INNOVATIONS 2005

World Innovations in Engineering Education and Research

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Edited by

Win Aung
International Network for Engineering Education
and Research, Potomac, MD, USA
National Science Foundation, Arlington, VA, USA

Robin W. King
University of South Australia
Mawson Lakes, Australia

Jerzy Moscinski
Silesian University of Technology
Gliwice, Poland

Shan-Hwei Ou
National Cheng-Kung University
Tainan, Taiwan, R.O.C.

Luis Manuel Sanchez Ruiz
Universidad Politécnica de Valencia
Valencia, Spain

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ineer@ineer.org

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PREFACE

This book is the fourth volume in the iNEER Special Volume series on innovations in engineering education and research. Reflecting the collaborative base of much of the work being reported, the forty-one articles came from ninety-one authors. Authorship came from fifteen countries: Australia, Botswana, Brazil, Canada, Greece, Namibia, Norway, Pakistan, Portugal, Russia, Sweden, R.O.C. (Taiwan), United Arab Emirates, United Kingdom, and USA. Providing comments during the peer review process were more than two hundred sixty reviewers from over forty countries.

We hope that the innovations described in this book will lead to new ideas for new pursuits, especially through cooperative partnerships. The quality and productivity of research and education endeavors can be enhanced through collaboration, but opportunities in international cooperation in engineering education and research, which can do much to propel future advances, have yet to be broadly explored and exploited.

A wide range of topics is covered in this volume, particularly as concerned teaching and learning in engineering and computer science. New curriculum models; the teaching of design; internationalization; linkage to industry; web-based instruction; linkage between education and research; learning assessment: these are some of the subjects of concern in the chapters to follow. Authors are senior educators and junior faculty members; they are from developed countries and developing countries, from major research universities and smaller regional colleges. These authors have one thing in common: They all have something important to say that can benefit all of us.

William Wulf, President of the National Academy of Engineering and author of the first chapter, notes that we as engineers have transformed society in ways that are not easily comprehensible to non-engineers (Chapter 1). He believes that, as engineers, we have a responsibility to help people cope in the environment *we* have created, and to proactively help non-engineering students acquire the technical literacy they need. An influential public speaker and writer, Wulf believes that engineers need to speak up on all public policy issues that have a technical dimension, such as through op-ed columns in local newspapers, involvement in civic groups, or even running for public office.

Davis (2) takes a parallel path, stating that engineers need to reach beyond a small circle of friends and family of engineers. She outlines a process to involve students in community-based projects, and presents the results obtained to-date. At Western Michigan University, the college of engineering and the college of education have teamed to help prepare science teachers in teaching the relevance of mathematics and science to K-12 students, particularly female students (3). A nationwide learning initiative in Taiwan for nanoscience and technology is incorporating education programs for elementary and high schools, the general public, and universities and colleges (4).

In Australia, four universities in and around Melbourne have teamed up with the microelectronics industry to start a Master of Engineering in Microelectronic Engineering program, presently cooperatively delivered by Victoria University and RMIT University (5). The program includes major industry-based projects undertaken by students with support from industry. Driven by the convergence occurring within the technology industry, the newly formed School of Information Sciences and Engineering at the University of Canberra has integrated three previously disparate courses (degree programs) into a unified and coherent offering (6). The University of South Australia has also directed its attention to industry, by starting an industry-based VLSI Design course (7). This learner-centric course is focused on development of skills for life-long learning and self-motivated learning, so students can adapt to changes in their professional career.

In the U.S., the Mechanical Engineering Department at San Diego State University has restructured its curriculum at both the course and program levels to reflect an emphasis on real-world problem-solving and learning-by-doing (8). In Taiwan, Tatung University has a senior capstone project course that is backed by industry (9), and that utilizes knowledge in thermodynamics, CAD/CAE, and integrated design methodology together with machine tool skills.

