OUTCOME P13

IMPLEMENTATION OF TUNING TEMPLATE TO THE BIOSYSTEMS ENGINEERING DISCIPLINE

developed by Working Group 4

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Lifelong Learning Programme

[This project has been funded with support from the European Commission. This report reflects the views only of the author(s), and the Commission cannot be held responsible for any use which may be made of the information contained therein].

TUNING template lines

TUNING has developed reference points for common curricula on the basis of agreed competences and learning outcomes, as well as cycle level descriptors for many subject areas, in order to enhance European recognition and integration of diplomas, taking into consideration the diversity of cultures.

The Outcome P13 of ERABEE-TN project "Implementation of TUNING Template" is a template for a summary of TUNING subject area findings applied to Biosystems Engineering discipline.

These findings are summarised in the following five lines:

1) introduction to the subject area;
2) degree profile(s);
3) workload and ECTS;
4) learning, teaching & assessment;
5) quality enhancement.

1. Introduction to the subject area

A general description of Biosystems Engineering subject area and its key characteristics is summarised in the definition written by ERABEE and published in Wikipedia under the auspices of the ERABEE network at the following link http://en.wikipedia.org/wiki/Biosystems_engineering.

"*Biosystems Engineering is a field of engineering which integrates engineering science and design with applied biological, environmental and agricultural sciences. It represents an evolution of the Agricultural Engineering discipline applied to all living organisms not including biomedical applications. Therefore, Biosystems Engineering is 'the branch of engineering that applies engineering sciences to solve problems involving biological systems*".

2. Degree profile(s)

2.1. Typical degrees offered in the subject area

The typical degrees offered in Biosystems Engineering subject area are shown in the web based database on European Agricultural/Biosystems Engineering programmes of studies, initially built up during the former EU-funded project USAEE-TN (University Studies of Agricultural Engineering in Europe; a Thematic Network) and updated during the ERABEE TN project life-time. This platform constitutes Outcome P15 of ERABEE-TN project (http://sunfire.aua.gr:8080/ects/Welcome.do).

Some examples of the first, second and third cycle degree study programs in Biosystems Engineering subject area are illustrated below:

First cycle in:

- Agricultural Engineering;
- Agricultural Biosystems & Technology;
- Agrotechnology & Food Sciences;
- Agroenergetics;
- Agricultural Mechanisation;
- Agricultural & Environmental Engineering;
- Biosystems Engineering;
- Horticulture Engineering.

Second cycle, including various specialisations (each of these is usually constituted by coursework and degree thesis) related to the areas of the first cycle :

- Farm Machinery;
- Bioprocessing;
- Materials, Structures and Environment;
- Energy Sources;
- Information Technology and Automation;
- Waste Management;
- Water Resources Engineering.

Integrated First and Second cycle in:

- Agricultural Engineering;
- Agricultural Biosystems & Technology;
- Agroenergetics;
- Agricultural Mechanisation;
- Biosystems Engineering.

Third cycle (Ph.D.) in:

- any specialised topic of Biosystems Engineering discipline, usually requiring examination and defence of an original research, described in a comprehensive thesis, e.g. :

post-harvest technology, food quality, bio-fuels, bio-based materials, waste management in agriculture and forestry, environmental engineering technology, renewable energy sources, robotics, ergonomics, land surveying, rural buildings, microclimate and gas emissions in dairy buildings, GPS and image processing and acquisition, water management and irrigation control, solar drying of material of biological origin, climate optimisation of greenhouse structures and equipment, development of biosensors and control issues of bio-system engineering, food and bioprocess engineering, energy use of agricultural and forestry biomass, agricultural mechanisation, environmental impacts of the cultivation of energy plants, Life Cycle Assessment (LCA), precision agriculture and environmental pollution, integration of urban and rural activities, rural development and reuse of existing rural structures, plant production under microgravity conditions on International Space Stations.

2.2. Typical occupations of the graduates in the subject area (map of professions)

- **First and second cycles**

At present only a few data about the typical occupations of the graduates in Biosystems Engineering subject area in Europe are available, so that a map of the related professions cannot be fully drawn.

However from 2006 to 2008 another project, entitled POMSEBES (Policy Oriented Measures in Support of the Evolving Biosystems Engineering Studies in USA - EU) and funded by Atlantis programme was carried out. The consortium consisted of 8 EU and 4 US HE institutions. This project pursued the overall goal to contribute, by means of specific policy measures, to the structural development of the emerging discipline of Biosystems Engineering and the enhancement of quality and linkage of Education and Research in this area, by increasing the collaboration between the European Union and the United States.

