

# The International Journal of Engineering Education

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### Part I

#### Special Issue

#### Trends in Agricultural, Biosystems and Biological Engineering Education (II)

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Linus Opara, Sultan Qaboos University, Sultanate of Oman

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#### (a) Curriculum Reform, Assessment and Accreditation

T. H. Walker, C. M. Drapcho and W. H. Allen	1123–1128	Zero-Based Curriculum Revision in Biological Engineering: Challenges for a New Century
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*To keep pace with rapid advancements in biology in the 21st century, a zero-based undergraduate curriculum revision was conducted at the Clemson University Biosystems Engineering program that incorporated more advanced biological sciences and biological engineering design while maintaining the basic engineering courses. The zero-based review incorporated surveys to both graduating seniors and advisors from biotechnology and the biopharmaceutical industry.*

**Keywords:** curriculum reform; biosystems engineering; portfolio

W. T. Monroe, M. Mailander and M. Lima	1129–1138	Focus on Experiential Education: A Freshman Engineering Program in Biological Engineering
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*This paper describes a freshman engineering program implemented in the Biological Engineering curriculum at Louisiana State University. This program was initiated to address low student retention rates and was subsequently modified to address new evaluation criteria and a university focus on writing across the curriculum. Our model includes the drawing, design, and construction of hands-on, group projects, and requires frequent use of oral, written, and teaming skills. Results show that retention and graduation rates have improved, and that the program is considered successful by virtue of student assessment, exit interviews, and faculty reflections.*

**Keywords:** engineering design, freshman, service-learning, experiential learning, retention.

L. U. Opara, J. S. Perret and D. B. Ampratwum	1139–1148	The Evolution of Agricultural Engineering Education and Curriculum Reform at Sultan Qaboos University
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*The objective of this article is to describe the evolution of agricultural engineering education at Sultan Qaboos University, including curriculum changes and employment status of its graduates. The agricultural mechanization program was established in the Department of Mechanization in 1986. After a decade, the department name and program were changed to Bioresource and Agricultural Engineering (BAE). Most recently, the department has been merged with the Department of Soil and Water Sciences to form a new Department of Soils, Water, and Agricultural Engineering. The name change in 1996 was considered to represent a paradigm shift from a focus on 'technology' content to greater emphasis on 'engineering' content and this re-orientation was further reflected by changes in the curriculum to increase the content of mathematics and basic engineering courses. Including the word 'engineering' in the name of the major appears to enhance its appeal and attractiveness to students. A comparison between the BAE curriculum and a generalized framework within which most accredited engineering curricula can be evaluated showed that the BAE undergraduate curriculum meets the minimum requirements of ABET professional program. Employment of graduates in the public sector has been very good, but appears to be recently stagnating.*

**Keywords:** agricultural engineering; bioresource engineering; curriculum reform; ABET accreditation

T. A. Costello and D. J. Carrier	1149–1156	Emergence of Biological Engineering at the University of Arkansas
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*This paper describes the changes that took place in 1984–2003 as the University of Arkansas developed an undergraduate program in biological engineering as a replacement for a traditional agricultural engineering program. In the early 1980s, the faculty recognized that engineers with biological tool sets could be utilized in a broader context (beyond traditional agricultural industries) with wider opportunities for employment. Program changes that were adopted to allow graduates to embrace these new opportunities included: (1) increased requirements for basic biological sciences, and (2) increased coverage of life support systems, growth kinetics and bio-processing. The accompanying changes in faculty expertise and student recruiting and enrolment are presented.*

**Keywords:** agricultural engineering; biological engineering; curriculum reform; ABET

R. L. Bengtson	1157–1162	Louisiana State University's Biological Engineering Program
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*In the mid 1980s, undergraduates entering Louisiana State University from rural backgrounds seeking to enter agricultural-related industries were replaced by students from urban settings seeking careers in biological, environmental and medical professions. In response to this, LSU developed an engineering curriculum explicitly integrating the biological sciences. This Biological Engineering curriculum is uniquely applied to develop engineering solutions to problems that affect plants, animals and the natural environment. It is a unitary program without any specialties. The students complete a 107 semester hours core curriculum plus 9 hours of design electives, 18 hours of general education electives, and 3 hours of free elective. The enrollment increased from 2 students in 1988 to 160 in 2003. The annual number of graduates increased from 0 in 1989 to 33 in 2003 with 188 total graduates as of 2004. Twenty-nine per cent of the graduates attended graduate school, 22% have gone to work in environmental consulting, 12% in manufacturing, and 10% have gone to medical school. This program has been very successful and provides needed biological engineers for the Louisiana and regional economy.*

