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Part I

- M. S. Wald** 187 Editorial
John Feland 188 Guest Editorial
Laurence P. Gebhardt 189–193 Engineers Are Entrepreneurs and Innovators

This paper is a scholar-practitioner synthesis that suggests that, while all engineers are somewhat entrepreneurial, there are academic and professional roadblocks and enabling pathways to entrepreneurial activity. The paper suggests a framework to perceive wider dimensions and systemic relationships that build entrepreneurial wholeness, beginning in the formative education process then throughout an engineering career. The paper's thesis is that a functionally entrepreneurial engineer is not a single tool (EE, ChE, CE, ME, etc.) but is multi-disciplinary, like a Swiss Army knife or Leatherman multi-tool. Some background, a multi-skill framework and some examples are provided. The conclusion calls for correction of technological illiteracy in America, a phenomenon that threatens entrepreneurial engineers.

- David F. Radcliffe** 194–199 Innovation as a Meta-Attribute for Graduate Engineers

This paper reviews the attitudes, skills and knowledge that engineering innovators should possess. It critically analyses and compares sets of graduate attributes from the USA, Australia and Malaysia in terms of which of these relate to the ability to innovate. Innovation can be described as an integrative, meta-attribute that overarches most of the other graduate attributes. Due to the 'graduate attribute paradox', it is shown how meeting the stated attributes of graduates by industry does not necessarily satisfy the requirements of industry. It is argued that the culture of the engineering school is an important influence on fostering innovation in engineers.

- Ed Leach and Timothy A. Little** 200–204 Weaving Innovation into the Fabric of Engineering Education

Generating wealth requires new ideas that find a path to market. In order to produce new ideas it is important to equip university graduates with creative thinking tools and an innovative mindset. This article chronicles the authors' quest to provide such an education to business and engineering students and suggests principles that could be used to replicate the experience.

- Lawrence E. Carlson and Jacquelyn F. Sullivan** 205–211 Bridging the Gap between Invention and Innovation

Bridging the gap between widgets that work but would never sell, and abstract entrepreneurial enterprises with little grounding in physical reality, students in an Invention and Innovation course create and test products with a focus on their potential to succeed in the marketplace. The primary component of the course consists of parallel activities: designing and building a proof-of-concept product prototype (invention), while exploring its potential for commercial success (innovation). Based on the precept that a foundation for entrepreneurship is to inspire engineers to perceive themselves as inventors, and arm them with the capabilities and confidence to tackle the marketplace, this paper describes an approach to convince students, through doing, that they do have what it takes to become an inventor and entrepreneur.

- David Stone, Mary B. Raber, Sheryl Sorby and Mark Plichta** 212–221 The Enterprise Program at Michigan Technological University

Entrepreneurial education has gained increased attention within the engineering education community in recent years resulting in the development of several new programs or options within existing programs. In response to this new national focus on entrepreneurial education and as part of the engineering curricular development at Michigan Technological University (MTU) associated with the calendar conversion from quarters to semesters, the university developed the Enterprise Program (www.enterprise.mtu.edu), a new and innovative experience that provides all students on campus, but especially engineering majors, an opportunity to start up and operate their own business. Within engineering programs the philosophy behind the Enterprise Program is to provide a flexible curricular structure that leads to a traditional engineering degree while at the same time enabling students to participate in the operation of a real enterprise over multiple years. Now in its fourth year of operation, the program has grown to nineteen different enterprises comprised of approximately 450 students from a variety of engineering, science, business, and communication disciplines. This paper presents an overview of the curricular structure of the program, a look at one of our established enterprises, the Wireless Communication Enterprise, and the results of assessment performed to date. Program feedback and successes and challenges associated with this innovative entrepreneurial curriculum will also be discussed.

- Burton V. Dean, Ashbjorn Osland and Michael Solt** 222–227 Lessons Learned in the Implementation of E-Teams

In the spring semester 2003, the San José State University (SJSU) initiated the formation of E-teams and launched its first business plan competition (BPC). The Entrepreneurial Society, a student-run organization, and several faculty and community advisers organized the E-teams and the BPC. 'E' is for excellence and entrepreneurship, as promoted by NCIIA. E-teams are composed of students from various colleges within the university, and they are engaged in developing new products and services leading to viable business plans. Our objective was to provide business, engineering, industrial design, and computer science students with the entrepreneurial skills to start businesses. The lessons learned are discussed in the paper.

- K. W. Chau** 228–232 Problem-based learning approach in accomplishing innovation and entrepreneurship of civil engineering undergraduates

A distinct feature of the civil engineering undergraduate study of Hong Kong Polytechnic University is a major assessment exercise in the form of a problem-based learning (PBL) group project. With the imminent implementation of an outcome-based accreditation assessment by the Hong Kong Institution of Engineers, student performance on this project can become a significant indicator of

learning outcomes. This final year group project can be viewed as the culminating learning experience of the engineering program and the quality of student output can be used as an indicator of the quality of the program as a whole. In this paper, the approach and attitude to the layout, management and assessment of this engineering project are presented. The experience gained in the operation of the project is shared. The evaluation by its key stakeholders, which are students, preceptors and employers, is also highlighted. The results authenticated that this PBL approach could accomplish innovation and entrepreneurship of civil engineering undergraduates.