The scope behind Objective 3 of that project "*Identify needs of industry*" (current and future employers) was to collect information from the current and future employers of Biosystems Engineers (that are, above all, industry representatives), in order to determine the competences required to the graduates in Biosystems Engineering for satisfying the needs of industry.

Therefore, a questionnaire entitled "University - Enterprise Cooperation" was circulated to a numerous of EU industries involved in Biosystems Engineering. More explicitly, 28 EU industries were chosen, out of which 14 industries replied back (which however constitute an almost significant sample). Among these "co-operating" industries, six produce agricultural machines, two are involved in food processing, three in production of building materials for greenhouses, animal farms and equipment, one is a company of GPS services for agriculture, topography, public works and instruction, one is a company of services for agriculture, forestry, environment, aquaculture and fisheries and one is a company of services for bioenergy/biogas from animal production, field agriculture, livestock engineering, horticulture technology and sensors.

In the majority (64%) of the above industries there are career options relevant to Agricultural/Biological or Biosystems Engineering.

About the 34% of these industries prefers B.Sc. degrees, the 33% prefers M.Sc. ones, only the 8% prefers Ph.D., the 17% indifferently does B.Sc. or M.Sc., and only the 8% does indifferently M.Sc. or Ph.D.

Only the 38% of these industries intends to recruit more graduates with the classical Agricultural Engineering background, while only the 40% of these industries prefers a change from the traditional Agricultural Engineering background into the emerging Biosystems Engineering one.

Even if the 50% of the contacted industries sent back the questionnaire filled-in, the given replies are rather homogeneous and show a common policy: a great interest for Biosystems Engineering discipline can be drawn and, at the same time, a good employability for the related graduates and a profitable University - enterprise co-operation can be foreseen in EU.

As far US is concerned, Biosystems Engineering exists for about 15 years, so a satisfactory amount of data about the typical occupations of the graduates in this subject area is available.

The information about US employers for Biosystems/Biological Engineers and job positions that US Engineering graduates may obtain upon graduation, are summarised in the following points (with reference to Iowa State University and Texas A&M University).

a) <u>Iowa State University</u>

Until fall 2008 Iowa State University offered one of the four options in Biosystems Engineering area, under the B.Sc. degree study program in Agricultural Engineering, but from fall 2008 it began to offer a new B.Sc. degree study program in Biosystems Engineering.

Nowadays students upon graduation in the Biosystems Engineering option find very high paying jobs in the three major industries: food and bioprocess engineering industry, e.g. General Mills, CARGILL, ADM, CongAgra, meat process industry; biofuels and bioproduct industry (ethanol, biodiesel, bioplastic, biomaterials, bioproducts, etc.), e.g. ADM, CARGILL, several ethanol plants, pharmaceutical industry. Moreover, major farm equipment industries, e.g. John Deere and AGCO, are recruiting biomanufacturing engineers to design harvesting equipment for emerging biofuel crops. In addition, several state and federal governmental agencies are beginning to recognise Biosystems Engineers, primarily in the environmental and bioremediation areas.

Typical job positions offered to the Biosystems Engineering graduates are: bioproducts engineer, biomanufacturing engineer, quality control engineer, design engineer, process engineer, bioremediation engineer, environmental manager/engineer, drug delivery/packaging design engineer, research engineer, etc.

b) Texas A&M University

Students of the Biological and Agricultural Engineering Department of Texas A&M University have been very successful in finding employment upon graduation.

These graduates have found job positions for the following enterprises: engineering and environmental consulting firms, e.g. Dannenbaum Engineering Corporation, Pape Dawson Engineering, Vickrey Associates, URS Corporation; oil, gas and energy industries, e.g. Halliburton, Exxon Mobile, FMC Tech, Panda Ethanol, Lynntech, TXU Power; agricultural and construction equipment manufacturers, e.g. John Deere, Alamo Group, CNH Global; food industries, e.g. Frito-Lay and Kraft Foods. They also find job positions in government and public sectors, e.g. Texas Commission on Environmental Quality (the State environmental regulatory agency), Texas Department of Transportation, municipal and utility management positions. They also find several job positions in a wide variety of small firms. Moreover, a large proportion of the above graduates attend graduate schools.

Job positions offered to the above graduates include: consulting engineer, systems engineer, civil engineer, plant engineer, field engineer, customer support marketing representative and environmental specialist. In addition, many graduates move rapidly to management positions.

Therefore, on the other side of Atlantic Ocean the demand for Biosystems Engineering graduates by industry is much more than US Universities can train. Thus, the future for Biosystems/Biological Engineering graduates is very bright in US.

