INNOVATIONS 2007

World Innovations in Engineering Education and Research

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PREFACE

This volume represents the 2007 edition in the iNEER Innovations Series. Past volumes in the series have highlighted world progress and accomplishments in accreditation and funding, multimedia learning and instruction, web-based curriculum innovations, teaching of large classes, remote experimentations, active and cooperative learning, design integration, learning assessment, and inculcating students with a global cultural and societal perspective. Some of these topics continue to be highlighted in the present book; however, the current edition is giving a sharper focus to issues relating to globalization, approaches to enhance student success, innovative curricula and e-learning, quality assurance, development of education infrastructure, design integration, multiculturalism, and recruitment and retention.

GLOBALIZATION IMPACT AND SOCIETAL CONNECTIONS

Sensing that the increasing globalization of the world economy is beginning to have a discernable impact in engineering education, Rosen (Chapter 1) sees the need for engineering educators to focus on quality assurance, relevance, recruiting and retaining students, promoting student learning and collaboration and partnerships, and other related issues. Talberg (2) examines various didactic approaches that may improve the English language competence of engineering students. Morell (3) addresses the interconnectedness of the individual, the corporation and the country, using her own experiences as a case study. Gjengedal (4) describes the establishment of high-tech industry in the Tromsø region in northern Norway, home to the University of Tromsø, and several research institutions and successful technology companies.

Several chapters in the present volume deal with the connections of engineering education with service for the public good, both inside and beyond the traditional classroom. Szendiuch (5) reports the teaching of eco-design in engineering education. At the University of Manchester, Tomkinson et al. (6) have implemented a pilot to embed sustainable development within science and engineering programs, and the Colorado School of Mines has established a Minor in Humanitarian Engineering with the aim of producing engineers who are sensitive to social contexts and committed and qualified to serve humanity by contributing to the solution of complex problems at regional, national, and international levels (7). Montero et al. (8) at the University of Burgos are promoting energy conservation through a four-nation international project aimed at encouraging the use of small-scale renewable energy sources (RES) applications in residential and commercial buildings. They have also developed a new RES postgraduate engineering program.

In Colombia, Duque et al. (9) at the Universidad de los Andes have initiated the Pequeños Científicos ('Little Scientists') initiative that initially targeted elementary schools, but that now includes graduate and undergraduate engineering schools as they transform their teaching practices into an inquiry-based pedagogy centered on active learning.

Gou et al. (10) have developed a new course entitled "Power System Blackout Analysis" at the University of Texas – Arlington. They took advantage of significant recent research advances made in the statistical laws governing global cascade of failures of complex electrical networks and the resultant electrical blackouts. They have made significant advances in the understanding of such cascades of failures, making it possible to design strategies of defense to prevent them from propagating through an entire network.

ENHANCING STUDENT SUCCESS AND LEADERSHIP

A course development effort at Michigan Technological University involves a Ph.D. student in a start-to-finish development experience that includes the work on the syllabus, course material, lecture notes, laboratory experiences and even the grading policy. As noted by Gershenson et al. (11), the experience enhances the student's ability to think logically, consistently, to present material, and to write papers, in addition to mastering the course materials and have a "ready-to-go" instructional material for a future career in academia or industry. On the other hand, in Norway, Christensen and Ribu (12) are integrating students into the teaching process, thereby reducing lecture preparation time by up to 75%. They employ a teaching method based on a combination of PowerPoint presentations, the blackboard, exercises, posing questions to the students, and student presentations. Martin et al. (13) use an inquiry-based engineering curriculum that seeks to help students develop innovation, based on the idea that generating ideas independently prior to consulting resources develops adaptiveness in students. The approach follows the "How People Learn" design principles, in which students consider a complex challenge problem independently and generate ideas about what they know and will need to learn. Using two experiments, the authors demonstrate how the associated curricular activities help students develop multiple perspectives and metacognition, important aspects of adaptive expertise.

