INNOVATIONS 2004

World Innovations in Engineering Education and Research

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CONTENTS

PREFACE

Covering topics ranging from curriculum changes to new, more effective approaches for teaching and learning, the forty chapters in this book showcase recent and ongoing developments in sixteen countries in engineering education. These articles show that efforts in engineering education are increasingly focused on learning-based pedagogical approaches. There is a broad recognition about the need to improve the quality of engineering education. New developments are being reported that deal with team-based as well as self-directed learning. As shown in these chapters, attention to outcomes assessment is now common in the world's leading institutions.

This volume starts with a guest commentary by Bordogna (Chapter 1), a leader of science and engineering education and research in the U.S., who writes from the U.S. perspective. He states that science and engineering is inherently international, but that he also believes in the need to recruit into engineering more of the native talents. To make this happen, he says, we must render engineering careers more appealing to the young generation and this will require a new model of engineering education, in which educators must understand how to produce engineers who are innovators, master integrators, holistic designers, change agents, and more.

Writing in the context of the nation of Colombia, Caro (2) outlines the challenges and opportunities facing the civil engineering profession in that country. She presents the current situation and the needs, including the actions needed to produce a modern civil engineering program in Colombia.

Focusing on a new interactive knowledge model, Bourgeois and Badillo (3) of France examine the implications of information technology in knowledge transmission, and conclude that the role of the instructor – the "pedagogue" – is crucial. In Israel, Waks and Merdler (4) explore aspects related to student creativity and conclude that both originality and innovation depend on the integration of disciplinary and interdisciplinary knowledge.

Several chapters in the book discuss new education programs and activities at specific institutions, and reflect the manner in which these institutions have responded to emerging opportunities in engineering education arising from new technological development. New education and research programs include that in NeuroEngineering at the University of California, Los Angeles (5), and in communications engineering education in Taiwan (6)(7). In Australia, four universities in the inner Melbourne area have collaborated to develop a new Master's degree program in microelectronics engineering (8).

To improve learning, student retention of prior course materials is important, and this can be facilitated through Web-based instruction, as shown by Schmahl (9) at Miami University in Ohio, USA. A remotely controlled heat exchanger experiment has been implemented by Colton (10) at the Massachusetts Institute of Technology and student responses have been assessed. From the University of Auckland in New Zealand comes a report by Tedford et al. (11) concerning a multimedia-based learning system that delivers immersive projects via a virtual company environment. Online delivery can be used also to improve distance communication and virtual teamwork skills of students, as demonstrated by Bohemia (12) of the University of Western Sydney in Australia, who discusses the online delivery of a course on design management.

Often, large lecture classes result when two or more classes are combined into one, and the large number of students in a large room often inhibits students from participating actively in the lectures. A solution adopted in Norway, as described by Sandnes and Talberg (13), is to have students in a class use mobile telephones to dial into a server and keying in questions and comments, which are then shown to the class and addressed by the instructor by projecting on screens located around the room. In Singapore, to encourage student attendance in large classes, instructors are presenting well-balanced course materials tailored to learners' performance that is monitored during and after a class by adaptive feedback (14). The problem of scheduling hands-on laboratory experiments for large classes is eased by using online access to remote, physical laboratory equipment, as is done in the U.S. (15) and in Norway (16).

Some of the recent education innovations are aimed at encouraging interactive learning, creative problem-solving and hands-on manipulation. In Europe, nine educational institutions in eight countries have collaborated to develop eMerge (17), an advance educational network infrastructure that permits dissemination of online laboratory experiments. In addition to remote manipulation of physical experiments, the use of technology in education includes the virtual laboratory concept. Here, Hutchinson and Kuester (18) at the University of California – Irvine uses visualization and display technologies to implement a framework that facilitates 3-dimensional spatial learning in a specially designed lecture room. In addition, the LabView platform has been applied by Holbert et al. (19) to provide flexible scheduling and remote access for experimentation in an electrical engineering laboratory, allowing students in the U.S. and Romania to share equipment such as a spectrum analyzer. Bachiller et al. (20) of the Universidad Politécnica de Valencia in Spain describe an interactive multimedia course in which students are provided with a self-learning tool for communications laboratory equipment.

In another course at the same university, Cerdá et al. (21) deals with the integration of theory and laboratory classes in circuit and electronic system design.

