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## **AC 2011-1512: TRANS-ATLANTIC BIOSYSTEMS ENGINEERING CURRICULUM AND MOBILITY (TABE.NET)**

### **Mary Leigh Wolfe, Virginia Tech**

Dr. Mary Leigh Wolfe is Professor and Interim Head in the Department of Biological Systems Engineering (BSE) at Virginia Tech. Dr. Wolfe conducts research and teaches undergraduate and graduate courses focused on hydrologic modeling, nonpoint source (NPS) pollution control strategies, and decision support tools for NPS pollution control and watershed management. She is active in the American Society of Agricultural Engineers, including two terms on the Board of Directors/Trustees and in leadership roles on technical committees. She is currently serving on the ASABE Foundation Board of Directors. Dr. Wolfe has been very active in accreditation of engineering educational programs, including serving as chair of the Engineering Accreditation Commission of ABET, Inc. for the 2007-08 accreditation cycle. Dr. Wolfe is a Fellow of ASABE, the American Institute for Medical and Biological Engineers (AIMBE), and ABET, Inc.

### **Dr. Nicholas M Holden, University College Dublin**

Associate Professor UCD Biosystems Engineering Dublin, Ireland

### **Dr. Demetres Briassoulis, Agricultural University of Athens**

Professor D. Briassoulis has a very strong background in education and research in both Agricultural Engineering (Diploma, AUA, 1976; M.S. 1982 & PhD 1985 in Ag. Engineering, University of Illinois) and in Civil Engineering (M.S. 1985 & PhD 1987 in Civil Engineering, University of Illinois). He has led and worked in many projects in structural and agricultural engineering and materials. He has published over 160 papers in refereed journals and proceedings of international congresses. He has gained a great deal of experience and demonstrated efficient management skills as being coordinator of 3 LLP projects and 16 EU research projects. He has published 25 papers in the field of Agricultural and Biosystems Engineering studies in Europe (<http://www.erabee.aua.gr/>).

### **Prof. Francisco Ayuga, BIPREE Research group, Universidad Politecnica de Madrid**

Catedrático (Professor) since 2002, previously Profesor Titular (Associate Professor) since 1987 always at UPM. PhD in Agricultural Engineering. President of CEIR, Spanish section of CIGR. Teaching subjects on Strength of Materials, Building Structures (concrete and steel), Foundations, Earth Works, Agricultural Building Design, Agrifood Industries Design, Rural Roads, Silos and Tanks. Total number of papers 263- 66 articles in scientific journals (37 in English and 29 in Spanish), 10 technical books or chapters in technical books (2 in English), 187 conference papers (in English and Spanish). Total number of research projects 53. Supervisor of 17 Ph.D. theses. Member of the educational thematic networks USAEE (Europe), POMSEBES (Europe and USA), ERABEE (Europe) and TABE.NET (Europe and USA)

### **Prof. Giacomo Scarascia Mugnozza, University of Bari, Italy**

# **Transatlantic Biosystems Engineering Curriculum and Mobility (TABE.NET)**

## **Introduction**

The academic discipline of Biosystems Engineering (BE) has emerged in the past 15-20 years in the US and Europe, as well as in other locations around the world. Most BE programs have evolved from Agricultural Engineering, which focuses on biological systems related to agriculture, while BE includes a broader array including applications in foods, pharmaceuticals, materials, energy, and environment. Biosystems Engineering is distinct from Biomedical Engineering (also known as Bioengineering), which focuses on medical applications.

While there are commonalities in BE curricula around the world, there are also differences due to the rate and manner in which programs are developing. Some of the differences in program development have hindered widespread recognition of the field. Internationalization of BE curricula could play an important role in addressing the need for unification, future evolution and development, and enhanced visibility of the discipline.

A consortium of four European and two U.S. institutions received funding in 2009 through the EU-US Atlantis program for a four-year mobility and curriculum development project focused on BE. This project follows an earlier Atlantis policy-oriented project completed by the consortium, along with other partners, focused on BE studies in the U.S. and EU. Key recommendations from the policy-oriented project, entitled “POMSEBES: Policy Oriented Measures in Support of the Evolving Biosystems Engineering Studies in USA-EU” (<http://www.pomsebes.aua.gr/>), include the following (<http://www.pomsebes.aua.gr/Report on Proposed Policy Measures-v6.pdf>):

- A list of domains, learning outcomes, and core competencies for students in BE should be developed to assist with the evolution and development of the discipline curriculum.
- A systematic comparison among study programs in the US and EU may lead to a standard definition of basics and a clarification of application areas, whereas a common definition of student course load should be developed to make EU and US BE curricula compatible.
- Relationships between quality assurance issues of programs of study and learning outcomes or student’s core competences should be encouraged. Accreditation processes for engineering degree programs in the EU and US provide a framework for establishing such a relationship.
- Publication of a database showing competencies of Biosystems Engineers and conversion tables of credits and grades between EU and US programs would enhance the mobility of EU and US BE graduates within global industry.