Undergraduate research programs can be tailored to encourage the development of socially and environmentally conscious engineers with outstanding leadership skills and practical, hands-on, international engineering experience. Gordon et al. (14) describe the program at Rice University that not only provides an experiential education and service learning, but also promotes the creation of innovative, humanitarian engineers for the 21st century. Frode et al. (15) share practical experiences in stimulating undergraduate research, including effective approaches for increasing students' enthusiasm in research.

Martin et al. (16) have developed a flexible training system for teaching Profibus and Interbus Fieldbus technology in industrial communications and automation. This flexible equipment has improved students' group work abilities in a realistic automation environment. A graduate course on "Electromechanics for Nanoengineering" has been taught at the University of Tennessee to electrical engineering students. The core content of the course is built around AC electrokinetic microfluidics, an emerging field with high potential for biofluid and nanoparticle manipulation (17). The course lectures introduce students to the concept of miniaturization, the role of microfluidics in nano-bio-research, transduction principles, interactions between micro-nano-particles and their applications.

Robotics can be a tool usable in various aspects of education. At Rowan University a program known as "Remotely Operated Vehicles (ROVS)" has been introduced (18). As a coursework project, graduating mechanical engineering seniors researched, designed, built, competed and reported with underwater ROVs, focusing design skills and soft skills such as teamwork, self-learning, communication and evaluation.

NEW CURRICULAR APPROACHES

At Oslo University College, an innovative approach to introduce new technologies into the curriculum has been adopted by Christensen and Ribu (19). They form training classes consisting of teachers and students for the purpose of learning software tools and new technology in a quick and efficient way. The idea is based on the experience the authors had teaching a group of students the basics of the engineering calculation software *MathCad*. The method is general and can be used for learning all kinds of software, and is not limited to software for engineering purposes.

A four-year civil and environmental engineering undergraduate degree program, directed towards people seeking a broadly based knowledge of and skills in the sustainable implementation and management of civil engineering infrastructure and the minimization of adverse impacts on the environment, has been introduced at Monash University in Australia (20). The program emphasizes the cross-fertilization and dynamic interactions between the civil units and environmental units. Site visits are an important component.

Based on what he perceives as the principal contrasts between study and work, Ferris (21) uses Pierre Bourdieu's theory of fields to develop a philosophical basis for a change of emphasis in engineering education, arguing that the holistic curriculum and assessment processes of engineering education should be changed to emphasize preparation of engineering students for professional work.

A Problem-Based Learning (PBL) curriculum has been adopted in the School of Electrical Engineering at Victoria University, Melbourne, Australia to render engineering graduates more employable, and at the same time reducing the failure rates of first year students (22). The development and structure of the PBL program is described, with a focus on the learning principles. Kornecki and Behi (23) reviews a 16-year evolution in offering instruction on real-time software development in undergraduate computing programs, underlining the role of real-time systems in undergraduate curriculum and an assessment methodology conforming to ABET accreditation standards.

Based on personal experience gained through many years of teaching engineers and technical teachers, Wagner (24) has introduced an engineering approach to educational modelling, in which he uses existing and well-known design techniques in engineering to structure teaching, treating as a system task the planning for a new course or the restructuring of an existing one. Here, the system is the course with input and output, defined system states, and an internal structure composed of fundamental educational elements such as intentions, themes, methods, media and organizational issues. This "course system" is designed according to established educational principles such as motivation, structure, demonstration, exercise or evaluation to optimize the "course system quality". In a first attempt, it will be exemplified how engineers and others can use UML diagrams to design or redesign their courses.

E-LEARNING AND INTERNET TECHNOLOGIES

Caracoche et al. (25) at the University of Buenos Aires are using a LINUS-based virtual laboratory to teach information security to undergraduate students. The system, which the authors call "CryptoCD," is PC-based and allows students to build complex, virtual networks, connect them, filter network traffic with a Firewall, construct a certification authority, and run security and cryptography tools to encrypt, hash or digitally sign a file. Student feedback has been highly positive. From the University of Portsmouth, Williams (26) reports that, after providing successful B.Sc. (Hons.) programs in engineering for many years, the University has successfully developed a learning design and architecture for online learning and has applied it to study programs in computing and mathematics for third year students to enable students, who already have the equivalent of the first two years' B.Sc. (Hons.) courses, to convert to a full honours degree, but who might not be able to study full-time or part-time on campus. The online resources are being taken full circle and used for on-campus courses as well.