**Keywords:** Biological engineering; curriculum

**T. J. Brumm, S. K. Mickelson,  
B. L. Steward and A. L. Kaleita** 1163–1172 Competency-based Outcomes Assessment for Agricultural Engineering Programs

*The ABET 2000 criteria have provided the impetus for the Agricultural and Biosystems Engineering Department at Iowa State University to re-structure the assessment of its undergraduate agricultural engineering program. We linked ABET student outcomes to validated work-place competencies with key actions that are measurable in academic and experiential education environments. Two tools are being used to assess competencies: an on-line assessment system and electronic portfolios developed by each student as a requirement for graduation. This paper discusses the overall philosophy of our assessment program, how the assessment tools are being implemented, and the implications for change in the curriculum.*

**Keywords:** Outcomes, assessment, competencies, electronic portfolios, on-line assessment, experiential education, internships, ABET.

**P. H. King and J. C. Collins** 1173–1181 Ethical and Professional Training of Biomedical Engineers

*Where once ethical concerns in biomedical engineering coursework involved primarily the effects of technology on medicine and health care distribution, several factors currently affect the presentation of ethical material to biomedical engineers. These include the maturation of the field as an ABET (Accreditation Board for Engineering and Technology) accreditable discipline, with the commitment for instruction in ethics and increasing student and faculty concerns over ethical misconduct relating to the profession. This paper reviews ethics instruction at Vanderbilt University, relating past history and current societal expectations to the current expression of ethical concerns in design and design seminars and in a specific course in ethics.*

**Keywords:** ethics; biomedical engineering; technology; design; syllabus

**A. R. M. Shariff** 1182–1188 ISO Certified Biological and Agricultural Engineering Tertiary

*This paper deals with the ISO 9001 certification and implementation of the new curriculum for Biological and Agricultural Engineering education at the Bachelors level at the Universiti Putra Malaysia. The paper outlines the goals behind the intentions to pursue the ISO certification, the method of formulation of the relevant teaching and academic procedures and the associated quality records. An assessment of the effectiveness of the ISO 9001 system in further enhancing the standard and quality of biological and agricultural engineering program is also demonstrated.*

**Keywords:** ISO 9001, biological engineering, curriculum.

#### **(b) Simulation, Resource Management and Field Demonstration Tools**

**E. R. Benson C. Krawczyk  
and G. F. Figueiredo** 1189–1196 Evaluation of Tablet and Laptop Computers in Field and Laboratory Settings

*Technology is a part of modern society. Desktop computers facilitated changes in the introduction of technology in education; however the form factor of most desktop computers limits mobility. Laptop computers allowed users flexibility and portability; although portable, laptop computers are often difficult to use during movement. Tablet computers are a cross between a flat screen monitor, laptop computer and a personal data assistant (PDA). The form factor for a tablet PC offers significant potential advantages for teaching and learning.*

*In this project, tablet computers were evaluated under classroom, laboratory and field applications in the Landscape Horticulture and Engineering Technology curricula. The tablet computers were fully implemented in two courses (Plant Science 330: Landscape Construction Details and PLSC 332: Basic Landscape Design) in Fall 2003. Both classes used laptop and tablet computers to record base data in the field, such as measurements of site data, details, utility, tree and other field locations. Site data gathered by students in Basic Landscape Design was used to produce base sheets for design projects. Students in the Landscape Construction Details class used the computers to learn AutoCAD and produce construction details from observations in the field. They also saved studio time by drawing details in field settings; thus producing more accurate drawings that were based on meticulous field notes, combined with the ability to verify information while still on the site. The alternative—taking field notes alone—requires follow-up visits if there is missing information. Implementing laptop and tablet personal computer technology has resulted in more accurate field information, more site-responsive design decisions and better use of time in design settings. Survey results and analyses are included in the paper.*