Moreover, based on the US data, it is possible to foresee similar effects in EU.

However, both in EU and US, Biosystems Engineers are also employed in the public sector, i.e. public institutions (Ministries of agriculture, environment, industry, education and foreign affairs), local governments (regions, municipalities and national parks), for carrying out tasks related to territory monitoring, land planning, agricultural politics, co-operation with developing countries. This employability sector must be promoted, because EU and US graduates in Biosystems Engineering can provide developing countries with a significant contribution to their progress and, at the same time, citizens of these countries can be taught at EU and US Universities on the most important subjects, e.g. irrigation, mechanisation and rural buildings.

- **Third cycle**

In most cases the Doctoral degree in Biosystems Engineering is associated with an academic or research University role.

2.3. Role of subject area in other degree programmes

Biosystems Engineering courses are often offered to support other degree study programs, in order to allow students from other disciplines to acquire competences, which can be proven helpful in a "holistic" approach to everyday issues.

Some examples of such degree study programs are the following ones:

- Plant Science (e.g. Protected Plant Production, Micro-environment Control);
- Animal Science (e.g. Livestock Housing, Indoor Air Contaminant Measurement and Control, Waste Management);
- Food Science (e.g. Post-harvest Technologies, Crop Preservation);
- Environmental Engineering (e.g. Indoor Air Contaminant Measurement and Control, Waste Management);
- Mechanical Engineering (e.g. tractors, farm machinery);
- Hydraulic Engineering (e.g. irrigation, drainage, land reclamation);
- Civil Engineering (e.g. livestock buildings, greenhouses).

2.4. Learning outcomes & competences - level cycle descriptors

The main learning outcomes, expressed in the relevant subject specific and generic competences for the different cycles and taking into account the level of the competences that has to be achieved, are summarised as follows.

- **First cycle**

The student, upon completion of a first cycle degree study program in Biosystems Engineering, should achieve the knowledge, competences and skills needed to: contribute to the consultancy, planning and design about rural buildings, roads for agricultural farms, irrigation and drainage plants, land reclamation, green areas, greenhouses, stables, etc.; choice machines and plants for agricultural and food productions; manage irrigation plants and hydraulic drainage of territory; analyse projects and approve funding for land enhancement works in agricultural farms; implement EU programmes for using the economical resources in agriculture.

- **Second cycle**

The student, upon completion of a second cycle degree study program in Biosystems Engineering, should achieve the knowledge, competences and skills needed to: edit, manage and assess development projects, territory plans, town and landscape plans, studies for rural territory classification, using also G.I.S.; design and manage green areas; carry out technical consultancy about issues concerning with the rural territory; contribute to design and choice plants for food processing, conservation and packaging; study, design and plan animal husbandry in conformity with the regulations about waste disposal, animal welfare and consumer health; supervise and manage agricultural and food firms; plan and carry out the supervision of works and approval of rural and food buildings; plan and supervise the works, approve and manage irrigation plants, including artificial lakes; plan and manage agricultural farm mechanisation on a large scale, and the plants of agricultural and food industry; manage the problems concerning with the safety in the use of machines and in work environments, the quality certification of product and process and the conformity with hygienic regulations for the protection of consumer health; study, plan and manage integrated systems for producing, valorising and using renewable energy sources.

- **Third cycle**

The Ph.D., upon completion of a third cycle study program, should achieve high level scientific and research competences, useful for public and private sectors, concerning with irrigation and drainage plants, agricultural and forestry mechanisation, precision agriculture, robotics for agriculture, food technology, safety and health of workers, environmental protection, land planning, environmental control inside rural buildings, bio-energy, bio-based materials, bio-sensors, etc.

2.5. Consultation process with stakeholders

In order to offer degree study programs that satisfy the needs of the possible employers of the future graduates, the University teaching staff must carry out a consultation process by means of meetings together with the related stakeholders, i.e. professional associations, farmer associations, industry representatives, consumer associations, local and national public authorities, for collecting their needs, suggestions and future perspectives.

Then, after planning the degree study programs, other meetings with the above stakeholders must be organised, in order that they can evaluate the programs themselves.

Moreover, periodically a feedback process can be carried out by the above stakeholders, and also the related students and graduates, together with the University teaching staff.

3. Workload and ECTS

The workload of the typical degree study programs, expressed in ECTS-credits, is summarised as follows.

- **First cycle**

  According to the implementation of 3+2 University education system, established during Bologna process, the 180 ECTS model is the most common.

- **Second cycle**

  According to Bologna process implementation, the 120 ECTS model is the most common.