Gerecke et al. (22) at the University of Hannover, Germany, have developed a modular educational robotic toolbox that incorporates ease of experimentation with the flexibility to work on multiple robot platforms. At the Technical University of Catalonia in Spain, Sánchez Robert (23) has applied the cooperative learning method in a digital electronics course that involves the learning of theory, problem solution, project design, portfolio preparation and the use of examinations to assess the progress of students.

The focus on ABET Engineering Criteria 2000, as exemplified by the work of Sharma et al. (24), has led to a widening emphasis on learner-centered pedagogy and acceptance of learning assessment as an integral part of new education development. This is illustrated by the recent work of Saliceti-Piazza et al. in Puerto Rico (25), Aziz in Australia (26), Berg et al. in the U.S. (27), Gillet in Switzerland (28), and Böhne et al. in Germany (29).

Convinced that laboratory classes can be used to inculcate student learning of scientific concept as well as organizational skills, Montero et al. in Spain (30) have identified eight characteristics of learning that can be applied in class. A similar emphasis on learning strategies is featured in the work by Duque et al. (31) at the Universidad de los Andes in Colombia, in which problem-based learning, teaching-for-understanding, virtual peer evaluation, and hands-on laboratory classes have been employed in automatic control courses. Concerning interaction with industry, Farrell et al. (32) report from Rowan University in the U.S. that all undergraduate engineering students at their institution are required to take a sequence known as Engineering Clinics in which students work in multidisciplinary teams on semester-long or year-long projects sponsored by industry.

With a view toward developing more effective teaching tools, a team comprising of educators from the U.S. and Iran, led by Eydgahi (33) of the University of Maryland Eastern Shore, has designed and implemented a MATLAB-based toolbox with a graphical user interface applicable to computing reduced order models of a large system. A collaborative effort among educators in LICEF Research Center and Télé-université in Canada, and the Research Unit PRINCE, Faculty of Science of Tunis in Tunisia (34), has led to development of a graphic system for use in electrical engineering and computer science education and research that simplifies the tasks of verification and execution of Grafcet, the French/European standard graphical tool, without the need of a real programmable logic controller or an operative part. In addressing the difficulties associated with adopting technical language and terminology in non-English speaking countries, Jian and Sandnes (35) conclude that students are a valuable and appropriate resource for discovering suitable terminology. In a chapter dealing with an improved pedagogical approach in dynamic programming, Iqbal and Alvi (36) use typical optimization problems to demonstrate a method that enables students to build graphical templates that take advantage of the power of visual processing.

Racial and gender diversity and inclusiveness, and outreach to elementary, middle and high school have been a hallmark of much of the recent education developments in the U.S. From Florida Atlantic University, Hsu et al. (37) highlight a summer enrichment program that has been used in part to encourage gifted and talented high school students to pursue careers in engineering. At the University of Puerto Rico at Humacao, the attention of Ramos and co-workers (38) is directed at the roles of undergraduate research and international cooperation in promoting the participation of women in research and education, while at Oslo University College in Norway, the issue of student diversity, relating to WIB students, that is, students With Immigrant Background, is addressed by Torvatn and Sandnes (39).

To conclude this volume, Grüter et al. (40) address the high failure rates and lack of student motivation and capabilities in applying mathematics to real world problems. Working from Germany's Hochschule Bremen, University of Allied Sciences, they present teleVISE, a Web-based tutoring system for mathematical modeling and reasoning.

In selecting the above chapters, we reviewed 68 articles authored by 214 individuals. A total of 249 reviewers from 58 countries helped with peer review. We appreciate the contributions made by all of the authors, including those whose articles we could not accept for one reason or another, including page limitation imposed on this volume. Through their in-depth comments, reviewers have contributed immensely to this publication. We have enjoyed and benefited from our interaction with authors and reviewers alike. To all of them, we do herewith once again extend our heart-felt thanks.

We also thank Robert Aung and Linnea Hasegawa without whose professional help the publication of this volume would not have been possible.

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In addition to being Secretary-General of iNEER, Win Aung is affiliated with the U.S. National Science Foundation (NSF) where he holds the position of Senior Staff Associate – Engineering Education. Prior to joining NSF, he carried out research at Bell Telephone Laboratories in Whippany, NJ. A member of the U.S. Senior Executive Service and the recipient of the first NSF Federal Engineer of the Year Award, he is a Fellow of American Society of Mechanical Engineers (ASME). He has written extensively on research and education and is a frequent speaker on campuses around the world and at international conferences. He has over 120 technical publications, and has edited or co-edited 9 books. In 1999, he received the ASME Classic Paper Award, and the *Doctorem Honoris Causa* (honorary doctorate degree) from VSB – Technical University of Ostrava (VSB), Czech Republic. He is the founder of the International Conference on Engineering Education series and is a co-founder of the International Network for Engineering Education and Research (iNEER). He is a member of the Scientific Board of VSB. He is a member of the ASME Board on Education, and was an editor of the Transactions of ASME, Journal of Heat Transfer. He is the principal editor of the iNEER Special Volume series.