**Keywords:** tablet computer; field setting; field notes; landscape design

**F. Rodríguez, M. Berenguel,  
J. L. Guzmán and S. Dormido** 1197–1209 A Virtual Course on Automation of Agricultural Systems

*New teaching methods and innovative techniques have recently appeared that aim to enhance students' motivation and improve their education. This paper describes the experience of developing a virtual course on modern automation of agricultural systems. It includes both classical teaching tools and novel teaching methods, taking advantage of new information and communication technologies (ICT). The course is based on the WebCT platform and includes interactive tools and both a virtual and a remote laboratory for greenhouse climate control and fertirrigation teaching/learning.*

**Keywords:** ICT; WebCT; virtual course; agricultural systems; control; automation

**R. Badal, S. Kim, J. Owens  
and H. Beck** 1210–1218 An Integrated Database Approach for Managing Educational Resources in Agricultural and Biological Engineering

*A database approach to managing educational materials is presented that uses ontologies, object management systems, and dynamically generated Websites to manage educational resources better and enhance learning in the agricultural engineering curriculum. An example in the area of bioprocess is presented. An ontology is used to define and organize the concepts in the domain: in this case concepts involving the biology, chemistry, and physics of bioprocess. A database, rather than files, is used to store and distribute concept objects. Instructors use Web-based data visualization tools to develop and manage course content. Objects can be projected to a number of different presentation formats including Websites and printed materials. Evaluation of a 2D simulation of a bioprocess experiment shows that Web-based simulation can offer many of the experiences of hands-on laboratory exercises. The database approach simplifies the development process and lowers the cost.*

**Keywords:** virtual lab; simulation; bioprocessing; content management system; ontology; database

**M. Omid** 1219–1223 Introducing Simulation Software as an Educational Tool to Enhance Student Understanding of Tractor Field Performance

*This paper presents a computer program that can be used for teaching tractor performance to undergraduate students of agricultural system management. One of the best ways to apply theory is the usage of simulation software and visualization techniques. Simulation software helps students to understand the performance aspects of tractors in the field from the pure science aspects of the subject. The interface was designed with Visual Basic 6.0 and can be used to predict the performance as well the tractor's specific volumetric fuel consumption for agricultural soils. Other features include provision for changing model parameters, adding new models, saving data using Excel spreadsheets and printing the results.*

**Keywords:** Tractor performance; simulation software; visual basic

**A. Šorgo and S. Kocijancic** 1224–1230 Demonstration of biological processes in lakes and fishponds through computerised laboratory practice

*Higher education in Slovenia is facing a decline in interest in the study of engineering and science, despite the fact that job opportunities for engineers have continually increased in recent years. In addition, the scientific and technical knowledge of students entering higher education has been observed to be rather theoretical and fragmented with a weak association to technological issues. This article presents an action designed to improve this situation. At a grammar school in Slovenia, inquiry based teaching has been introduced to biology laboratory lessons. The aim of these lessons is to study biological processes in fishponds, focusing on the concentration of dissolved oxygen. Students are asked to predict the outcome in four different situations that may arise in a fishpond. To verify their hypotheses, the students are required to design and analyse computer supported measurements in an aquarium that reflects the processes in the fishpond. Feedback from students during lessons, as well as their responses to a questionnaire administered afterwards are encouraging. Although computerised school laboratory and inquiry-based teaching is not foreseen in the official curriculum, certain prescribed learning goals were fulfilled. Furthermore, students achieved knowledge and skills that are not anticipated in the curriculum, but may be of equal or greater importance.*

**Keywords:** school science laboratory; data acquisition; plant physiology; model experiments; biology teaching; inquiry-based teaching; problem-based teaching

**H. Sumali** 1231–1240 Developing a Laboratory Course in Sensors and Data Acquisition for Agricultural Engineering

*This paper reports an endeavor to outfit a laboratory for a new course that teaches physical process variable measurements, signal conditioning, data acquisition using computers, data processing, and transmission and communication of measurement results. Major effort was spent on designing and building new instrumentation test stands. Each test stand has a computer, a data acquisition system, various transducers for pressure, flow, and temperature, and several other process control components such as valves, a pressure accumulator, a heat exchanger and heaters. The test stands are self-contained, modular, movable, and can be used wherever there is electric power. Internet connection allows monitoring and control of the test stands from anywhere in the world. Students write graphical programs to acquire, process, and present data. Students have applied the skills gained in the course to research and industry. The course has helped one of its students win an international scholarship. Initiated at Purdue University, the course has been taught at a university in Brazil.*

