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BIOSYSTEMS ENGINEERING CURRICULA IN EUROPE

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ABSTRACT The harmonization process of the European degree study programs in Agricultural/Biosystems Engineering was started in 1989 and is still in progress. At present this process benefits from the results of two European thematic networks: USAEE-TN, whose best achievements are the core curricula to be used as benchmarks for degree study programs in Agricultural/Biosystems Engineering; ERABEE-TN, still working towards developing the results of USAEE-TN itself. Another important contribution towards the harmonization of the European curricula in Agricultural/Biosystems Engineering was achieved through the cooperation between the EU and the US, during the project of POMSEBES consortium. This paper describes the harmonization process of degree study programs in Agricultural/Biosystems Engineering in Europe.

Keywords: Harmonization, Degree study programs, Agricultural/Biosystems Engineering.

1. AGRICULTURAL ENGINEERING CURRICULA : FROM 1989 TO USAEE-TN

At the end of 1989 the International Commission of Agricultural Engineering (CIGR), under the chairmanship of Prof. Giuseppe Pellizzi, with the cooperation of the former Italian Association of Agricultural Engineering (AIGR, now AIIA) and the University of Milan, sponsored a project designed to compare University curricula in Agricultural Engineering in the 12 Countries of the former European Community. The aim of this project was to facilitate the creation of academic harmonisation, in view of the Unique Market, beginning in 1993, and to facilitate the free exchange of University graduates in Agriculture and Agricultural Engineering throughout the EC.

As a consequence, two study seminars, attended by representatives of EC Countries, were held at Gargnano (Italy), in May 1991, and Silsoe (UK), in May 1992; several papers were presented at conferences or published in Italian or international journals (Pellizzi and Febo, 1991c,d, 1994b,c, Febo and Ward, 1995, Febo, 1998); two Working Groups were created, called WG 1, within CIGR, and SIG 12 “Education and Communication”, within the European Association of Agricultural Engineers (EurAgEng).

From 1990 to 1994 surveys were carried out in several Countries, in order to investigate the organisation of the University degree study programs or specialisations, with special regard to Agricultural Engineering (Pellizzi and Febo, 1990, 1991a,b, 1994a).

From 1996 to 1999 the surveys were updated and extended to other Countries and Universities (Febo and Sun, 1997, 1998).

In June 2000 the results of the last survey of the study programmes in Agricultural Engineering were presented in the report “The University Structure and Curricula on Agricultural Engineering. An overview of 36 Countries”, issued by FAO; this work was presented in July 2000, during the EurAgEng Conference, held in Warwick (UK) (Febo and Sun, 2000).

In 2001 the Working Package 3 of AFANet (EU Socrates Thematic Network for Agriculture, Forestry, Aquaculture and the Environment) issued the report “Towards a European Standard for Agricultural Engineering Curricula”, which outlines the basis for four European core curricula :

- a 5-year diploma degree, more scientifically oriented;
- a 3-year Bachelor degree, more application-oriented;
- a Master’s degree, corresponding to the long term 5-year diploma degree;
- a Master’s degree, corresponding to the short term 3-year Bachelor degree.

In this report an accreditation system is also proposed and the European University faculties and departments offering diplomas in Agricultural Engineering, Agriculture with specialisations in Agricultural Engineering and Engineering (Agricultural Engineering courses) are listed (Briassoulis et al., 2001).

The beginning of the third millennium brings a crisis in the Agricultural Engineering sector. Several institutes, departments and research centres of Agricultural Engineering were closed or had their staff significantly reduced.

Meanwhile, with the advent of new topics (e.g. Precision Agriculture, Robotics, Information Systems for Agriculture) in several Universities the Department of Agricultural Engineering and the related study programs changed their name, course contents and research topics towards Applied Biology. This trend also led to the progressive substitution of the name “Agricultural Engineering” with “Bio-Engineering” or “Biosystems Engineering”. In order to take into account this trend, in 2002 EurAgEng changed the name of its official journal from “Journal of Agricultural Engineering Research” to “Biosystems Engineering”.

