
INNOVATIONS 2014

*World Innovations in Engineering Education
and Research*

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*World Innovations in Engineering
Education and Research*

Edited by

Win Aung, *Principal Editor, Innovations 2014
International Network for Engineering Education
and Research, Potomac, MD, USA*

Thomas Doyle
*McMaster University
Hamilton, Ontario, Canada*

Frode Eika Sandnes
*Oslo and Akershus University College of Applied Sciences
Oslo, Norway*

Larissa Zaitseva
*Riga Technical University
Riga, Latvia*

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PREFACE

In this edition of the Innovations Series, we present a selection of peer-reviewed papers from different countries that focus on recent innovations in engineering education and research. The authors of the 18 chapters in this book discuss recent advances in teaching and learning through application of new technology, leveraging of engineering education accreditation, linkage with K-12, experiential learning, service engineering, international collaboration, and the integration of education with research and with industry.

In Chapter 1, Martin, Benton, Velasquez, Maughn, Janisiewicz, and Diller (1), from the United States, describe their work on Adaptive Expertise (AE), an amalgamation of traditional routine or core skills-based expertise and its correct application, referred to by the authors as *efficiency*, and the skills and habits to use that knowledge in new ways on novel problems, referred to as *innovation*. Using statistical and learning analytics methods, Martin et al. carried out experiments in the classroom that showed the appropriate use of innovation and efficiency by students in solving problems. Furthermore, regarding the development of adaptive expertise, the authors' experiments showed that, in a learning environment that provided opportunities to develop innovation and efficiency, they do develop together.

The teaching of project management by a mixed lecture/PBL oriented scheme is considered by Inoue, Maruyama, and Nagaya (2) in Japan. While the basic elements of the scheme are well-known, an interesting method for teaching project management is presented that employs simulation, real experience and virtualization, along with interdisciplinary communication and teamwork skill, and leadership training.

Contending that the theories of education and cognitive science support the role of Virtual Reality as a training tool, Valdez, Ferreira and Barbosa (3), in Portugal, present VEMA, a virtual reality desktop prototype that can be used for e-learning in the area of Circuit Theory. The underlying learning object and education software development are discussed and examples of usage are shown. The platform can be utilized to enhance security and resourcefulness in using electrical equipment. Several interactive scenes have been developed to illustrate the idea using the measurements and instrumentation laboratory as virtual environment.

The chapter by Borges (4) deals with ongoing learning experiences in engineering design graphics courses given at the Federal University of Juiz de Fora in Brazil. The experiences address the graphic and spatial reasoning abilities developed by Mechanical Engineering students. Questions on how undergraduate engineering students acquire knowledge in this area and how this amount of information and knowledge can be accessed in a short period of time are addressed. Experiences gained during the past three

years are discussed along with preliminary results from a survey done with the students. Guidelines for future research are also indicated.

Shakur and Sinatra (5) of the United States deals with the use of a smartphone as an inexpensive tool for the physics and engineering curriculum. They employ the phone to measure its own centripetal acceleration as it spins on a commercially available turntable. The output from the accelerometer and the gyroscope is recorded within the smartphone itself. The software (“app” or application program) needed to record the output of these sensors is available for free download through a website set up by the authors.

Also from the United States, Chaturvedi and Abdel-Salam (6) describe the results of a research project aimed at enhancing student learning effectiveness using web-based simulation and visualization modules in engineering science lecture and laboratory courses. Several web-based modules have been created and embedded in thermodynamics and thermofluids laboratory courses in mechanical engineering. Assessment results indicate that students’ learning effectiveness improved when they used the web-based modules in the supplementation mode.

The worldwide demand for technical personnel is focused on engineers who are not just technically competent, but also versatile in the non-technical field. Hillmer (7) of Austria reports that, to address this issue, the technical programs at Management Center Innsbruck (MCI) have been revised so that courses on business and management, and social and soft skills are part of the bachelors’ programs. A set of modules with “non-traditional topics” have been developed to addresses important learning outcomes related to General Management Skills, Social and Soft Skills, Integrative Skills, and Reflective Skills.

From Brazil, Galhardi and Azevedo (8) describe the National Examination of Student Performance System (ENADE) in the context of Bloom’s Taxonomy, which deals with the classification of the education objectives of students. The thirty five item ENADE questionnaire are analyzed to identify the level of Bloom’s Taxonomy that corresponds to each question. The percentage correspondence to each level of the Taxonomy is also determined.

Kukk (9) of Estonia considers the problem of extracting the maximum information about the competency of a learner while processing answers in multiple choice tests. The basic idea is to find the probabilities of correct application of competences using evaluation maximin applied over all the answer items. The emphasis is on obtaining the maximum information about the learner’s knowledge. The results of his analysis can be used, for example, in creating input data in models based on Item Response Theory, or evaluation of ability levels and forgetting parameters, etc.

Cecil and Chandler (10) of the United States review the current status in the development of cyber physical systems. Recent initiatives in the U.S. which focuses on the design of the next generation of Internet including the deployment of software designed networks and cloud-based technologies are discussed. The premise here is that the new technologies have important implications for engineering education, particularly in supporting interactive learning and distributed e-learning. The key technological and educational challenges, such as costs and safety, are outlined.

