

The International Journal of Engineering Education

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- M. S. Wald** 369 Editorial
- C. Whitbeck** 370–372 Guest Editorial
- Stephen H. Unger** 373–377 How Best to Inject Ethics into an Engineering Curriculum with a Required Course

Engineering students should, in the course of their undergraduate education, learn about the professional responsibilities associated with their chosen profession. They should learn about major technology-society issues involving such matters as energy, war, the environment and privacy. Ways to accomplish this include the incorporation of such ideas in regular engineering courses, occasional colloquium talks, and special courses devoted to this general area. It is argued that, whatever else is done, at least one such course should be required for graduation. Some practical aspects of such a course are discussed.

- Hiroshi Iino** 378–383 Introductory and Engineering Ethics Education for Engineering Students in Japan

In 1996, the author developed a new introductory subject for freshmen called 'Society and Engineers', which is suited to the special educational situation in Japan. To date approximately three thousand five hundred students have taken this course. The goal of that course is for students to learn for themselves who engineers are and the world context for engineering work before studying engineering ethics. It uses three cases of accidents in nuclear energy development in Japan. Before 1999, few technical institutes provided engineering ethics education, but the new accreditation requirements for education set forth in 2000, prompted about twenty technical institutes to offer engineering ethics that year, and its influence on engineering students is increasing rapidly. A workshop and symposium were held and the textbooks and case studies for the education were developed and published. The influence and importance of corporate social responsibility for engineers' behavior and the needs for education of managers are emphasized.

- Steven P. Nichols** 384–390 A Design Engineer's View of Liability in Engineering Practice: Negligence and Other Potential Liabilities

This paper examines concept of professional liability for engineering activities and products and its relation to the concepts of professional negligence and product liability as defined in law, particularly in the United States. Elements of tort liability discussed in this paper reflect societal expectations for engineering practice and engineering products. The paper first examines the basis for legal liability for general tortious conduct and then specifically examines the concepts of professional 'malpractice' (professional negligence) and strict liability for products in the United States.

- Michiel Brumsen** 391–401 Ethics in Engineering in the Netherlands: The Role of Professional Associations, Universities, and Law

The paper starts with a sketch of engineering in the Netherlands. The different curricula in engineering (both 'vocational' and 'scientific') are described, their accreditation, and the membership and role of professional societies. The regulation of the engineering profession, and the role played by professional societies, is very different in the Netherlands than in the USA, mainly because there is no licensing of engineers. The situation in the Netherlands is also compared with the situation in other countries in Western Europe. The second part of the paper concentrates on engineering ethics education in the Netherlands. The history of such topics within the engineering curricula is described. Engineering ethics in the Netherlands is very much a discipline 'directed' by teaching staff in the Universities; with the occasional exception, the ethical awareness within the professional societies is not highly developed. This situation may however change, since interest in ethical issues is being shown by employers' organisations and trade unions, and awareness within professional societies appears to be on the rise. The paper closes with some suggestions for topics for research in ethics and engineering.

- S. Ratnajeevan H. Hoole and Dushyanthi Hoole** 402–414 Asian Values and the Human Rights Basis of Professional Ethics

Engineering programs in Sri Lanka, like others that were long ago modelled on the British system, are analysis-intensive and weak on liberal studies components such as ethics, although Britain herself has now adopted broader educational goals for engineering education. This paper describes our attempts to include professional ethics in the engineering curriculum in Sri Lanka. We make the case that 'Asian values' in the narrow technical sense in which the term is defined in the literature for Southeast Asia is equally applicable to South Asia. In particular, two of these common Asian values militate against the ethical norms frequently encountered in a Western class. First, there is really little support in Sri Lankan or South Asian culture for keeping religion out of public life. The religious ethos where multiculturalism is understood to be polytheistic favors a Hindu/Buddhist celebration of religion involving all gods at public functions which is then passed off as multiculturalism. Second, there is strong loyalty to the family and clan and obedience to elders that works against administrative impartiality. We therefore use in our teaching a legislatively and democratically evolved and socially accepted system of international human rights law as the proper basis for justifying ethics. Though human rights exhibits some cultural conflicts with Asian values, it is neutral with respect to the parties to the civil war in Sri Lanka.

- Mike Pritchard** 415–423 Perception and Imagination in Engineering Ethics

Engineers are counted on to employ their expertise in exercising responsible judgement. Ethical rules and principles have an important role to play in this. However, so do perception and imagination. How engineers come to perceive engineering problems and their possible solutions in the ways they do is a function of their expertise, experience and the dispositions they bring to bear on their work. This paper discusses relationships between ethical commitment and expertise. It argues that what is required is the integration of ethical commitment and engineering expertise, such that, in the midst of engineering practice, perception and imagination contribute to responsible engineering judgement.

