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Part I
Special Issue I

a) Agricultural Engineering and the Emergence of Biological Engineering
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Biological Engineering, the engineering discipline that connects engineering and biology, encompasses both ‘connecting engineering to biology’ and ‘connecting biology to engineering’ in its engineering design process. The first directional case of ‘connecting engineering to biology’ pertains to the application of the engineering design process to regulate and manipulate a given biological system for the purpose of achieving a desired end. The second directional case of ‘connecting biology to engineering’ pertains to employing the knowledge of the attributes of biological systems to inform or guide the engineering design of a physical system for the purpose of achieving a desired end. For ‘connecting engineering to biology,’ the object of the design process is a biological system and its design factors are limited by physicochemical principles. Contrastively, for ‘connecting biology to engineering,’ the object of the design process is a physical system and its design factors are limited by biological attributes. The first case of ‘connecting engineering to biology’ addresses the design of: (1) protocol for biological system; (2) structure for biological system; and (3) model for biological system. The second case of ‘connecting biology to engineering’ addresses the design of: (4) material based on biological system; (5) machine/device based on biological system; and (6) instrument based on biological system.

Keywords: biological engineering; design

The genealogy of Biological Engineering, spanning a period of at least four millennia, shows that Biological Engineering is descended from the intersections of various disciplines that originate from three ancient pillars of knowledge, including the practices of engineering and medicine and the discipline of philosophy. The descent of Biological Engineering through the ages flowed from the demise of Teleology and from the triumph of Mechanism, making Biological Engineering a thoroughgoing mechanistic discipline, no different in this respect from all the other modern engineering disciplines. It is the mechanistic nature of Biological Engineering that enables the basic technical activity of Biological Engineering, engineering design, to be successfully accomplished. The genealogy of Biological Engineering also underscores that, based on historical evolution, Biomedical Engineering precedes Biological Engineering. Based on the disciplinary hierarchy, however, Biomedical Engineering falls under the rubric of the broader, more inclusive, Biological Engineering.

Keywords: biomedical engineering; biological engineering

The discipline of Biological Engineering is an academic structure evolving to address educational needs based on technologies arising from the new advances in the life sciences. This paper focuses on presenting concepts that distinguish Biological Engineering as a discipline, distinct from existing engineering disciplines, based on unique principles that define biology/living systems. It presents a perspective of Biological Engineering that focuses on the engineering of the inherent, central principles of living systems versus the application of externally engineered systems to existing living systems to alter their behavior or structure. Important concepts in educational curricular topics and concepts are also discussed, along with the historical background to the development of Agricultural Engineering into Biological Engineering.

Keywords: biological engineering; agricultural engineering; historical overview; living systems

Agricultural engineering is the only traditional engineering discipline in which biology and living systems have always played a major role. The emerging field of biological engineering, therefore, finds a natural home in agricultural engineering departments, many of which have recently changed their names to reflect their inherent and growing emphasis on biology. These departments are restructuring, or expanding to integrate focused biological engineering programs into their educational infrastructure. The goal is to create a new community of engineers who are savvy in the biological sciences and can engineer living systems. This paper discusses the challenges specific to building biological engineering programs in a historically agricultural engineering department at the undergraduate level and suggests a framework for meeting these challenges. The student perspective is emphasized and the author draws on personal experience as both a former student and a current faculty member in biological engineering. The recent efforts within Purdue University's department of Agricultural and Biological Engineering are used as an example and a backdrop for discussion.

Keywords: biological engineering; agricultural engineering; program development

During the past decade, there has been a worldwide debate on the future of Agricultural Engineering education. In a previous paper, we discussed the historical evolution of and curriculum reforms in agricultural engineering (AE) education at Sultan Qaboos University. Some of the significant changes implemented during the last decade have included renaming the department and degree major, and restructuring the curriculum to meet ABET's minimum requirements for professional accreditation. Our objective in the present article is to assess students' perceptions on several issues affecting the future of agricultural engineering education, especially the factors which influence its attractiveness to students. Our results show that the majority of students perceived the public profile of AE and public understanding of the role of AE in society to be very low. The poor image of agricultural engineering was mostly attributed to its association with agriculture (74%) rather than engineering (26%). The majority of students expressed a preference for a degree name that includes ‘Engineering’ or ‘Technology’ rather than ‘Agriculture’ or ‘Science’. The low appeal of names connected with biology among the students was attributed to the high esteem accorded to the engineering profession in society and also a strong connection made by students between engineering and ‘machines’ and between engineering and maths/physics, instead of engineering and biology. Students also suggested practical steps to enhance the image, visibility and appeal of AE among students through targeted promotional campaigns and community outreach programs.