In Agricultural Engineering study programs the learning outcomes (knowledge, competencies and skills) of many courses are integrated with each other, so that graduates can :

- develop new technologies and materials, in order to improve the quality and reliability of agricultural products;
- plan field operations with high energy efficiency;
control electronically agricultural production;
- design environmental structures and systems;
- develop efficient technologies for processing agricultural products.

In most European Countries (e.g. Italy) the University study programs in Agricultural Engineering are very varied; often they are a specialisation of a degree in Agricultural Sciences rather than a specific study program in Agricultural Engineering, so that the Engineering learning outcomes are limited and, therefore, the graduates are Agronomists rather than Agricultural Engineers.

The third millennium also brought the new structure of the study programs (3+2) (1st level or 3-year Bachelor, 2nd level or 2-year Master), according to the Bologna Declaration of 1999; several EU Countries felt the need to update all the University study programs, including those in Agricultural Engineering, in order to satisfy general economical conditions, the scientific and technological development and the need to develop competitive study programs.

From this background the need to establish a European thematic network on Agricultural Engineering was felt, as is described in the report of AFANet - Working Package 3.

Therefore, the idea of carrying out, at European level, a project aimed at developing basic core curricula to be used as benchmarks for local development of Agricultural Engineering and for training future agricultural engineers, was created.

In 2002 the thematic network USAEE (University Studies of Agricultural Engineering in Europe), comprising 30 institutions from 27 European Countries, was established with the aim of developing this project, approved and supported by EurAgEng through the SIG RD12, and funded by the Socrates-Erasmus EU programme (<http://www.eurageng.net/usaae-tn.htm>).

The main objectives of USAEE-TN were to :

- define and develop core curricula, to be used as benchmarks for Agricultural Engineering studies in Europe;
- determine a set of minimum criteria/requirements, against which any curriculum can be tested, in order to decide whether it meets these criteria/requisites and, therefore, can be recognised as a program in Agricultural Engineering;
- define common accreditation procedures, also in terms of ECTS (European Credit Transfer System) credits and establish the bodies/committees for carrying out these procedures.

In order to be recognised, a core curriculum must meet both the criteria of FEANI (European Federation of the National Associations of Engineers) for an Engineering study program, concerning the basic Engineering course contents and the related ECTS, and the criteria of EurAgEng, concerning the Agricultural and Biological course contents and the related ECTS (Comparetti et al., 2005).

In 2005 the USAEE-TN produced the draft report “Core Curricula of Agricultural/Biosystems Engineering for the First Cycle Pivot Point Degrees of the Integrated M.Sc. or Long Cycle Academic Orientation Programs of Studies”.

In this report it is recognised that the weak area of Agricultural Engineering studies in Europe is the inadequate Engineering foundation of the corresponding curricula. Therefore, the main challenges are to :

- enhance the Engineering part of the European core curricula, so that they meet the FEANI criteria for Engineering study programs;
- significantly reduce the Agricultural and/or Biological Sciences part of the core curricula.

In several European Countries intermediate 3-year degree study programs, named “pivot point”, were established, in order to facilitate the exchange of students between Universities and Countries. These study programs are different from those “relevant for the job market”, defined by Bologna Declaration.

The degree study programs should be adapted to the Bologna Declaration Scheme and coexist with the new intermediate 3-year “pivot point” degree study programs (Bachelor’s Science), according to the history, industrial and social conditions, and the traditions of each Country.

The main challenge is to agree on a set of minimum standards for core curricula and to describe the criteria to be used for professional and academic applications clearly. In this respect the work carried out by the Thematic Network E4 (Enhancing Engineering Education in Europe), run by the University of Florence in cooperation with SEFI (European Society for Engineering Education) and other organisations, is relevant. Therefore, from the outset the USAEE-TN established strong collaboration with both SEFI and E4 TN towards common objectives.

In the first step of the development of Agricultural Engineering core curricula the 1st study cycle was examined and two different schemes were defined.

Scheme A, with academic orientation, consists of :

- core curricula of integrated 5-year degree study programs (M.Sc.);
- core curricula of “pivot-point” 1st cycle 3-year degree study programs (B.Sc.).

Scheme B, with application-technological orientation, is represented by the core curricula of a professional 1st cycle (mostly 3-year) degree study programs.