Part II

Parviz A. Koushki, Andreas Christoforou, Alison M. Larkin and Anwar Al-Roomi 424–433 Engineering Students' Attitudes towards Teaching and Teachers

The findings of a research study aimed at the examination of Kuwait engineering students' evaluation of teaching effectiveness are reported. Following a review of the related literature, the spatial transferability of the faculty evaluation mechanisms, without regard to spatial socio-cultural differences, are discussed. The influence of engineering students' attitudes towards this important teaching evaluative mechanism is then documented. It was found that the ratings of a large percentage of engineering students were positively influenced when their exam grades were inflated; the entire course material was not covered during the semester; a project was not assigned to the course; and students were allowed to arrive late as well as be absent from lectures from time-to-time. This may partly be due to the influence of the socio-cultural environment on students' motivation and attitudes toward learning and education. On the other hand, it was also found that the evaluation of a large majority of students (high and low academic performers) was influenced very positively when lecture materials were tied to real-life situations; lectures were delivered in a clear and understandable manner; the faculty was fair in grading, and punctual and efficient in the use of class times. The faculty evaluations of this group is in conformity with those of their peer groups elsewhere. Students' GPAs affected their attitudes towards the evaluation of teaching effectiveness significantly. The rest of their socio-demographic traits did not.

Steven M. Nesbit, Scott R. Hummel, Polly R. Piergiovanni and James P. Schaffer 434–445 A Design and Assessment-Based Introductory Engineering Course

The Engineering Division at Lafayette College has developed an innovative assessment-based first-year engineering course which introduces the engineering method and design/problem-solving approach. The course goals are to improve student motivation and retention, stimulate interest in and build bridges to mathematics, sciences, and the humanities courses, and to teach the students about engineering and how an engineer solves problems. Our experience suggests that it is possible to teach first-year engineering students how to begin to think and function as an engineer even though they lack the tools and experience of the practicing engineer. Lecture and laboratory topics include the structured design/problem-solving approach, design methods, modeling, analytical methods and analysis, materials and failure analysis, graphics, data acquisition, and control systems. The unifying element of the course is the semester design project where teams of students design, construct, and evaluate a solution to a technical problem. A thorough assessment process is in place that has guided the evolution of the course and assured fulfillment of the course outcomes. This paper discusses the philosophy and structure of the course, course topics, laboratory exercises, semester design project, assessment methods, course evolution, course effectiveness, and resource and personnel requirements.

P. David Fisher, Dawn M. Zeligman and James S. Fairweather 446–456 Self-Assessed Student Learning Outcomes in an Engineering Service Course

Michigan State University (MSU) received a grant from the GE Fund to reform the early undergraduate engineering learning experience. Focusing on the key service course in Electrical and Computer Engineering (ECE 345), this project developed and implemented over a six-year period a new section based on innovative instructional approaches, including cross-disciplinary experiences in teamwork, design, and the use of advanced teaching technologies. This paper compares student self-assessed outcomes from these innovative sections with those from traditional sections of the course. Results support a central tenet of active and collaborative instruction, namely that student involvement in their own learning significantly improves self-assessed learning outcomes.

Jed Lyons and Christine Ebert 457–466 A Survey of Engineering, Science and Mathematics Education Centers in the United States

A survey of centers in the United States that are engaged in engineering, science or mathematics education was conducted to help understand current practices. The survey addressed sources of funding, types of pre-college outreach activities, activities related to improvement of teaching in higher education, and methods of promoting collaboration between faculty. Also collected were recommendations, based on the experience of the survey respondent, which would help others develop a successful center. Response to the study was high, with 173 of 271 returned. This paper discusses the results and suggests a set of best practices for engineering education centers.

Joan M. T. Walker, David S. Cordray, Paul H. King and Richard C. Fries 467–479 Expert and Student Conceptions of the Design Process: Developmental Differences with Implications for Educators

These studies identified key concepts and developmental differences in people's conceptions of the engineering design process. The method of assessment was concept mapping. Key concepts were derived from the concept maps of 15 experts and organized into six broad categories. Expert data served as benchmarks for assessing the conceptual development of 32 undergraduates who constructed individual maps at the beginning and end of a year-long design course. In general, students' conceptions tended to be more narrow, with consistently fewer references to larger societal issues such as ethics and marketing. Over time the expert-student gap closed regarding knowledge of the design process and the motivations underlying a design (e.g. customer need, scientific need). Findings suggest that an important difference between experts and students is that experts are more likely to situate the design process in a sociocultural context.