Innovations in applying everyday digital appliances to teaching and learning are exemplified by the work of Sandnes et al. (10). In dealing with the sometimes large numbers of e-mail inquiries from students in large classes when a new project or assignment is published, these teachers have adopted the FAQ (frequently asked questions) robot, which employs modern document classification technology borrowed from web mining to automatically classify and respond pseudo-automatically to student questions. Yong (11) at the University of Singapore has implemented a new e-Learning portal, called e-Learning Hub, which integrates "doing" into every step of the learning process. By combining various learning styles, e-Learning Hub presents a learner-centered environment that makes learning more effective, efficient, meaningful, and joyful in a large class.

Sampaio et al. (12) deal with applying virtual reality to make it possible for civil engineering students in construction subjects to visualize and interact with the construction process, and access quantitative and qualitative information at each construction stage. At Chalmers University in Sweden recent advances in research in fluid mechanics have been integrated into teaching (13). Advanced topics in computational fluid dynamics, such as Large Eddy Simulations that were rarely taught in scheduled classes in the past, are now incorporated into a Master's degree program.

A course in Mechatronics Engineering has been used by faculty at Queen's University and the University of Victoria in Canada to solve what they call the Challenge Line Problem (14). Addressing pedagogical issues in working with two extremes in engineering, viz., involving students with highly constrained problems in which there is a clearly defined solution, and with open-ended problems that have multiple potential solutions or maybe no viable solution, the course moves in stages from the highly constrained extreme to the open-ended extreme, providing both a broad and stimulating learning experience for the students.

At the University of Botswana, Uziak, Gizejowski, and Foster (15) have employed the spreadsheet as a tool for use in a second year course on Strength of Materials. Duan (16) presents the results of a survey concerning the characteristics of CAD education programs at public community colleges and two-year branches of universities in the United States. The results show that over 80% of community colleges offer CAD curricula in mechanical engineering with AutoCAD as the most commonly used software package.

At Minnesota State University, which has a small civil engineering program, an innovative expansion of the capstone design project experience has been adopted (17). The evolving ocean environmental engineering option at the U.S. Naval Academy is now introducing students to research and design projects that have a global significance (18).

Following a survey of available syllabi of reliability courses from fifty colleges, Pong et al. (19) have developed a technology transfer short course aimed at professional engineers, centering around the load and resistance factor design (LRFD) method.

Recently, Lab-on-Web, the Internet enabled laboratory developed by the Norwegian University of Science and Technology, has adapted to Web Services standards by means of Microsoft's .NET framework, allowing for a strong integration between backbone programs, web applications, and services such as modern learning management systems (20).

VizION, a software framework that addresses and simplifies common problems inherent to the development of IT classroom environments, is described by Groeneveld, Hutchinson and Kuester (21) in the context of VizClass, a test bed project. Billaud, Geoffroy, and Zimmer (22) discuss the eLab platform for electrical engineering education. This e-learning portal permits a wide range of experiments in electronics to be run via the Internet. A virtual and remote laboratory platform in the field of robotics has been developed by Tzafestas, Alifragis and Palaiologou (23). The system aims at enabling distance training of students in realistic scenarios of robot manipulator programming. The user interface is based on Java technologies and integrates concepts and techniques from telerobotics and virtual reality. The work of Leu, Chao, Wen and Wu (24) concerns a Multi-User Micro Avionics System Laboratory, a general-purpose micromachining facility designed to provide foundry service for educational purposes.

Regarding teaching effectiveness and student learning, Low (25) proposes a new Action Assessment method, in which students will be "continuously assessed" over the span of the engineering program using specific elements for assessment. In computer science, a recent study undertaken by Benest, Carter and Chandler (26) to identify learning preferences and personality biases of students show that computer scientists have different personality traits than both engineers and scientists. Based on scores obtained by students in the final exam of a course on Programming with C++ in 2002, and comparing them with the same students' GPAs two years later, Pioro (27) concludes that by knowing a student's score on the programming problem part of an exam in a computer programming course, it is possible to estimate the student's GPA two years later.