This report contains not only the core curricula (Fig. 1) but also seven modules or specialisations in Agricultural Engineering :

- Water Resources Engineering;
- Mechanical Systems and Mechanisms used in Agricultural and Bioprocess Engineering (Annexes A and B);
- Structural Systems and Materials in Agricultural and Bioprocess Engineering;
- Waste Management in Agricultural and Bioprocess Engineering;
- Bioprocessing;
- Energy Supply and Management in Agricultural and Bioprocess Engineering;
- Information Technology and Automation in Agricultural and Bioprocess Engineering.

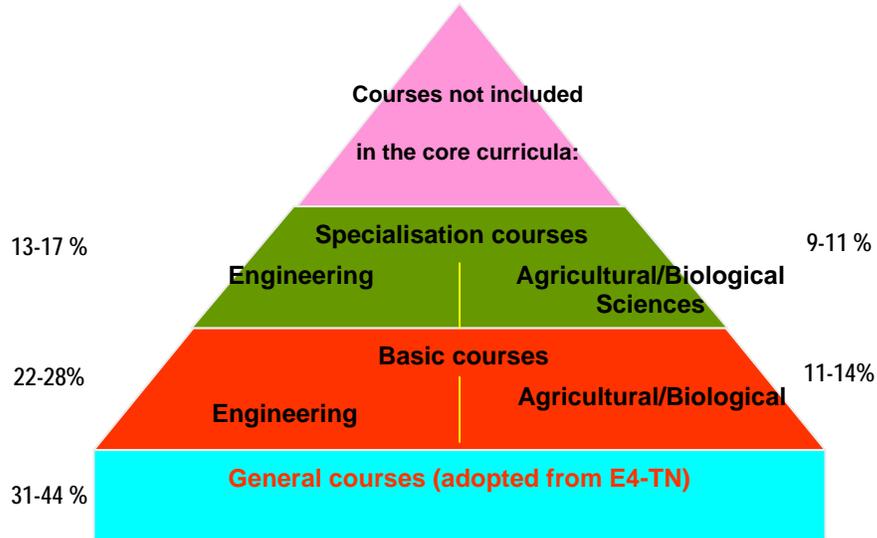


Figure 1. Agricultural Engineering core curricula of 1st cycle “pivot point” integrated degree study programs (3+2) and 5-year degree study programs with academic orientation.

In September 2004 this draft report was distributed to the Executive Committees of FEANI and EurAgEng for evaluation and comment. At the end of 2005 the European Monitoring Committee (EMC) of FEANI assessed this draft and, then, requested some modifications :

- to explain the contents of “general” within Basic Sciences;
- to specify the number of ECTS of Mathematics (which must be at least 24);
- to specify the percentage of Engineering Basic Sciences (which must be at least 20% and 36 ECTS) of the study program;
- to provide all the seven specialisations with at least 60% of Engineering subjects;
- to specify the percentage of non-technical subjects (which must be at least 10% of the study program).

The EMC of FEANI also implicitly required an accreditation process for Agricultural/Biosystems Engineering curricula, as well as an overview of academic and professional qualification of the teaching staff and laboratory facilities.

EurAgEng agreed to undertake the task of establishing the recognition process of the core curricula.

Since it was necessary for the results of the USAEE-TN project to be widely disseminated and promoted, in August 2005 the dissemination proposal submitted to the DG for Education and Culture of the EU was selected, so that on the 1st October 2005 the 4th and last year of the USAEE-TN project, mainly aimed at the dissemination of its results, started. The duration of USAEE-TN project was therefore four years (01/10/2002-30/09/2006).