In one of the first studies that link engineering education accreditation to employability of graduates, the Republic of South Korea’s Kim, Son, and Kim (11) investigated the employment history of graduates at the University of Seoul for the three academic years from February 2010 - August 2012. The results of the study confirm the

beneficial impact of accreditation on the employment of graduates. They analyzed the impact of design credit acquired, credits in mathematics, science, and computers, and grade point average and found that grade point average has the largest beneficial impact on student employment.

Kalambokis and Zacharopoulou (12) of Greece describe the “Pre-Engineering Weekends” project implemented in Anatolia College at its Thessaloniki campus in Greece. The innovative program introduces high school students to basic principles of engineering using a hands-on approach, enabling them to get a real “feel” for engineering. The program is open to students of the broader region of the Balkans and is offered in English. The Program is based on simple projects, using every-day, low-cost materials, and can easily be organized in other schools, both in Greece and abroad, as an addition to existing curricula or as extra-curricular activity.

Conceive-Design-Implement-Operate (CDIO) is an initiative that seeks to close the gap between engineering education and real-world requirements; it has been adopted by universities and colleges in several countries. In Japan, Takemata, Minamide, Kodaka and Nakamura (13) at Kanazawa Technical College employed CDIO to develop a program to educate high school students about manufacturing. Students were tasked with developing an easy-to-use cup for the elderly. A survey found that the students judged that their cup design was easy to use for the elderly. Feedback from seniors who actually used the students’ design also provided positive evaluations of its usability.

Focusing on the integration of the CDIO approach and the Innovation Pedagogy approach originating at the authors’ institution, Finland’s Penttilä, Kontio, Kairisto-Mertanen and Mertanen (14) discuss the application of these approaches at their institution in its two largest faculties that have engineering education as their biggest field of study. The authors conclude that Innovation Pedagogy strengthened with the CDIO approach is taking engineering education further from traditional theoretical learning to the application of learned skills to practical challenges in the workplace.

The fabrication of a mobile 3D projection system as performed by 5th grade students using the CDIO approach as a capstone project is described by Minamide, Takemata, Kodaka, and Yamada (15). The authors are from Kanazawa Technical College (KTC) in Japan, an intensive 5-year educational institution focusing on experiential learning. KTC officially joined the CDIO initiative in 2010, and has started to use it as a framework for its engineering curriculum, in which students pursue their learning through the design and product development process.

While learning and working in teams can provide benefits to students, it also can present challenges in the fair assessment of a student’s contribution to team work and team learning. Jaeger, Adair and Al-Qudah (16) used an Evidential Reasoning (ER) method for portfolio assessments and compare the assessment of two instructors and analysed the feasibility of the ER method for aggregation of the assessment results. They incorporated an ER approach into portfolio assessment of an undergraduate engineering design course delivered it as a Project-Based Learning (PBL) course. They found that the results based on the ER approach and two assessments are similar and that the ER method is capable of successfully aggregating assessments. They conclude that the ER approach is a commendable alternative to traditional holistic judgment-based assessments of Project-Based Learning portfolios. The authors of this work are respectively affiliated with universities in Kuwait and Kazakhstan.

In the field of energy and power utilization, which lies at the core of multiple engineering and applied science disciplines, systems integration exercises, such as device fabrication, can challenge the students due to its potential complexity. Reporting from the United States, Sahoo, Villareal, Cardona, and Santiago-Ailes (17) describe the transition from engineering design to device manufacture as an example of the integration between engineering research and education. The influence of processing parameters on super-capacitors energy and power density are presented so as to permit the choice of best practice sequence in the preparation and fabrication of experimental devices.

Finally, Gjengedal (18) of the University of Tromsø, reports that bachelor degree students in Norway can choose practical work in their third year for 10 credit points (ECTS). He describes the framework and the practical implementation. He gives examples of how the practice is applied in different businesses, and reflects on practical work as a learning strategy, and the benefits to students, industry and the university.

These then are the papers you see in this volume. The innovations they report are evidence that, despite economic and political challenges that invariably intrude from time to time, the globalization of engineering education, which levels the playing field across countries, marches forward. They show that the world is flat not only in commerce but also in opportunities to advance engineering education and research!

As for editors in previous editions, we have felt the weight of the awesome responsibility as we assume the editorship. The challenge of discharging our duties responsibly and in a timely manner seems almost daunting. Precisely for that, the work is exhilarating as it draws to a close. Ultimately, however, the overwhelming feeling is one of gratitude. We are grateful to the authors for their contributions to this volume, especially for their trust in allowing us to be the arbiters who will decide on how their papers will be presented, or even if they will be presented at all. We are equally awed by the trust and friendship inherent in the reviewers' willing acceptance of our request for review, often with very short notice. Their insight and advice on the papers are invaluable. To these great friends and colleagues, we are truly grateful.