Iqbal, Hashmi, and Nadeem (28) present the use of discovery-based learning strategies in a computer science course. In this, the teacher does not deliver a formal lecture, but asks questions to help students find connections in their current knowledge. The process of acquiring knowledge becomes an exercise in formulating questions in order to solve a problem, and students find and establish relationships among facts on their own, increasing their level of understanding with no or little direct help from the teacher.

The work by Cardella and Atman (29) deals with the students' use of mathematics in engineering design. Concerning engineering design, at National Central University in Taiwan, a methodology for capturing and tracing the development of novice engineering students engaged in a yearlong creative design and implementation project has been developed (30). The Setback Episode Based Analysis methodology reveals the complicated situations encountered as students faced roadblocks in the innovation process starting from creative product idea generation to its design and implementation.

In the area of biomedical engineering, King (31) focuses on a teaching approach that, besides the technical contents of courses, graduates will also acquire techniques and skills needed for engineering practice. To achieve this, a uniform programming language, Matlab, is adopted throughout the undergraduate biomedical engineering curriculum. Diller and Martin (32) present an introductory biotransport course in which students are guided according to the How People Learn (HPL) pedagogical model.

As engineering programs worldwide increasingly focus on students' ability to function effectively on project teams and to communicate effectively, faculty are addressing the challenge of finding cost-effective ways of enabling students to acquire skills needed for collaborative work. Kvadsheim (33) of the Oslo University College has developed a simple set of low-cost tools and procedures that may be employed by student project teams and their tutors in developing collaboration skills.

Stating that, although there are large percentages of U.S. engineering faculty and students who are foreign born, students in the U.S. are not sufficiently exposed to an international perspective in the curricula, or to experience anything truly international, Yurtseven (34) reviews the newly instituted Accreditation Board for Engineering and Technology (ABET) requirements for engineering and engineering technology curricula that relate to international issues, and recommends approaches for internationalization of these programs as a means of addressing these requirements.

Convinced that engineering education must prepare students for the varying environmental, economic, and business competency requirements around the world, Le (35) analyzes the linkage between courses and the flow of knowledge in most existing engineering programs, and proposes modifications to optimize the learning efficiency while accelerating the attainment of technical and "soft" skills by engineering graduates.

To increase student exposure to different cultures, faculty at Michigan State University (MSU) have joined forces with faculty at the Volgograd State University of Architecture and Civil Engineering in Russia to develop a study-abroad engineering education program (36). Recently, the curriculum has been expanded through collaboration with faculty experts on Russian culture and language, and is now available to students on the entire campus as well as students in regional institutions.

Fox et al. (37) describe a cross-cultural, international experiential course that has been adopted at Indiana University Purdue University Indianapolis. The course examines sustainability practices of international companies in Germany and the United States. Scott (38) highlights a unique experience in intercultural adaptation of an engineering design program from the Colorado School of Mines to the Petroleum Institute at Abu Dhabi in the United Arab Emirates. Clara Amelia de Oliveira (39) deals with the thematic-based theoretical formulation that unifies terminology from complex modeling in informatics systems and from the philosophic domain. She applies these concepts to complex projects in engineering education and shows examples of application from the international community, as an illustration of efforts in migrating to an integrative educational paradigm that can lead to a universal international curriculum.

Chikuni, Peyton, and Weilbacher (40) provide an overview of a Summer Institute for faculty development and continuous improvement held each summer during the past three years. The initiative brought together instructors and administrators from the U.S. and Namibia. Participant-driven and project-based, the Institute encourages innovative approaches to problem-solving, and is assessment- and community-centered. Its international scope renders it unique.

To help round out the topics covered in this volume, Bzymek (41) outlines the basis and use of the Brief Theory of Inventive Problem Solving (BTIPS) for design problems, providing a framework that allows generating solutions closer to the ideal solution than the brain storming method. He reviews the details of the method, its effectiveness, and its use in engineering design teaching and research.

In closing, we wish to express our deep appreciation to the individuals who contributed to this volume as authors and reviewers. Our special thanks go to the authors for allowing us to consider their work. Reviewers provided us with their insightful comments; many of them also shared with us their general views on the state of engineering education today, and its future prospects. We are grateful to all of these individuals.

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