E-learning is also being used to address the need to provide students with help beyond the scheduled lecture and tutorial periods, as is done at the University of Salford, according to Law (27). She is employing the technique to cope with a disparate range of student abilities. A Blackboard Web portal has been shown to be useful for this purpose. MS PowerPoint has been integrated for delivery via the Web to provide an opportunity for students to re-play a lecture in their own time. This offers students the opportunity to reinforce their learning and to work at their own pace.

At Old Dominion University, Chaturvedi et al. (28) are mapping a physical experiment in the undergraduate thermo-fluids laboratory in the mechanical engineering curriculum into a web-based virtual experiment. Students are using it as a prelab practice session before the scheduled physical laboratory experiment. The web-based module has been assessed for its effectiveness as a student learning tool, using an assessment method known as the intact-group comparison design that involves a "control group" and an "experimental group." Performance of the "experimental group" shows a definite improvement over the "control group" that did not conduct the web-based prelab session.

Based on a collaborative project between institutions in the Netherlands and Slovak Republic, Bauer (29) presents an overview of the use of e-learning in Electrical Engineering at the by surveying the state of the art and outlining the steps in the development of e-learning practice. Results achieved in the development of multimedia-based e-learning tools in the field of electrical drives and power electronics are also summarized. Challenges for future development of e-learning are discussed.

ASSESSMENT, QUALITY ASSURANCE, AND EDUCATION INFRASTRUCTURE

In a study on effective grading of student performance, Ieta et al. (30) explain that the practice of using arithmetic mean for grade aggregation renders correct results only for equivalent scales as defined in the chapter. They propose a new grading technique based on the equivalent scale analysis that has been tested on engineering and science students with student feedback. At the North Carolina A&T State University, Poiro (31) has conducted an investigation of student performance in a college-level, introductory computer programming course. Results show that high scores on the verbal part of the Scholastic Aptitude Test (SAT) facilitate generating solutions on word programming problems; however, the high scores obtained on the SAT test are not significant if the students do not posses specific problem solving skills in their background.

Recently, the PNG University of Technology (UOT) in Papua New Guinea has established a quality assurance process across all academic programs of the university. As described by Satter (32), the process is centered on the use of the Quality Function Deployment (QFD) planning tool known as the House of Quality (HOQ).The paper starts with an introduction to different types of curricula, explains the model and finally presents the curriculum review by HOQ planning method. To evaluate a students' teamwork ability, Furukawa (33) employs criteria that include self-evaluation and peer evaluation in which students assessed other members' team activities compared to their own team activities, and found correlations between them, leading to the conclusion that this method may be used to evaluate the quality of group studies.

The Technical University Vienna is using a Web-based, custom-designed publication database that features simple extraction of lists and counts of publications based on a variety of query criteria (34). The database dynamically creates publication lists and records, and exports its contents to the university library system. The Technical University of Ostrava has implemented a certified quality management system based on ISO 9000 standards (35). As shown by Farana and Smutny, the system is motivated by the belief that an engineering faculty can improve its management system by adapting one that is commonly used in the industry that they serve, the faculty of Farana and Smutny describe the implementation of the quality system using the experience of the Faculty of Mechanical Engineering, and recommend its adoption by other universities.

MULTIDISCIPLINARY DESIGN AND INTEGRATION

In Taiwan, a novel system-on-chip (SoC) design methodology has been implemented that makes it possible for academic research teams to experiment with their SoC designs in a highly cost-efficient manner. As reported by Lee et al. (36), the new method saves about 82.91% of silicon area as compared with the case where multiple SoC projects are fabricated individually.

To support interdisciplinary curriculum design and planning, Lu (37) proposes a framework through which to facilitate a seamless course content design method for better collaboration among faculty from various disciplines. A knowledge map is developed to serve as a guide for faculty members in preparing their teaching material.