The main outputs achieved during the USAEE Dissemination Year are to :

- develop a web-based database, containing the courses or modules (set of courses) of the study programs, including the course ECTS, in order to facilitate the recognition of the core curricula and, therefore, promote student mobility throughout the EU; this database will be continuously updated and made available using a specific authorisation;
- enhance the USAEE web-site, by creating links with organisations, other related thematic networks and projects (ICA, TREE, ARCHIPELAGOS and TUNING, etc.);
- disseminate and promote the USAEE-TN results to the wider area of Higher Engineering Education in Europe, through synergic activities with TECHNO/ARCHIPELAGOS on issues concerning ECTS, quality assessment and employability;
- disseminate and promote the USAEE-TN results to the wider international Agricultural/Biosystems Engineering community outside Europe, through the TUNING III web-site and synergic activities with TUNING III;
- disseminate the USAEE-TN results, through contacts with student associations (in order to promote student mobility and participation), alumni associations (in order to promote alumni involvement), Deans, Rectors, ERASMUS officials, policy makers and other academic bodies, representatives of enterprises, companies and industries involved in Agricultural Engineering;
- cooperate with FEANI and, through FEANI itself, with the major professional stakeholders in Europe, aimed at the final approval of the core curricula developed by USAEE-TN;
- cooperate with EUR-ACE towards a common accreditation system for the Higher Engineering Education in Europe, according to the current developments of Bologna process;
- organise dissemination events, at national level, in which the national professional societies of Agricultural Engineers, also representing strong national contact and dissemination points towards the students and the industrial and the broader non-academic sector of Agricultural Engineering, will participate;
- develop synergic activities (together with ICA, SEFI, TREE, etc.), for promoting the USAEE-TN results to academic and non-academic communities and targeted groups, including industries and professional societies;
- support short-term student mobility, through the participation of student associations (e.g. International Association of Students in Agricultural and related sciences - IAAS, Board of European Students of Technology - BEST) in workshops, with contributions to presentations and proceedings and in the dissemination activities addressed to them, the European market and the students of Agricultural/Biosystems Engineering University studies in Europe (in synergy with IROICA) (Febo, 2006).

2. FROM AGRICULTURAL ENGINEERING TO BIOSYSTEMS ENGINEERING CURRICULA : ERABEE-TN In November 2005 the same partners of USAEE-TN, and others, proposed a new Thematic Network, aimed at using and developing the results achieved through the previous project.

Thus, in 2007 the thematic network ERABEE (Education and Research in Biosystems Engineering in Europe), comprising 35 institutions from 27 Erasmus Countries, of which 33 were Higher Education Area institutions and 2 student associations, was established with the aim of developing this project, co-funded by EU, under the umbrella of the Lifelong Learning Programme (<http://www.erabee.aula.gr>).

The objectives of ERABEE-TN project are to :

- promote the transition from Agricultural Engineering to Biosystems Engineering;
- establish the recognition procedures of the new European study programs in Biosystems Engineering by FEANI and EurAgEng, based on the core curricula of the first two cycles developed by USAEE-TN;
- enhance compatibility between the new European study programs in Biosystems Engineering, in order to promote their recognition and accreditation, in synergy with EUR-ACE and in support of the establishment of European Quality Labels in Bio-Engineering;
- organise case studies of the implementation of new European study programs in Biosystems Engineering, based on the core curricula of the first two cycles developed by USAEE-TN, aimed at recognition by FEANI and EurAgEng;
- “map” and promote the 3rd cycle University study programs and the European Doctorate in Biosystems Engineering, following the recognition by FEANI and EurAgEng, through the implementation of the core curricula of the first two cycles developed by USAEE-TN;
- develop synergies for strengthening the link between research and education in all three cycles of the University studies (above all in the 3rd cycle) in Biosystems Engineering in Europe;
- promote the adoption of European Standards on quality assessment and assurance of European study programs in Biosystems Engineering, in accordance with the emerging European Qualifications Framework (EQF);
- enhance the attractiveness of European study programs in Biosystems Engineering, both within and outside Europe;
- promote the mobility of researchers and students;
- implement the main lines of TUNING, based on the outcomes of USAEE-TN.

The beneficiary target groups of ERABEE-TN project are :

- the Universities offering Biosystems Engineering graduate and postgraduate studies;
- graduates in Biosystems Engineering, professional societies, companies and enterprises involved in agricultural production and processing, the industry and market in the field of the technical support of agriculture, etc.;
- European and national accreditation bodies, policy makers, ministries of education and the academic society of higher education in Europe;
- students, scholars and researchers from regions outside Europe;
- other related disciplines, associations and thematic networks in synergy with ERABEE-TN itself.