Keywords: agricultural engineering; student perceptions; image surveys

b) Agricultural Engineering Education in Developing and Transitional Countries

To serve the economic development needs of developing and transition countries, two distinct ‘agricultural engineering’ curricula are proposed. One to educate bio-process engineers and the other to educate engineering technologists. The bio-process engineers are expected to create innovative products that meet market expectations and to solve complex and diverse processing problems. It is suggested that the on-farm needs of agriculture are best met by a specialisation in agricultural engineering technology. An agricultural engineering technologist is a broadly educated agriculturalist with the ability to solve straightforward engineering problems through application of proven systems.

Keywords: bio-process engineering; agricultural engineering technology; curricula

While training in traditional branches of agricultural engineering has never been in doubt in developing countries because of the agro-based economies, of late, the relevance of this training has come under scrutiny as the world order shifts towards more market-oriented economies with the resultant requirement of efficient resource utilisation, environmental integrity and social equity. Traditional programmes as previously designed based on developed country models are becoming marginal as most conditions do not obtain in developing countries. This paper analyses the relevance of tertiary agricultural engineering education in southern Africa in the face of world and regional dynamics taking place. It will be argued that traditional agricultural engineering education is becoming dated as there is a need for more dynamic programmes. On one hand, many economies in Southern Africa are stagnating, and yet on the other, the requirements of agriculture and agro-industry are changing, leading to the need to review and modify curricula regularly. Formal research and development departments are almost non-existent in industry, but do exist in the informal sector and small and medium enterprises (SMEs) at a very basic level. Developing countries tend to be net importers of equipment and machinery yet training offered is geared towards research and development. The informal sector and SMEs, which are expanding, require entrepreneurial agricultural engineers yet the training is geared towards formal employment. Alternative engineering programmes are coming on line with resultant shrinkage in enrolments in agricultural engineering. It is apparent that the basic tenets of agricultural engineering education need to be revolutionised to serve the real needs of society and for the discipline to remain relevant and competitive. The paper gives examples from agricultural engineering degree programmes from the region including South Africa and Zimbabwe. Suggestions are given on the desirable curriculum reform.

Keywords: agricultural engineering; developing countries; university funding; curriculum reform; entrepreneurial skills

Currently there are over 164 universities in 31 countries offering undergraduate degree programs (or as an emphasis) in agricultural engineering (AE). Many of these programs are not offered through engineering colleges and thus are not accredited as engineering degrees. Some of the AE curriculums have less than 50% of the coursework in engineering and as a result, inadequate training in engineering is given to AE graduates to compete with those with traditional engineering degrees. Many AE programs place very little emphasis on the areas like bioprocess engineering or biomedical engineering that can make the graduates more marketable. National engineering institutions of some of the developing countries do not welcome agricultural and biological engineers on board for professional membership. This manuscript will critically evaluate such problems and the current situation of agricultural engineering education in developing countries and will attempt to create awareness among universities and professional organizations of what is necessary for a thriving agricultural and biological (systems) engineering profession.

Keywords: agricultural degrees; developing countries; declining enrolments

The education of agricultural machinery technicians is performed by the vocational schools in Turkey. One of the main problems of the agricultural sector in Turkey is the lack of qualified technicians. Parallel to the changing agricultural engineering concept in Europe, new technologies have been launched for teaching of agricultural machinery technicians. New and expanded areas like GPS and GPRS for management, technical-biological system analysis, and natural Resources Technology have been included in the agricultural technologies disciplines of traditional Universities of Agricultural Colleges in the EU. Modern agricultural machinery technician courses include the subjects of information technologies, mechatronics, sensor technology and robotics. The most important step to take in Agricultural machinery programs is to increase the quality of agricultural education and to identify where it stands in international standards. Throughout the membership application process of Turkey prior to joining the EC, there has been a need for the application of new technologies and more qualified, sustainable education for agricultural machinery technicians who will be welcomed by the EU countries. In this paper, we describe the model and curriculum of agricultural machinery technician education of the Uludag University.

Keywords: agricultural machinery; technician education; European Union programs; credit transfer

The objective of this paper is to illustrate the scope, uniqueness and opportunities for Agricultural Engineering and to present an overview of Agricultural Engineering education in South Africa. The need for engineers in South Africa is assessed, and the output from the schooling system in South Africa to meet this need is illustrated. Thereafter, the performance of engineering students at the University of Natal is analysed and selected challenges and opportunities for agricultural engineers in South Africa are summarized. From the results of the study it is evident that the performance of students in their final year of school is a poor indication of their performance in their first year of engineering studies and the standard of the school education system presents challenges to tertiary engineering educational institutions that need to focus on the retention and throughput of students.