MATLAB Simulink is a platform for multi-domain simulation and model-based design for dynamic systems that can significantly enhance both teaching and learning in undergraduate classes. Using examples from a variety of engineering classes, Kumpaty and Haeg (38) show the use of this pedagogical tool and suggest that academia is yet to realize the full potential of its use while industry is far ahead. Duan (39) is directing his attention to community colleges, and discusses the upgrade of Computer-Aided Design and design engineering courses to meet industry needs. Based on a survey of industry experts, he identified fifty critical skills in six categories that can be used to help faculty more effectively prepare students with the knowledge and skills required to face today's challenges.

Noting that processes of biological evolution, such as mutation, recombination, transformation, transduction, and fusion, can occur in an organism in a single step, Vincent et al. (40) argue that essentially identical processes exist in the realm of engineering design. They suggest that this metaphor can assist young engineers in their understanding of, and ability to create, innovative products, processes, and services.

DIVERSITY, MULTICULTURALISM, RECRUITMENT AND RETENTION

Yue (41) discusses classroom teaching techniques that address cultural differences between the East and the West, with an emphasis on Chinese culture, relating Chinese students' behavior to the influence of Confucian philosophy, which has dominated Chinese culture for twenty-five hundred years.

In a study that explored team performance on design projects when one or two female students were added to a team, Bannerot (42) found that, on average the teams with one or two females slightly outperformed the all-male teams in all categories. However, the increased performance is not statistically significant.

The underrepresentation of women in science and engineering is being addressed at Oslo University College through a new Committee for Mainstreaming (43). A mentoring project has been initiated. A women's network group has been formed. At the Washington State University, Doty et al. (44) have designed and implemented a program to increase Native American high school students' interest and success in science, engineering, and higher education. The program employs a combination of modern teaching methods and introductory nanotechnology for water quality monitoring.

Recruitment and retention of students is critical to the efforts by many academic institutions to increase the number of engineering professionals, and is a priority for the Computer Science and Engineering Department at the University of North Texas. Akl et al. (45) describe the efforts and results of a plan for actively recruiting students to undergraduate computer science and engineering programs, including activities aimed at improving retention rates of students already in their programs. Garlick and Akl (46) present the results of a year-long experiment in an intra-class competitive assignment in the second C++ programming course at the University of North Texas. Metrics of student performance on the assignment, correlation with course grade, student surveys of the project, and retention statistics are presented. Results show overwhelmingly positive response and high levels of effort among students. Application of the results to student recruiting, retention, and curriculum design is discussed.

Coyle et al. (47) describe the recent success in turning around the drastic decline in student enrollment and retention in the engineering program at the Dublin Institute of Technology. Key to the success was a reappraisal and redefinition of the program and of international best practice, leading to a program upgrade. Also important are the introduction of academic and peer mentoring and the creation of a math learning center.

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Following baccalaureate and post-graduate studies at the Rangoon Institute of Technology and the University of Minnesota, respectively, Win Aung joined Bell Laboratories in Whippany, NJ in 1969 as a Member of Technical Staff. In 1974 he joined the U.S. National Science Foundation (NSF) where he has held positions with programmatic and management responsibilities. He was appointed to the U.S. Senior Executive Service in 1985 and was recipient of the first NSF Federal Engineer of the Year Award in the same year. From 1976 - 1996, he held adjunct and visiting professorships at several universities in the U.S. and abroad, with an active schedule of teaching, research and student mentorship. In 1994, he initiated the ICEE (International Conference on Engineering Education) series and, in 2004, established the International Conference on Engineering Education and Research (iCEER) series. He co-founded the International Network for Engineering Education and Research (iNEER) in 2000, and is serving as its Secretary-General. He is the principal editor of the iNEER Innovations Series. A Fellow of American Society of Mechanical Engineers (ASME) since 1983, he has written extensively on research and education and is a frequent speaker on campuses around the world and at international conferences. He has published over 120 technical papers, and has edited or co-edited more than 10 books. In 1999, he was awarded an honorary doctorate (*Doctorem Honoris Causa)* by VSB – Technical University of Ostrava in Ostrava, Czech Republic, and in 2005, he was awarded the Medal of Merit by Silesian University of Technology in Gliwice, Poland. He was a member of the Standing Committee on Theory and Fundamental Research of the ASME Heat Transfer Division, the ASME Board on Engineering Education, and the ASME Council on Education. He is a member of the Scientific Board of VSB - Technical University of Ostrava and was an editor of Transactions of ASME, Journal of Heat Transfer.