## **Project Objectives**

The overall goal of the new (2009-2013 funding period) project, “Transatlantic Biosystems Engineering Curriculum and Mobility (TABE.NET)”, is to advance internationalization of BE curricula and to develop a global awareness within the discipline. The specific objectives to achieve this goal include the following:

1. Define the common threads within the BE discipline;
2. Globalize core BE courses by creating a database of multinational examples that can be drawn upon by instructors around the world;
3. Develop innovative courses to advance the continuing development of BE programs in the US and EU (and globally);
4. Design student and staff/faculty mobility experiences to enhance the global perspectives of both; and
5. Create a cohort of students aware of, and able to work in, a global employment market.

The objectives are being accomplished through a variety of activities that can be grouped into two categories: mobility and curriculum development. Mobility includes study abroad experiences for students from the six partner institutions. The student mobility aspect of the project was initiated in fall 2010 with six EU and six US students studying abroad for one or two semesters during the 2010-2011 academic year. There are also limited funds for faculty mobility, which will be used largely in conjunction with the curriculum development activities described in the remainder of this paper.

### **Curriculum Development Activities**

The emphasis of the curriculum development activities is to produce resources that can be implemented in a variety of ways by BE programs around the world. The outcomes of the project will be available for other programs to select from, based on their own emphases and constraints. Materials are being developed in English, with abstracts translated into the languages of the partners. Each of the activities is being conducted in a manner to produce scholarly publications.

There are six partner institutions in the project, with a lead investigator from each partner. The lead investigators met in person and identified a lead investigator to lead each curriculum development team. The leaders also agreed on the objectives of each curriculum activity. Then, each leader solicited interest from faculty members at his/her home institution to participate on the various teams. The goal was to have at least one member from each partner institution on each activity team. That goal was achieved, with approximately 35 faculty members from across the six partners now involved in the activity teams. The proposal included specific ideas about each curriculum development activity; however, the lead investigators have told each development team that it is up to the team members to decide how to achieve the objective of the team. In some cases, the activity is following the proposal closely, while, in others, the team has a different vision for accomplishing the same objective. More detail about each activity is given below.

Each team has generally followed the same approach in initiating the activities. To date, the teams have used conference calls on Skype and email to communicate. Some of the teams have set up project sites on Scholar, an on-line learning and collaboration environment used at one of the partner institutions that is accessible to both internal and external participants. Most of the people involved in the teams have not met face-to-face, so the first conference call for each team focused on team members getting to know about each others' interests and expertise. Teams then exchanged information via Scholar and email about their own programs relative to the team's

assignment. The teams are at various stages of developing and implementing work plans. The progress and plans of the various teams are described in the following paragraphs.

**Activity 1. Common Threads of the Biosystems Engineering Discipline**

The core concepts, or threads, of BE are variously understood by those within the discipline, but have never been unequivocally defined due to the comparative youth of the discipline. This makes communication and teaching difficult compared to other well established engineering subjects. The Atlantis POMSEBES project and Erasmus Network “ERABEE” have worked towards defining a core curriculum for the discipline, but this needs to be taken further by defining the threads that link courses together. Once defined, these threads will be available for global development of the BE discipline.

The “Threads” team has decided to define competences and then move to identifying threads. Core competences regard the general competences, i.e., mostly related to math, science, engineering, and humanities-economics, and to generic competences of the graduate related to communication, cooperation, design ability, etc. Mid-level competences relate to applied BE topics or specializations. Mid-level competences are addressed with applied courses on specialised areas of expertise over the 2<sup>nd</sup> cycle program of studies (or during the last two years of the integrated programs of studies). The team is focusing on identifying mid-level competences in specific specializations or domains within BE. The team has identified the specializations (or domains) to focus on and the lead person and contributor for each specialized area (Table 1). The work plan calls for definition of mid-level competences to be complete by April 2011. The team will then evaluate the competences to identify the common threads.

