability, information processing and process control and management
- Analytical competencies, self learning abilities
- Team working, and initiative competencies
- Basic skills in communication, control, computer and sensor technologies

These will correspond to the following learning outcomes: on successful completion of the course a student will be able to

- Understand the dynamic, operation and management of an environmental process
- Demonstrate how to perform basic analyses, modelling and control of existing water/wastewater process and networks
- Understand the rules and regulations in water industry
- Understand the control, monitoring and optimisation issues
- Understand the applications and motivations behind information technology, control and sensors and communication technologies through detailed case studies within the water industry
- Demonstrate the requirements for system engineering techniques and methods in operation and management of resources and processes
- Show the analytical abilities and skills for system integration and control

The mastering of IT techniques and tools will provide students graduating from this programme a suitable framework to face the problem. Use of advanced Modelling and Simulation approaches will represent the basis for a methodology where solutions can be validated prior to their implementation. It is a fact that there are specialists on environmental sciences as well as good engineers that know about automation and automatically controlled systems. These aspects made clear to the consortium the need for both: an Engineering profile that realizes the European dimension of the problem and has the adequate Systems

Engineering methodological skills to successfully face the problem. This common body of knowledge is what this master's title is aimed to synthesize: Environmental Process Control Engineering.

On the management side, the adopted roles and procedures for running the course are: (i) the use of tools for collaborative work is showed to play a central role in the sharing of information and in the development of coordination and communication aspects among partners, (ii) creation of Committees (steering, admission, quality) to tackle the different management aspects and assuring all partners are involved in the different tasks.

EPCE has been created in line with the "Bologna" framework aiming to improve European development. Mobility of students and teachers will give rise to scientific and pedagogical development, and also cultural understanding, through the increase of knowledge and by exchanging expertise. It is important to bear in mind the establishment of this Joint programme as the result of a strategy of long-term cooperation between the universities and academics involved, who are willing to create new top-end educational products beyond the limits of each institution. This framework contributes to European development on different aspects:

From the point of view of Students and staff:

- Students/Staff benefit from different social environments (language learning, culture)
- Enables students to develop international research/work experience (appreciated for their CV)
- Students/Staff gain from different academic environments/traditions
- Tested and developed network ties establish solid international research contacts
- Developed research ties emphasise complementarities in programme teaching and foster interaction between teaching and research in specialised areas

From the point of view of the European Dimension

- Encourage rapid implementation of Bologna reform

- Degree recognition and the use of ECTS and Diploma Supplement.
- Able to respond to European professional development needs (training in an international environment on transnational issues).
- Develops European citizenship and cultural understanding.
- Exciting and innovative programmes may retain Europe's best students, attract overseas students, and encourage cooperation with non-European institutions (in the name of international understanding).

4 Conclusions

A new, interdisciplinary Master's curriculum in Environmental Process Control Engineering has been designed by a 4-partner European University Consortium. The new Curriculum will adopt the Systems Engineering approach as an adequate methodology to teach students to tackle large scale problems such as those related to the management of water and wastewater, as well as other environmental problems.

The curriculum was designed keeping in mind Bologna's declaration principles and the use of all the tools to enhance student mobility and international degree recognition. It will be open to both EU and third countries students.

The programme has been submitted for possible funding under the Erasmus Mundus action.

Acknowledgements

The authors would like to acknowledge the European Commission, Education, Audiovisual & Culture Executive agency for his support to this project under the Socrates Curriculum Development programme.

References

- [1] *Developing Joint Masters Programmes for Europe*. Results of the EUA Joint Masters Project, March 2002 - January 2004 (<http://www.eua.be>)
- [2] Capodaglio, A.G., R. Katebi, D. Butler, P.S. Mikkelsen, U. Jeppsson, R. Vilanova, M. Papageorgiu (2005) Integrated water quality management in river basins through an innovative integrated educational approach, *Proceedings, Agua 2005 "From Local Action to Global Targets"*, Cali, Colombia, October

[3] D. Butler, R. Katebi, U. Jeppsson, J.A. Baeza, M. Marinaki, P.S. Mikkelsen, A.G. Capodaglio (2004) Towards a systems engineering approach to integrated catchment management. *Proceedings, WATERMATEX 2004*, Beijing, China, October

[4] Capodaglio, A.G., R. Katebi, U. Jeppsson, J.A. Baeza, M. Marinaki, P.S. Mikkelsen, D. Butler (2004) Systems engineering-based approach to integrated water quality management in river basins. *Proceedings, SIDISA 2004*, Taormina, Giugno