**Keywords:** sensors; data acquisition; agricultural engineering

## Part II

### Contributions in: Engineering Education Research, Engineering Design, Engineering Ethics, Control Engineering, Industrial Engineering and Geotechnical Engineering

**F. Bullen and D. Knight** 1241–1251 The Broad and Strategic Value of the Freshmen Engineering Experience—FEE

*Many papers have been written on the teaching and learning value of the 'freshmen engineering experience' (FEE), where FEE is an experimental, design project based course that provides a stimulating introduction to engineering for freshmen students. The research has largely focused on the pedagogical benefits obtained via the problem-based learning techniques implicit in well designed FEEs. Less well reported are the accompanying issues of pass and retention rates, integration with K-12 outreach programs, contributions towards national rankings and their overall strategic importance in engineering programs. This paper reviews the broad value and strategic role of FEE programs in the framework of engineering education.*

**Keywords:** freshmen experience; design; retention; integration; internationalization

**J. L. Cano, I. Lidon, R. Rebollar, P. Roman and M. J. Saenz** 1252–1260 Student Groups Solving Real-life Projects. A Case Study of Experiential Learning

*A Project Management (PM) training approach is presented based on the solution of real-life projects by groups of students in their last year at the School of Engineering of the University of Zaragoza. The training dynamics simulates the functioning of a consulting firm, where students are the consultants and the teachers work as mentors, sharing a common methodology to help the student groups to successfully bring their projects to completion. The 'problems' to be solved are proposed by real customers. During the academic years 2003/04 and 2004/05, 41 customers and 240 students have taken part in the course, with very satisfactory results. With the ultimate goal of increasing the satisfaction of all participants in this course, our priority has evolved in this period and we currently seek to ensure that no project group ends in failure. The results of this experience are based mainly on the analysis of 'failed' groups (5 out of 41 cases), the periodic group self-assessment sessions and the feedback received from students. According to this research, coordination within a project group appears to be a key aspect in influencing the results obtained. Those groups with an assigned 'coordinator' worked better. It is also worth pointing out that, as the project advanced, it was noted that all of the groups felt more confident and more optimistic about the quality of their work and the level of satisfaction expected from the customer, regardless of the actual results. Also, the vast majority of the groups grossly underestimated the time needed to complete the work. The paper concludes by describing future lines of work and collaboration in the model framework presented.*

**Keywords:** cooperative learning; project management; Project Management Office; experiential learning; newly formed groups

**D. Oehlers and D. Walker** 1261–1268 Assessment of Deep Learning Ability for Problem Solvers

*Teaching design in engineering is a complex but challenging task requiring the development of numerous attributes by the students. Furthermore, with the increasing diversity of subjects taught in civil engineering less time is available for addressing individual subjects, let alone individual attributes. There is also the tension caused by the need to impart a deeper long-term training for engineering problem solvers while maintaining the short-term training of the essential but straightforward prescriptive design tools and skills. It is shown that it is still possible to develop design courses that train and, more importantly, assess a student's problem solving abilities by implementing assessment schemes that acknowledge and reward higher level learning while still maintaining an element that ensures the basic skills have been mastered.*

**Keywords:** assessment; learning; teaching; engineering design; fundamental principles

**C. Williams and F. Mistree** 1269–1280 Empowering Students to Learn how to Learn: Mass Customization of a Graduate Engineering Design Course

*ME 6101 Engineering Design, is a graduate level course offered through the George W. Woodruff School of Mechanical Engineering at the Georgia Institute of Technology. To empower students to learn how to learn, the orchestrators of ME 6101 strive to offer an individual course in a group setting. In this paper, the techniques utilized to create this type of learning environment are described in terms parallel to those of the mass customization paradigm. Excerpts from students' essays are presented as anecdotal evidence that the concerted use of these methods aids and empowers students both in the internalization of course content and the development of critical analysis, abstraction, and synthesizing skills that will help them become lifelong learners.*