Judi Dohn, Darrell W. Pepper and Eric Sandgren 233–238 Creating Innovative Curricula: Developing New Programs with New Paradigms

Preparing students to adapt and excel in an ever changing technological environment, recruitment and retention of new and continuing students at the freshman/sophomore levels and identifying effective undergraduate and graduate internships are challenges facing all engineering schools. The Colleges of Engineering and Fine Arts at the University of Nevada, Las Vegas are developing a new interdisciplinary program in Entertainment: Engineering & Design that incorporates unique public/private partnerships, introduces engineering opportunities to pre-college student, and expands the creative, technical and entrepreneurial potential in students through this innovative new program.

Chelsea Hamilton, Gregory P. Crawford and Eric M. Suuberg 239–256 A Technology-Based Entrepreneurship Course

This paper provides a brief description of experiences with a technology-based entrepreneurship course developed in an engineering program, but serving the needs of a liberal arts university. The course, started with assistance from the National Science Foundation and the local business community, has been offered at Brown University over the last five years and was first described in an earlier article [1]. The course model is designed to spin-in high technology product concepts into the university environment, which are further developed by an undergraduate entrepreneurship team and mentored by industrial professionals and academic faculty. This paper re-examines some of the key features of the course in light of the accrued experiences and addresses some of the more commonly asked questions, such as how the intellectual property issues are handled. In addition, we explore the impact the course has had on its alumni and their future plans, both in entrepreneurship and in business in general.

Part II

Abir Ziyad Qamhiyah and Bruno Ramond 257–261 Internationalization of the Undergraduate Engineering Program (Part 2): Application Example

This paper details the challenges, risks, and rewards associated with the initiation and maintenance of web-based distance collaboration projects as experienced by the two co-authors as a result of the development of their Computer Aided Design Across Universities (CADAU) project of 1999. The goal is to promote the application of distance education tools to the integration of the international engineering education experience into the undergraduate curriculum.

H. Y. K. Lau and K. L. Mak 262–276 A Configurable E-Learning System for Industrial Engineering

A generic interactive multimedia e-learning system (IMELS) for industrial engineering that uses a problem-based learning approach is developed. The system is designed to be a learning shell with an open architecture for the hosting and delivery of knowledge, case problems and other web-based material in industrial engineering. This problem-based e-learning system is designed to revitalize the teaching/learning process of industrial engineering and to create a learning platform that overcomes the boundaries of space and time. A number of configurable modules are introduced, including a multimedia introduction to industrial engineering, an electronics knowledgebase, and a platform that facilitates interactive problem-based learning through realistic case problems. As the principal objectives of the system are to use the computer-based materials with conventional teaching, and as an up-to-date repository for practitioners in the field, an architecture that accommodates flexible re-configuration, building-up of new information and updating existing materials is provided. This paper presents the design of the IMELS with special focuses on the architecture of the 'virtual company' that supports the problem-based learning paradigm, facilitates dynamic reconfiguration and tracking of student learning activities.

B. L. Stewart, S. K. Mickelson and T. J. Brumm 277–287 Continuous Engineering Course Improvement through Synergistic use of Multiple Assessment

During two terms of a fluid power engineering course, four formative and summative course assessments, weekly e-mail feedback journals, midterm e-surveys, focus groups, and departmental student evaluation of instruction (SEI) forms, were used to assess student perceptions of their learning and the instruction methods used. The weekly e-mail feedback journals and midterm e-surveys enabled several course adjustments during each course term. Focus groups were used to explore students' perceptions of both the course and the formative assessments. The SEI provided quantitative measures of student satisfaction that correlated with the focus group discussions. Using multiple formative and summative course assessments techniques had a synergistic effect on gaining insights into the teaching-learning process.

Wai L. Chan and Zhihua Qu 288–296 Using XML/Java to Enhance an Online Learning Architecture for Engineering Education

This paper will present the architecture for designing and developing a web-based teaching enhancement tool for engineering education. This architecture will enhance student learning by providing an innovative way for them to interact with standard engineering software through the web. The new architecture will provide a flexible online learning environment that will allow the students to present, test and evaluate their own ideas. To demonstrate its capabilities, we will present a Java application platform using this architecture. Moreover, we shall briefly discuss an XML-based markup language, Control Block Diagram Markup Language (CBDML), that was written during the development of this application. The design of the architecture described in this article has many possible applications, but this paper only presents the core results; more applications could enrich the architecture and CBDML, thus making possible a wide variety of production ideas.

Enrique J. Berjano and Albert Lozano-Nieto 297–305 A New Methodology for Teaching the Performance Characteristics of Measurement Systems

The traditional approach to teaching the performance characteristics of measurement systems does not differentiate between manufacturer performance characteristics (in-factory calibration, development of data sheets) and end-user characteristics (interpretation of data sheets, performance estimation and in-situ calibration). This paper presents a novel approach to including teaching the performance characteristics of measurement systems from both points of view. We accomplish this by introducing an active-learning approach in which the students first play the role of manufacturers and later the role of end-users, thus being exposed to the different metrics used in each part of the whole design process.