To date the main achievements of the ERABEE project have been to :

- define the emerging Biosystems Engineering discipline in Europe, by describing the current situation in each partner Country;

- describe the current situation and perspectives in each partner Country of the development of Biosystems Engineering study programs towards bio-fuels, bio-materials and quality of products;
- describe the current schemes and the possible structured study programs of the 3rd cycle University studies in Agricultural Engineering and in the emerging discipline of Biosystems Engineering in each partner Country;
- describe the research activities in the first two cycles of Biosystems Engineering University studies in each partner Country (Comparetti et al., 2008a, b, 2009, a, b).

The duration of the ERABEE-TN project will be three years (01/10/2007-30/09/2010).

3. A CASE OF EU-US COOPERATION IN BIOSYSTEMS ENGINEERING CURRICULA : POMSEBES During the ERABEE-TN project, from 01/11/2006 to 31/10/2008, the Consortium POMSEBES (Policy Oriented Measures in Support of the Evolving Biosystems Engineering Studies in USA - EU) was established (<http://www.pomsebes.aua.gr>).

The project of this consortium, comprising 12 Higher Education Area institutions, of which 8 are from the EU and 4 from the USA, was funded by the European Commission, jointly with the US Department of Education, Fund for the Improvement of Post Secondary Education (FIPSE), under the ATLANTIS programme (Actions for Transatlantic Links and Academic Networks for Training and Integrated Studies), in the framework of the 2006-2013 EU-US Agreement in higher education and vocational training.

The objectives of the POMSEBES project, which were mostly achieved, were to :

- provide a platform for a systematic exchange of experiences and ideas between the USA and the EU, in order to contribute to the enhancement of the quality and linkage of education and research and to establish appropriate policy oriented measures;
- develop policy as well as appropriate curricula for Biosystems Engineering;
- encourage compatible study programs, within the EU as well as between the EU and the USA.

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APPENDIX A

Proposed module or specialisation in “Mechanical Systems and Mechanisms used in Agricultural and Bioprocess Engineering” within the 1st cycle “pivot point” degree study programs.

ENGINEERING PART OF THE CORE CURRICULA: OPTIONAL COURSES

24-30 ECTS CREDITS: equal to 13-17% of total 180 ECTS CREDITS

Learning outcomes and contents follow this table

Assuming 6 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework:

1. Kinematics of Mechanisms
2. Power Generation Engines
3. Mechatronics
4. Soil Mechanics
5. Electrotechnics
6. Electronic Circuits
7. Instrumentation and Measurements
8. Engineering Surveying - GIS

AGRICULTURAL / BIOLOGICAL SCIENCES PART OF THE CORE CURRICULA: OPTIONAL COURSES

(16-20 ECTS CREDITS: equal to 9-11% of total 180 ECTS CREDITS

Learning outcomes and contents follow this table

Assuming 4 course units with 4 or 5 ECTS credits per unit, respectively, or equivalent, the learning outcomes that follow may be delivered through the following structured coursework:

1. Crop Science and Management
2. Crop Protection
3. Agro-chemicals
4. Animal Science and Management
5. Environmental Impact Assessment

APPENDIX B

Indicative list of Agricultural Engineering courses included in the proposed module or specialisation in “Mechanical Systems and Mechanisms used in Agricultural and Bioprocess Engineering”.

1. Agricultural Machinery Design
2. Farm Power Units
3. Farmstead Equipment
4. Analysis and Design of Biomachinery
5. Techniques in Precision Agriculture
6. Automatic Controls
7. Computer Control of Machines and Processes
8. Ergonomics, Health and Safety
9. Design Methods for Machines for Biosystems
10. Remote Sensing
11. Soil Erosion
12. Landscape Planning
13. Free Technical or Agricultural / Biological Electives

APPENDIX C

Abbreviations

FAO = Food and Agriculture Organization of the United Nations

ICA = Interuniversity Conference of Agriculture and Related Sciences

TREE = Training & Resources in Early Education

EUR-ACE = Accreditation of European Engineering Programmes and Graduates

UNESCO = United Nations Educational, Scientific and Cultural Organization

AGSE = Agricultural Engineering Branch

IROICA = European Network of International Relations Officers at Higher Education Institutes for Agricultural and Related Sciences