**Keywords:** Engineering design education; Mass customization of education; Learning how to learn.

**Y. Zhao** 1281–1286 How to Design and Interpret a Multiple-Choice-Question Test: A Probabilistic Approach

*Multiple choice question (MCQ) tests involve an element of guesswork, which affects the reliability and interpretation of test scores. This article studies the probability of obtaining a certain score by pure guesswork and introduces a conversion scheme which converts raw test scores into standard percentage marks. The probabilistic analysis shows that the optimum number of choices of answers for MCQ questions is four, and for a four-choice question test, increasing from 8 questions to 18 and 48 questions reduces the probability of obtaining a converted mark above 40 by pure guesswork from about 5% to below 1% and 0.01%, respectively.*

**Keywords:** MCQ; conversion scheme; probability; score; mark.

**T. P. Rich** 1287–1296 Lessons in Social Responsibility from the Austin Dam Failure

*While many are familiar with the Johnstown Flood of 1889, another significant dam failure in Pennsylvania occurred twenty-two years later in Austin. This paper tells the story behind the design, construction and ultimate failure of this early concrete dam and the subsequent disaster in the town below it. Correspondence between the design engineer and the dam's owner along with other period documentation provide important insights into social responsibility leading to the question: how should society protect the public from the misuse of technology? The roles played by the town citizens, engineer, owner, state and Federal governments, and a professional engineering society are examined.*

**Keywords:** ethics; social responsibility; dam failure

**J. Petric and Z. Šitum** 1297–1303 Pneumatic Balancing Mechanisms in Control Education

*The paper presents three balancing mechanisms, which have been utilized as experimental systems in the control education of mechanical engineering students. Their uniqueness is the pneumatic drive, which makes them more affordable, simpler and more interesting to control. These balancing mechanisms are the inverted pendulum, the inverted wedge and the ball and beam, while the pneumatic infrastructure includes a variety of valves. This paper describes these experimental systems and some methods applied to control them.*

**Keywords:** control education; experimental systems; mechatronics; pneumatics

**J. Marcos-Acevedo, J. M. Vilas-Iglesias and S. A. Pérez-López** 1304–1318 Multimedia System for the Teaching of Proximity Sensors

*Throughout this article we will outline a new software tool aimed at explaining the major features of proximity sensors, as well as their different types, to engineering students and automation experts. We propose an interactive multimedia application that shows the basics of this type of sensor, their electrical, physical, mechanical and operating characteristics, the types of electrical outputs, operating modes and configurations. Through a large number of simulations, animations, industrial system videos, links to manufacturer Web pages, catalogues and data sheets we introduce a comprehensive view of inductive, capacitive, optoelectronic, ultrasonic and magnetic sensors, micro-switches and limit detectors intended to work as proximity sensors in an industrial environment.*

**Keywords:** e-Learning; multimedia; proximity sensors.

**M. D. Bovea and A. Gallardo** 1319–1324 Work Placements and the Final Year Project: A Joint Experience in the Industrial Engineering Degree

*Since the academic year 1998/1999, industrial engineering students at the Universitat Jaume I in Castellón (Spain) have been encouraged to do their final year project as part of a work placement. This paper presents the findings from this experience. Once students have successfully completed more than 90% of the credits in core and compulsory subjects in their programme of studies, they then have a work placement in a public or private company in the industrial sector in the province of Castellón. During this period they receive the support and guidance of a supervisor in the company and a tutor at the University, both of whom are thoroughly familiar with the topic being dealt with in the placement. Students' final year projects are derived from the work they carried out during their stay at the company. Both students and members of the teaching staff rate this experience as being extremely positive, as can be seen from the results of the evaluation surveys.*

**Keywords:** final year project; work placement; industrial engineering

**D. Elton, D. Shannon, B. Luke, F. Townsend and M. Roch** 1325–1336 Adding Excitement to Soils: A Geotechnical Student Design Competition

*Undergraduate soil mechanics/engineering/design can be made more interesting by appealing to students' team spirit and competitive nature. A scale-model Mechanically Stabilized Backfill (MSB) wall design/build competition has been developed and tested that generates enthusiasm, engages students in teams, implements design, and teaches about soils engineering. The competition has been used in local, regional and national competitions in the US with much success. The processes followed to develop the MSB wall competition can be adapted for use in other engineering education disciplines.*

**Keywords:** competition; design; geotechnical.