- **Third cycle**

  Credits are not always used. The minimum duration for a third cycle is generally three years (equivalent to 180 ECTS, if credits are used), even if in some European countries the duration is longer. In addition, the duration of the third cycle can be longer than three years, depending on the completion and approval of an original research thesis (Doctoral thesis).

As far as the differences within the European Higher Education Area in Biosystems Engineering discipline, the workload and ECTS of the typical degree study programs in this subject area are shown in the database on European Agricultural/Biosystems Engineering programmes of studies (http://sunfire.aua.gr:8080/ects/Welcome.do).

As far as the trends within the European Higher Education Area in Biosystems Engineering discipline, most of partners of ERABEE-TN are trying to harmonise the workload and ECTS of the typical degree study programs in this subject area, according to Bologna process implementation.

4. Learning, teaching & assessment

Biosystems Engineering subject area lays down as a principle, which may be applied in all European countries, that teaching of this discipline must be linked to the related research, i.e. students must have direct contact with the results of the tests carried out on the topics taught.

Three examples of best practice in learning, teaching and assessment to achieve competences relevant to Biosystems Engineering subject area are summarised in Table 1.

Table 1. Three examples of best practice in learning, teaching and assessment to achieve competences relevant to Biosystems Engineering subject area.

Clusters of competences	Approaches to learning/teaching and assessment
Basic knowledge of the subject. Analysis and synthesis. Ability to identify problems concerning with Biosystems Engineering. Capacity to connect and compare.	According to Bologna process implementation, case studies are presented during lectures, relying on the personal research of the teacher or using examples drawn from scientific journals. Different methods for problem solving are discussed. Lessons are taught on: fundamental elements, knowledge of application criteria, planning solutions and criteria, problem solving, connection of learning outcomes aimed at joining and comparing problems and solutions. Students are required to carry out practical training, in laboratory and field, and also planning projects. The teacher explains to students that all the possible solutions must be taken into account, even if these contradict the working hypothesis. Thus, the intellectual honesty and the use of scientific method are encouraged. Students are required to work out their own hypotheses with a rigorous scientific method. Students are required to compare and connect the methods and knowledge acquired in different subjects, in order to be able to transfer innovative practice from one field to another. The final exam can be oral and/or written (by means of exercises or questions with multiple answers) but can also include editing and discussion of projects and problem solving. During the oral exam the student discusses general and specific questions with the teacher, who can assess what the student has achieved and guide him in critically understanding the full implications of the results.

Clusters of competences	Approaches to learning/teaching and assessment
Awareness of the need for critically analysing any information, view or method. Awareness of the complex nature of the information and attitudes. Ability to express critical views in a constructive way. Ability to critically think about the own values, practices and perspectives.	During methodological courses the teacher can encourage and assess the critical and self-critical thinking of students. After the initial stages of study, students participate to seminars, during which they can orally express their constructive criticism. Assessment is usually based on an oral exam, during which the student is required to expose research papers.
Critical and self-critical abilities. Awareness of and respect for the points of view deriving from other national or cultural backgrounds.	During lessons and practical training the teacher has to promote the discussions in the classroom, in order to increase the critical ability of students, encourage their curiosity, creativity, analysis and proposal abilities. The teacher has to promote team building, in order that each team of students can perform exercises, projects, talks about case studies for solving everyday problems (e.g. energy crisis, increase of the price of raw materials, labour cost, variation of markets and products, new available technologies) and acquire self-critical ability.

In the situations where the mobility of staff or shared experience can take place (e.g. Erasmus programme) staff and students can achieve a much higher degree of understanding of their own systems, their strengths and weakness, and/or the usefulness of certain solutions used in other countries.

5. Quality enhancement

The observations related to Biosystems Engineering subject area on the use of TUNING tools in the design, delivery, monitoring and improvement of degree study programs are summarised as follows:

The reference points and the competences of this subject area have been developed in close synergy with the actual on-going debate on the quality and delivery of degree study programs.

On one hand, in many countries where the Bologna process has been implemented, members of ERABEE-TN were involved in designing new degree study programs, based on competences and learning outcomes, and in building useful elements for ensuring quality (refer to the relevant supplement of outcome P8).

On the other hand, the pan-European results of TUNING, such as reference points, competences, shared knowledge about learning, teaching and assessment, could be used and evaluated in local and national contexts.

The outcome P13 of ERABEE-TN project will be addressed all over EU to the following target groups:

- European and international academic (e.g. EurAgEng, ASABE, CIGR) and professional associations (e.g. CEDIA);
- related thematic networks and projects;
- public sector;
- policy makers;
- companies involved in agricultural production and processing.