ROBERT ALTENKIRCH
Robert Altenkirch is President of New Jersey Institute of Technology, Newark, New Jersey, USA. Prior to that he was Vice President for Research at Mississippi State University (MSU), and served as Dean of College of Engineering and Architecture at Washington State University, and Dean of Engineering at MSU. A mechanical engineer, Altenkirch received the Ph.D. from Purdue, and has hundreds of publications and presentations to his credit. Altenkirch is a fellow of ASME, a member of Phi Eta Sigma, Tau Beta Pi, Sigma Xi, ASEE and the iNEER Board.

TOMAS CERMAK
Professor Tomas Cermak was elected as Rector of VSB – Technical University of Ostrava, Ostrava, Czech Republic in elections held in November 2002. He assumed the position on February 1, 2003 succeeding Vaclav Roubicek. Cermak first came to VSB in 1964 as a senior assistant, rising to become Head of the Department of Electrical Machines and Drives at VSB in 1985. In 1990 he became Rector, which position he held until 1997. In 1997, he was appointed as Vice Rector for R&D and Foreign Affairs. His service record includes membership of the Scientific Board of VSB and of the State Committee for Scientific Degrees. He chairs the Engineering Division of the Grant Agency of the Czech Republic. He was past member of the Scientific Board of the Technical University of Kosice, Slovak Republic; the Czech Engineering Academy; Vice

President of Czech Universities Council; and General Assembly of Czech Academy of Science. An early believer of the value of international cooperation in engineering education and research, he was actively involved with the organization of ICEE since ICEE-1997. He is the current Chair of the iNEER Board, and is a member of the ICEE and iCEER International Steering Committees. He is Chairman of the Board of Vesuvius (formerly Hinckley) Slavia Group. He is also Chairman and Vice Chairman of the Supervisory Boards of OZOBEL and Vitkovice Steel Company, respectively. He teaches courses in control of electrical drives and machines; power energy systems, among others. He has written 9 textbooks, and published 50 papers in journals and conference proceedings, with another 35 research papers based on industrial collaboration. He holds 4 patents.

ROBIN W. KING
Robin King is Pro Vice Chancellor, Division of Information Technology, Engineering & the Environment at the University of South Australia, Mawson Lakes, Australia. He received his Ph.D. in Electronic Engineering from Imperial College, University of London in 1972. He was a research engineer with the British Broadcasting Corporation from 1971 – 1974, and has held several academic positions in Papua New Guinea, UK and Australia. As an Associate Professor at the University of Sydney from 1989 – 1996 he led the speech technology research group, and was Associate Dean (undergraduate). He has more than 80 publications, and has been involved with a number of progressive engineering education initiatives, and with the Australasian Association for Engineering Education. In his current position he is responsible for the management and strategic development of a wide range of academic and research programs that span information technology and engineering, the built and natural environment and mathematics. He is a member of the Australian Council of Engineering Deans, and continues to be involved with accreditation of Australian engineering degrees through his work with the Institution of Engineers, Australia.

LUIS MANUEL SÁNCHEZ RUIZ
Luis Manuel Sánchez Ruiz has been affiliated with Universidad Politécnica de Valencia (UPV), Spain since 1980 and has been Professor of Mathematics since 2000. He graduated and received his Ph.D. from Universidad de Valencia in 1980 and 1988, respectively, and was a Visiting Professor at the University of Florida, Gainesville, FL, USA on several occasions during 1992-99. His current research interests include functional analysis from both theoretical and applied points of view. He has published over 80 papers in scientific journals and conference proceedings and more than 10 textbooks on mathematics for engineers, and is co-author of the research monograph *Metrizable Barrelled Spaces* published by Longman. The former Academic Coordinator of Mediterranean University of Science and Technology, he is responsible for several research projects granted by the Spanish Ministry of Education. He is currently a reviewer for several international journals, publishing companies and research projects, as well as a member of the Editorial Board of Scientiae Mathematicae Japonicae and of the on-line Scientiae Mathematicae. He is a member of the International Steering Committee of International Conference on Engineering Education and was General Chair of ICEE-2003 held in Valencia.

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