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WIN AUNG earned the B.Sc. in Mechanical Engineering from the Rangoon Institute of Technology in Rangoon (now Yangon), Burma (now Myanmar), and the M.S. and Ph.D. degrees in Mechanical Engineering from the University of Minnesota, Minneapolis, MN, USA. He was a Member of Technical Staff at Bell Laboratories, Whippany, NJ, USA from 1969 to 1974. From 1974 to 2010, he served at the U.S. National Science Foundation and was a member of the U.S. Senior Executive Service. Since 2000, he has served as the Secretary-General of iNEER which he co-founded. He is the principal editor of the iNEER *Innovations Series*. He was awarded the first NSF Federal Engineer of the Year Award in 1985. He has held visiting professorships at several universities in the U.S. and abroad, published over 120 technical papers and co-edited more than 10 books in heat and mass transfer, and engineering education. A Fellow and Life Member of the American Society of Mechanical Engineers, he served on the ASME Board on Engineering Education, the Council on Education, and was an editor of the Journal of Heat Transfer. He received the *Doctorem Honoris Causa* (honorary doctorate degree) from VSB – Technical University of Ostrava, Czech Republic in 1999, the University of Pećs, Hungary in 2008, and the Saratov State Technical University, Russia in 2012. In 2005 he received the Medal of Merit from the Silesian University of Technology in Poland.

THOMAS DOYLE attained simultaneously the B.E.Sc. in Electrical and Computer Engineering Science and the B.Sc. in Computer Science from the University of Western Ontario in London, Ontario, Canada. He continued there to earn the M.E.Sc. and Ph.D. degrees in Electrical and Computer Engineering Science. Following that, he taught at the University of Western Ontario, London, ON, Canada, the University of Ontario's Institute of Technology, Oshawa, ON, Canada, and at McMaster University, Hamilton, ON, Canada. After receiving his Ph.D. in 2006 he became the first Teaching Professor in the Faculty of Engineering at McMaster University and has earned the rank of Associate Professor. In recognition of his pedagogical research, innovation, and contributions to teaching and learning he was awarded the highest honour from the President of the University in 2013. In addition to his publications on pedagogical methods and research, since 2010 he has further disseminated his work through international workshops and American Society of Engineering Education and industry webinars. His research is applied to engineering education in the novel Experiential Playground and Innovation Classroom, of which he is a co-designer. He is the Canadian Engineering Education Association's Regional Director for Ontario and Technical Chair for the International Conference of Engineering Education and Research – McMaster (iCEER-2014 McMaster). In 2014 he was appointed Director of the interfaculty e-Health Informatics

graduate program at McMaster University. His research interests combine education, health, and technology in the domains of engineering education, human computer interfacing, embedded systems, biomedical signal processing, and machine learning.

FRODE EIKA SANDNES received a B.Sc. in computer science from the University of Newcastle upon Tyne, U.K., and a Ph.D. in computer science from the University of Reading, U.K. He is currently the Pro-Rector for Research and Internationalization at Oslo and Akershus University College of Applied Sciences in Norway (formerly Oslo University College and now the 3rd largest higher education institution in Norway), and a full Professor in the Institute of Information Technology, Faculty of Technology, Art and Design (formerly Faculty of Engineering). His research interests include human computer interaction, multimedia processing and engineering education. Dr. Sandnes has published extensively in both technical and engineering education journals including the IEEE Transactions on Education, European Journal of Engineering Education, International Journal of Engineering Education, and Computer Assisted Learning Journal. He is an editorial member of several international journals including Journal of Systems and Software, Human-centric Computing and Information Sciences, International Journal of Communication, Consumer and Control, Journal of Information Technologies and Applications, The Open Cybernetics and Systemics Journal, International Journal of Smart Home, and International Journal of Computational Science and Engineering. He has chaired and been involved in the organization of nearly 50 international conferences including the steering committees of several ICEE conferences. Sandnes has also served on the national panel of evaluators for quality assurance in higher education and participated in several audits in Norway, Lithuania and Denmark and chaired the evaluation committees for two institutional evaluations. Sandnes has also been an evaluator for the accreditation of a Ph.D. programme in Computer Science.

LARISSA ZAITSEVA has been a Professor in the Department of Software Engineering, Riga Technical University, Riga, Latvia since 2002. From 1974-2013, she served consecutively as Senior lecturer, Department of Computer Software (Informatics and Programming); Associate Professor, Department of Informatics and Programming; Head of the Department of Informatics and Programming; Associate Professor, Department of Software Engineering; and Chair of Software Engineering. She received the Dr.sc.ing in Technical Cybernetics and Theory of Information (USSR Diploma) in 1981; Docent in 1988 (USSR Diploma); Dr.sc.ing. (Latvian Diploma) in 1992; and the RTU Professor title (RTU diploma) in 2002. Her research interests include: e-learning systems; software engineering, and software quality and reliability. Since 2003, she has served as a member of editorial board of the internet journal *Educational Technology & Society* of the IEEE Learning Technology Task Force Eastern Europe Group. She has published 1 monograph, 107 papers and 38 methodical guides.

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