W. Ernst Eder 480–501 Survey of Pedagogics Applicable to Design Education: An English-Language Viewpoint

Teaching and learning, as processes that are performed by teachers and students respectively, are outlined. Consideration is given to various types of knowledge, especially the knowledge required for designing in engineering. A relationship among theory, subject and method is postulated. Methods may be strategic (for education, these are called pedagogic) or tactical (didactic). Various factors that influence education are brought into relationship with a model of general transformation processes. On this basis, several educational theories are discussed, individually and in their relationships to one another and to engineering design education.

Daniel Grove, Felician Campean and Ed Henshall 502–511 A Course in Statistical Engineering

A course in statistical engineering has recently been added to the Ford Motor Company's Technical Education Program. The aim was to produce materials suitable for use by Ford but which could also be promoted by the UK's Royal Statistical Society within the university sector. The course is built around a sequence of realistic tasks dictated by the flow of the product creation process. Its structure and content is thus driven by engineering need rather than statistical method, promoting constructivist learning. Before describing the course content we review the changing role of the engineer and comment on the relationships between Systems Engineering, Design for Six Sigma and Statistical Engineering. We give details of a case study which plays a crucial role in the course. We focus on some important features of the development process and conclude with a discussion of the approach we have taken and possible future developments.

**Stuart Burgess, Julian Booker,
Gordon Barr and Kazem Alemzadeh** 512-524 An Investigation into Engineering graduates' understanding of Probability Theory

This paper presents an investigation into the understanding of probability theory by recent graduates in engineering. The investigation included a specially set one-hour examination in probability theory taken by over 40 graduate engineers. The answers to the exam questions showed that engineering graduates could remember only a limited number of concepts from probability theory they had been taught as undergraduates. Since probability theory is generally taught as a special mathematics topic, this means that many probabilistic concepts are quickly forgotten by the time that students graduate. A solution to the problem is to incorporate probabilistic concepts into mainstream engineering subjects like design and solid mechanics and materials.

**M. Fernández Chimenó,
M. A. García González and J. Ramos Castro** 525-533 Teaching Measurement Uncertainty to Undergraduate Electronic Instrumentation Students

Measurement uncertainty is an important concept for electronic instrumentation students. This paper presents an easy way to explain this difficult concept that has been developed in the telecommunication engineering school of the Polytechnic University of Catalonia (Barcelona, Spain). The lesson development is based on a number of references from metrological associations that can be obtained from the internet. Two examples illustrate the process of evaluation and calculation of uncertainty in simple measurement situations.

**Javad Hashemi,
Katherine A. Austin-Stalcup,
Edward E. Anderson, Naveen Chandrashekar
and Adam Majkowski** 534-545 Elements of a Realistic Virtual Laboratory Experience in Materials Science: Development and Evaluation

The development and evaluation of a realistic virtual materials science laboratory experiment on metallography is reported in this paper. This virtual laboratory is highly interactive and has been designed considering a number of learning styles. All standard laboratory functions such as stating the objectives of the experiment, background, procedure, analysis, and establishing conclusions are performed in a virtual environment. A novel 'decision tree' structure is devised that allows the user to make decisions from an available menu of options (both correct and incorrect options are given) and view the results of the decision. The students can view the outcome of an incorrect decision using the decision tree concept. The objectives of this tool are to 1) emphasize and verify the learning objectives, 2) prepare the students for an actual in-class laboratory experiment, and 3) serve as a replacement experience for universities and colleges that do not have a materials science laboratory. Preliminary evaluation of the software by students has shown that the software can be effective in achieving the learning objectives and in serving as a preparation tool for laboratory students. An interactive version of this paper is available on the IJEE website (www.ijee.dit.ie).

**Y. Lawrence Yao, Gary J. Cheng,
Steve Feiner, Wenwu Zhang,
K. P. Rajurkar and Radovan Kovacevic** 546-554 A Web-Based Curriculum Development on Nontraditional Manufacturing with Interactive Features

The engineering challenges faced by traditional manufacturing has facilitated the development of nontraditional manufacturing (NTM) processes. The multidisciplinary nature and the diversity of NTM education have posed more challenges than education in traditional manufacturing processes. To overcome these challenges, the different NTM processes are systematically presented from introductory to advanced levels by web implementation with interactive capabilities. Apart from text, images and sound, the interactive methods employed in this project include: interactive exploration of physical processes with JAVA applet; Macromedia Shockwave based animation; 3D virtual reality (VR) animation of NTM process simulations; and 2D movies of process simulation by finite element modeling (FEM).