**Table 1. Assigned responsibilities for defining mid-level competences by specialization**

<b>Specialization or Domain</b>	<b>Responsible</b>	<b>Contributor</b>
Bioprocess engineering	K. Mallikarjunan, VT*	
Bioenergy systems	M. Pantaleo, UB	P. Owende, UCD
Bio-based materials	P. Owende, UCD	D. Briassoulis, AUA
Biosystems informatics and analysis	K.C. Ting, UIUC	
Water resources engineering	E. Gallego, UPM	
Structural systems, materials and environment for agricultural/biological systems	D. Briassoulis, AUA	E. Gallego, UPM
Automation and mechanical systems for agricultural/biological systems		
Waste management for agricultural/biological systems		

\*AUA = Agricultural University of Athens (Greece), UB = University of Bari (Italy); UCD = University College Dublin (Ireland); UIUC = University of Illinois at Urbana-Champaign (US); UPM = Universidad Politecnica de Madrid (Spain); VT = Virginia Tech (US)

### **Activity 2. Database of Multinational Examples for Core Courses**

Activity 2 has not yet been initiated, but will be in early 2011. The project proposal describes this activity as follows. While the BE curriculum is built on a foundation of mathematics, science and engineering science, as are all engineering disciplines, key courses for biosystems engineers include:

- *Biology for engineers*, including specific consideration of: (i) plants; (ii) animals; (iii) microbiology; and (iv) molecular biology
- *Thermodynamics of biological systems*
- *Unit operations in biological systems*, including specific consideration of biological, chemical and physical processes
- *Fundamentals of sustainable environmental engineering*
- *Innovation: sustaining biological resources utilization*

Including multinational examples in these courses will increase the global relevance of the courses and enhance the learning experience of the students. The plan for this activity is to first design the database structure, and then develop a format for describing a multinational example. Examples will be solicited from faculty of the partner institutions; the examples will be submitted in the given format. The examples will be entered into the database, which will be made accessible through the project website ([www.ucd.ie/tabe](http://www.ucd.ie/tabe)). Of particular interest are examples that illustrate the variability and similarity of global issues with respect to geography, climate, political system, culture, and other characteristics. Examples might include:

- Environmental transport, e.g. pollutant transfer in desert, Mediterranean, humid temperate and frozen environments
- Applications of fermentation processes, e.g. beverage production, biofuels and food safety
- Food safety processes and procedures, e.g. standards and processes for maintaining food chain integrity
- Bioenergy: production, conversion, environmental impact
- Biosensors and/or bioinstrumentation to assess biological processes including plant and crop health, and animal health and welfare.

### **Activity 3. Collaborative Online (web-based) Design Project Course**

The project proposal stated, “Design and teamwork are fundamental engineering skills that have to be developed by all professionals. We will develop a web-based course built around a simple design task. Students enrolled in the partners’ programs will be eligible to enrol in the course. The course coordinator will compile international teams to work on the design problem using eTutors/eMentors to support the teams and provide structured learning support materials. The course will be based on the UCD course BSEN10010 *Biosystems Engineering Design Challenge* (found by following links at [http://www.ucd.ie/students/course\\_search.htm](http://www.ucd.ie/students/course_search.htm)).”

The “Design” team has initiated its work but has not yet decided on the final format for the course. The team has established a Scholar project site through which team members have shared their CVs and information about the current design activities in their respective programs.

#### **Activity 4. Online (web based) Innovation and Entrepreneurship Course**

The project proposal described this activity as follows. Recent international developments are driving universities to move beyond teaching and research and extension into the realms of innovation and job creation. It is incumbent on BE as a discipline to provide training in innovation and entrepreneurship. A web-based module will be developed using resources from UCD Nova (see example material at <http://www.ucd.ie/nova/podcasts/>) and other partner institutes addressing issues such as business plans, intellectual property, marketing finances and law. Core curriculum will be supplemented by localization and examples drawn from BE and existing entrepreneurship courses (e.g. [engineering.illinois.edu/news/index.php?xId=071509120742](http://engineering.illinois.edu/news/index.php?xId=071509120742)).

The “Innovation” team has formed and had an initial meeting to share ideas. Progress will continue in 2011.

#### **Activity 5. Course Development: What is Biosystems Engineering?**

The proposal described this course as a BE seminar course for all partners, focusing on key global issues about which biosystems engineers have expertise, specifically, water, air, biological resources, energy, and food. The goal would be to introduce BE students to these global issues, including the role of biosystems engineers in addressing problems in these areas. Seminar materials will be developed and contributed by all partners. A blended learning approach will be used, including common lectures (seminar presentations) on-line and local tutorials. The target student will be a mid-level undergraduate, for example a sophomore or junior in the US and in the 3<sup>rd</sup> year of level 1 or 1<sup>st</sup> year of level two in EU. The implementation of this course would also serve as a recruiting tool on each campus for the planned student exchanges.