Courseware is presented here, based on Java applets, that is designed to facilitate better understanding of some of the most popular algorithms in semi-custom IC physical design automation. The applets have been applied successfully in the course *Microelectronic Design II*, a telecommunication engineering fifth-year subject at the University of Vigo (Spain). This method does not wholly replace traditional lecture classes, but it enhances them by displaying graphically the intermediate solutions of an algorithm's execution. Thus, students can easily and quickly assimilate what implies a change of value in a certain design parameter, such as the annealing temperature, the crossover or mutation operators, the cost function of a placement, a routing, etc. In fact, they not only understood much more rapidly all those concepts inherited from nature, but they repeatedly enjoyed executing the algorithms by changing their parameters, with one criterion in mind (not randomly), in order to optimize a given layout.

R. Joe Stanley, Steve E. Watkins and Randy H. Moss 318–326 Integration of Real-World Problems into an Image Processing Curriculum

An image processing curriculum requires a hands-on environment to facilitate student learning of theoretical concepts and techniques. Software tools including Matlab[®] allow students to focus on concepts and techniques without requiring significant attention to learn to use the tools. Laboratory exercises and projects are commonly used to provide students with a hands-on experience in imaging-related courses. Exercises and projects based on real-world problems which use realistic imagery further enhance student learning and skill development beyond the classroom. Survey results are presented to evaluate student responses to real-world problem-based exercises and projects performed in a Machine Vision course taught at the University of Missouri-Rolla.

Mark A. Haidekker 327–334 A Hands-on Model-computed Tomography Scanner for Teaching Biomedical Imaging Principles

The physical and mathematical foundations of computed topography are notoriously difficult to understand. A newly designed hands-on model laser optical tomography system—suitable for both classroom and lab—can help students grasp the abstract concepts, such as projections, the Radon transform, and filtered backprojection. The model bridges the gap between the well-known need and the lack of hands-on imaging equipment in most educational programs. The device consists of simple elements that can be easily fabricated and assembled, for example within a capstone design class. Image generation can be watched on the controlling computer in a step-by-step process. In class, the majority of the students attested to the effectiveness of the demonstration. Particularly students who had not taken a related class before favored the model and generally considered it a significant teaching help for biomedical imaging.

Erik Cheever and Yue Li 335–340 A Tool for Construction of Bode Diagrams from Piecewise Linear Asymptotic Approximations

This paper describes a program intended to be an aid for teaching and learning the process of creating Bode diagrams by hand. Bode diagrams are a fundamental tool for understanding the frequency domain behavior of systems. The program, *BodePlotGui*, is a GUI (graphical user interface) tool written in the MATLAB[®] programming language. This program takes as input a transfer function, splits it into its constituent elements, then draws the piecewise linear asymptotic approximation for each element. This paper is available in interactive form on the IJEE website (<http://www.ijee.dit.ie>).

Russell M. Cummings and David W. Hall 341–349 Aircraft Design for Second-year Undergraduate Students

As part of our department's 'learn by doing' curricular philosophy, and to help infuse design throughout our curriculum, we have evolved a sophomore-level programming course into an introduction to aerospace design course. The evolution has occurred over the past three years, as we have increasingly added design requirements to the course. We have found that sophomores can learn a great deal from designing a complex system with the use of software or semi-empirical design methods to supplement their lack of background knowledge. We have used new, innovative aircraft specifications to get the students to think about requirements, markets, and the importance of customer-based thinking in the design cycle.

Timothy A. Philpot and Richard H. Hall 350–360 The Role of MDSolids in International Mechanics of Materials Education

MDSolids is educational software intended primarily for students in the Mechanics of Materials course. MDSolids has been available free-of-charge to the engineering education community since 1997, and it has been provided to hundreds of schools and universities around the world. Although MDSolids has been widely used, there has not been a formal study of its role in Mechanics of Materials education. To gather information on its use, a survey was conducted to gather information about (1) the types of learners who use MDSolids, (2) student attitudes about using the software, (3) information about how professors utilize MDSolids in their teaching, and (4) effects of MDSolids on student performance in selected topics as perceived by professors. The survey results show that MDSolids is used in all types of settings in a variety of ways. Professors note that MDSolids serves to help motivate students and that it seems to be a factor in the noticeable improvement in their students' performance in several topic areas.

Bedir Tekinerdoğan 361–368 Introducing a Graduate Course on Aspect-Oriented Software Development

Aspect-oriented software development (AOSD) is an advanced paradigm for separation of concerns (SOC) in software development, which provides explicit concepts to modularize so-called crosscutting concerns. After being accepted both by a broad community of researchers and the industry it is now getting introduced in courses in universities. This paper describes the experiences of the graduate course Aspect-Oriented Software Development that was introduced at Bilkent University in Ankara, Turkey. The lessons learned can be useful for peer educators who teach or aim to teach a similar course.