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IAN ROUSE

A Professor and the Executive Dean of the Faculty of Health, Engineering and Sciences at Victoria University since 2005, Ian Rouse formerly served as a Professor of Health Sciences at Curtin University of Technology where he held the positions of Dean of Research and Enterprise and Acting Head of the School of Public Health. He graduated with first class honours in Biochemistry from the University of Western Australia in 1975 and completed a Doctorate in Epidemiology in the Department of Medicine of the University of Western Australia in 1986. He also completed with distinction a Graduate Diploma in Health Sciences from the Western Australian Institute of Technology in 1983. He worked in the fields of medical research, public health, epidemiology and health informatics in Western Australia, South Australia and at Harvard University. He held several prestigious fellowships including the Wyn Spence Medical Research Fellowship in 1983 and the CSIRO Division of Human Nutrition Research Fellowship at in Adelaide from 1986-1987. He was the General Manager of the Health Information Centre during 1995 – 1997, Chief Information Officer in the Department of Human Services in South Australia during 1997 – 1998, and Acting Chief Information Officer at Curtin University of Technology, 2000 - 2003. He has authored or co-authored more than 100 refereed papers, review articles and book chapters and have been associated with approximately 40 presentations at scientific meetings.

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Bernardo Wagner received a M.Sc. (Dipl.-Ing., 1984) and a Ph.D. (Dr.-Ing., 1989) degree in Electrical Engineering from the University of Stuttgart, Germany. From 1985 to 1988, he worked at GPP in Oberhaching/Munich and was in charge of several commercial software development projects. In 1991 he was appointed Professor of Computer Science at the University of Applied Sciences in Ulm, Germany, where he was in charge of the software laboratory. Professor Wagner has been a full professor at the University of Hannover since 1997. He is the head of the Real Time Systems Group that is part of the Institute for Systems Engineering. His research interests include autonomous service robots, embedded real-time systems. He works on real-time algorithms and system software for outdoor service robot localization and navigation in unstructured environments. Professor Wagner is also director of the Center for Technical Didactics where he puts his research focus on new concepts for multimedia and net-based learning environments as well as remote experimenting and project-based learning. He gives lectures on discrete control, design for real-time systems and technical didactics. Currently Professor Wagner is vice dean of the faculty of electrical engineering and computer science.

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Peter Willmot is Principal University Teacher and Director of Undergraduate Studies in the School of Mechanical and Manufacturing Engineering at Loughborough University, England. He graduated with a BSc in Mechanical Engineering in 1976 and a PhD in 1990. During the intervening period, he worked in the high voltage switchgear, automotive component and petrochemical valve industries holding various design, production engineering and project management roles. He is a Chartered Engineer and a Member of the Institution of Engineering Designers. Peter was appointed Lecturer in Engineering Design at Loughborough University in 1985 and subsequently promoted to the senior staff in 2001 within the Teaching and Scholarship job family. He now has responsibility for teaching, developing the curriculum and the professional accreditation of five undergraduate programmes. He sits on various university committees and has worked as external validator for the degree programmes of other universities. Winner of a university teaching prize in 2004 and an academic practice award for excellence and innovation in supporting learning in 2006 he has published widely on educational practice at national and international forums. Peter is also actively engaged on a number of substantial funded Teaching and Development projects including the Centre of Excellence in Teaching and Learning.

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Sameer Naik, *USA*
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Shu-San Hsiau, *Taiwan*
Subha K. Kumpaty, *USA*
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Vojislav Ilic, *Australia*
Weining Feng, *USA*
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William E. Kelly, *USA*
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