At the first meeting (Skype conference call) of the “Intro to BE” team, the team decided to develop a new Introduction to BE that would be a first or second year course, depending on the individual BE program structure, instead of the seminar course described in the proposal. The team concluded that the Introduction to BE course is a higher priority and is very interested in developing it. The seminar course might come later. The team concluded that the most effective approach for developing the Introduction to BE course would be to develop modules, with each module focusing on a particular concept with which BE students should be familiar. After the modules are developed, each BE program can select multiple modules to combine into a course that will meet that program’s needs.

The team has begun identifying concepts and taking responsibility for development of the modules (Table 2). For each module concept, the team will identify multiple applications of the concept in BE. Each module will include a variety of activities, e.g., lectures, laboratory exercises, and projects. In creating the modules, the team will build on the strengths of each participating university, with each participant taking the lead on developing selected modules. All partners will have the opportunity to contribute to each module.

Table 2. Module development assignments for the Introduction to BE course development team

<b>Concept</b>	<b>Applications</b>	<b>Module Development Leader</b>	<b>Module Development Participants</b>
mass balance	animal housing greenhouse environments	P. Panagakis, AUA	G. Russo, UB M-G. Danao, UIUC
energy balance	animal housing	P. Panagakis, AUA	M-G. Danao, UIUC
hydraulics	Watershed water balance Flow measurement	T. Wynn, VT	F. Gentile, UB
systems analysis		M.L. Wolfe, VT	
fundamentals of microbial stuff (bacteria, microbes)			M-G. Danao, UIUC
ecodesign	It could complement the animal or plant housing proposed above. Materials used in the construction, type of energy supplied, management of waste produced...	Á. Ramírez, UPM	
instrumentation – basic measurements	Measurement: Strain (stresses and pressures inference) temperature. Device: Strain gauges, semiconductors, RTDs, thermocouples, thermistors. Application: Structural (animal or plant housing)		G. Vox, UB Á. Ramírez, UPM
engineering ethics		M.L. Wolfe, VT	
teamwork			M-G. Danao, UIUC
technical writing			M.L. Wolfe, VT F. Gentile, UB P. Panagakis, AUA
data presentation	Technical reports, papers		T. Wynn, VT P. Panagakis, AUA
intro to statistics	Data summary and interpretation	T. Wynn, VT	
engineering design process			M.L. Wolfe, VT Á. Ramírez, UPM

## Anticipated Results

Project outcomes will include both tangible products and more globally aware and educated students and staff/faculty. Some of the tangible products that will improve teaching and student learning include the following: (1) common threads of BE; (2) a globally accessible database of multinational examples that are relevant to core BE courses; (3) a collaborative online (web-based) design project course for students at partner institutions who are not traveling; (4) online (web based) innovation and entrepreneurship course with multinational examples; (5) library of learning modules on basic BE concepts for Introduction to BE courses; and (6) scholarly publications related to the curriculum development activities.

The project will provide participants the opportunity to acquire more than just a technical BE education. Using both mobility and home programs, participants will have opportunities to develop their professional skills in an international context, including written and oral presentation, social skills, interactive communications, personal and team management, and cultural awareness. The combination of technical and professional skills will enhance the mobility of graduates in the global marketplace.

## Future Plans

Work on all of the curriculum development activities will continue through the spring 2011 semester. Specific results will be available related to each activity to report at the ASEE meeting presentation.

## Related Resources

1. ASABE, American Society of Agricultural and Biological Engineers, <http://www.asabe.org/>
2. Biosystems Engineering, Wikipedia [http://en.wikipedia.org/wiki/Biosystems\\_engineering](http://en.wikipedia.org/wiki/Biosystems_engineering)
3. ERABEE TN Education & Research in Biosystems Engineering in Europe; a Thematic Network; <http://www.erabee.aua.gr/>
4. EURAGENG, <http://www.eurageng.eu/>
5. POMSEBES, Policy Oriented Measures in Support of the Evolving Biosystems Engineering Studies in USA - EU. Project No. 2006-4563/003-001, CPT CPTUSA. <http://www.pomsebes.aua.gr/>
6. IBE, Institute of Biological Engineering, <http://www.ibe.org>
7. USAEE, University Studies of Agricultural Engineering in Europe, 2007: <http://www.hostforce.co.uk/nondrup/usae/usae-tn.htm>
8. USAEE Core Curriculum, [http://www.hostforce.co.uk/nondrup/usae/files/USAEE%20Core%20Curricula%20Pivot%20FEANI\\_final%20version.pdf](http://www.hostforce.co.uk/nondrup/usae/files/USAEE%20Core%20Curricula%20Pivot%20FEANI_final%20version.pdf)