Keywords: agricultural engineering; bioresources engineering; agricultural degree accreditation; GPA

Part II

Papers in Engineering Education Research, Assessment, Design Theory, Mechanical Engineering, Biomechanics, Chemical Engineering, Electrical and Control Engineering

This paper reports on an attempt to enhance the learning outcomes obtained from a computer simulation aimed at extending students' understanding of distillation. The approach taken draws on a contemporary education perspective known as variation theory. The design uses the notion of a learning study to identify the key aspects of the learning situation. In-depth interviews were used to gain insights into the learning outcomes of the redesigned simulation experience. The overall finding is that the students were able to draw on their previous knowledge and expand it in ways that made them feel positive about the experience.

Keywords: variation theory; learning outcomes; computer simulation; distillation

Since the lack of creative potential in graduating engineers has been and continues to be a concern for industry leaders, most educators have added a common ideation approach—brainstorming—to engineering design curricula. However, because brainstorming requires the designer to look inward for inspiration, it can be a daunting task, which is not always fruitful. Some systematic creativity methods, on the other hand, use solution patterns derived from problems similar to the one being solved. These methods have typically been introduced in senior or graduate elective courses, if at all. This paper presents the rationale for, and our experience with introducing one of these methods, the theory of inventive problem solving (TRIZ) in a first-year engineering design course. In addition, a study, comparing the ideation quantity in course sections that used TRIZ against control sections that did not, is presented. Results indicate that student teams from sections, where TRIZ was taught, generated substantially more feasible design concepts for an industry-sponsored design problem that was common to all sections.

Keywords: creativity; inventive problems; TRIZ

This paper presents the findings from a study of the development of transferable skills and considers the most effective approach to teaching transferable skills in four university departments of chemical engineering in the UK. Case study methods, incorporating mind maps, follow-up interviews, focus groups and questionnaires, were used to collect data. Although the literature suggests that skills development is best taught in engineering curricula through integrated teaching approaches, findings from this study suggest that embedded and bolt-on teaching approaches are also helpful in augmenting the development of transferable skills. All three approaches help build student awareness of transferable-skills education.

Keywords: transferable skills; mind maps; developing skills; bolt-on method; integrated method; embedded method

The College of Engineering at Iowa State University (ISU) partnered with constituents and assessment professionals to identify and validate 14 observable and measurable competencies necessary and sufficient to measure program outcomes. Constituents identified the engineering and experiential workplaces as settings most likely to develop and demonstrate the competencies, and the traditional classroom as least likely. Engineering students in the experiential workplace are assessed on the competencies by their supervisors, providing feedback for curricular change. These results confirm that we must re-examine how we use the classroom to educate engineers and our belief that experiential education is critical to students' success.

Keywords: assessment; ABET; competencies; workplace assessment; internships

Data showing an increase in grade point average of 0.41 over the past 30 years at the Georgia Institute of Technology were presented. The grade point average (GPA) increased for virtually all departments. Graduate school GPA's also increased. Several unexpected factors were shown to influence grades. For example, Summer school grades were higher than for other terms. Possible causes and consequences of increasing GPAs are reviewed as well as actions that may be warranted to allow for a return to a grading system that permits greater differentiation between students' performances.

Keywords: grade inflation; GPA

This paper outlines a new 4th-year undergraduate course on the generation of system configuration (geometry, architecture, and drawing) during the maximization of performance of flow systems. The configuration is free to morph. Real systems are destined to remain imperfect because of finiteness constraints. They are plagued by resistances to the flow of fluid, heat, and electricity. The balancing and distributing of resistances (irreversibility) through the available volume is the mechanism that generates the architecture. The course teaches the generation of configuration, multi-scale and multi-objective hierarchical structures for fluid flow and heat flow, tree-shaped networks for collection and distribution, and strategies for reducing the cost of generating the flow configuration.

Keywords: constructal theory; design; flow; mechanical structures

The purpose of this article is to show how the Revised Bloom's Taxonomy has been used in designing an instruction module in an analytical course in engineering for distance learning. Identification of the type of knowledge and cognitive process associated with each task is found to be useful in informing the selection of appropriate instructional strategies. Using bending stress calculation as a sample case study, potential opportunities and challenges facing the instructor are discussed. Problems associated with the original taxonomy and the enabling features in the revised taxonomy for more informed analyses are also described.

Keywords: instructional design; mechanics; Bloom's taxonomy; bending stress; flexure formula

In this paper, we discuss the development, implementation and evaluation of a 'Research Experiences for Undergraduates' program in nanomaterials processing and characterization offered at the University of Central Florida. Here, we focus in particular on details pertaining to the program's instructional design and subsequent evaluation that may be useful for other engineering educators involved in undergraduate research and education in nanotechnology. Based on our analysis of program outcomes, implications are suggested for undergraduate and postgraduate engineering education programs that focus on aspects of nanoscale science and technology.

Keywords: nanotechnology; undergraduate research

Evaluation of courses and programs has received greater attention recently because of efforts to improve engineering education following processes recommended by the Accreditation Board for Engineering and Technology. The empowerment evaluation process has been used at Kansas State University for both program development and the evaluation of a Geoenvironmental Engineering Design course. We have developed and instituted a Geoenvironmental Certificate Program through funding from the National Science Foundation Combined Research and Curriculum Development Program. The Geoenvironmental Engineering Design course was taught for the first time in the fall of 2004, and an empowerment evaluation of the course was conducted immediately after final grades were submitted. The empowerment evaluation process is illustrated in this manuscript, and the results of the evaluation are presented. A culture of evidence and a community of learners is fostered through the empowerment evaluation process. The results show that the students appreciated the opportunity to work in multidisciplinary teams on real design problems with an interdisciplinary team of faculty. The students considered the feedback that they received on written and oral progress reports to be a significant aspect in their learning.

Keywords: empowerment evaluation; geoenvironmental engineering; learning objectives; design project; course reform

Continuum Biomechanics is a graduate level course taught in the Department of Bioengineering at Rice University, Houston, Texas. The course is primarily a theoretical one, based on advanced mathematical concepts. An important element of this course is the development of a lecture by each graduate student. The project involves the entire process of developing a board-based, graduate-level lecture, including conception, presentation and post-lecture support. This project allows graduate students to develop and improve important teaching skills, including developing a lecture, managing a board legibly, and understanding how much material can be covered effectively in an allotted amount of time.

Keywords: biomechanics; stimulent presentation; communication; assignments

An integrated chemical engineering lab experiment is described in this paper. It makes use of a laminar-flow tubular reactor (LFTR) through consecutive lab sessions. In a first session (not described here), the pseudo first-order kinetic constant for the reaction between crystal violet and sodium hydroxide is determined at different temperatures in a batch reactor. Then a tracer experiment is used to characterize the flow pattern in the LFTR, and finally the steady-state conversion of crystal violet in the reactor is measured. For computing the theoretical reactor conversion, students must use the previously collected kinetic and tracer data, in a concept-integration exercise. A computational fluid dynamics (CFD) code (Fluent) is also used to simulate both the tracer and the isothermal reaction experiments performed in the LFTR. A very good agreement is obtained between experimental and simulated results and both only differ slightly from the theoretical predictions. The use of the CFD program is particularly noteworthy. For instance, transient simulations allow a very nice visualization of the tracer concentration front evolution, while the steady-state profiles along the axial position provide a good perspective of how reactant concentration varies within the reactor.

Keywords: chemical reactors; computational fluid dynamics; simulation

This paper presents an educational tool developed for neural network (NN) control of brushless DC (BLDC) motors. Neural networks courses are widely offered at the graduate and undergraduate level due to the successful applications of neural networks to the nonlinear and unmodelled systems control. However, teaching of neural network control in a laboratory may be time consuming and an expensive task. The developed software helps students learn the application of neural network control to the electric machinery. It provides flexible structure and graphical interface which permits the design of the neural networks and its training with various learning algorithms. Using the proposed tool, neural network control performance of BLDC motors can be monitored graphically for different NN control structure under different load conditions and parameter variations.

Keywords: control; neural network; DC motors

A real-time control laboratory is presented here. The experiments are based on a non-linear plant and are oriented to undergraduate courses on digital control and intelligent control. The strategies proposed are both classical and intelligent techniques. Thus, the students can compare, on the real plant, the results obtained with both approaches. The control problem is to eliminate the load oscillations in a transport crane. To solve this problem the students will apply a classical state feedback controller and then will improve this algorithm with intelligent techniques based on neural networks (NN) and fuzzy logic (FL). The experiments are carried out on a low-cost scale prototype.

Keywords: control laboratory; low cost plant; fuzzy logic; student motivation