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Guest Editorial: eLearning Research Opportunities in Engineering Education

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What is elearning? U.S. readers are far more familiar with the terms "cyberinfrastructure" and "cyberlearning." But in the rest of the world, the term elearning is much more common for describing educational activities that make use of information and communication technology. Technology has always played a critical role in engineering education, but the growing reach and potential of advances in communication, computational, and information technologies are creating new capabilities for advancing research and innovation in engineering education.

The U.S. National Science Foundation (NSF) has been leading efforts to report on the implementation and evaluation of an emerging cyberinfrastructure to enhance research (Atkins, 2003; NSF, 2007). They use the term cyberinfrastructure to refer to an infrastructure based upon distributed computers, information and communication technologies, all of which are required for a knowledge economy. In a recent report, the NSF expands the applicability of cyberinfrastructure into the classroom, defining cyberlearning as the "use of networked computing and communication technologies to enhance learning" (Borgman et al., 2008). According to the report:

> "Cyberlearning has the potential to transform education throughout a lifetime, enabling customized interaction with diverse learning materials on any topic—from anthropology to biochemistry to civil engineering to zoology. Learning does not stop with K-12 or higher education; cyberlearning supports continuous education at any age" (Borgman et al., 2008, p. 5).

Networked technologies play two critical roles in enabling engineering and science education. In its first role, cyber-technologies act as platforms for facilitating research on learning. By allowing shared access to data, computers, and networking resources, cyberinfrastructure allows research in learning to be accelerated. However, the second role of cyberinfrastructure, in which it acts as a platform for delivering learning content, is the focus of this special issue.

The genesis for this special issue was a U.S. NSF-funded workshop held in conjunction with the Australasian Association for Engineering Education conference in Adelaide in December 2009. This workshop brought together 10 participants from the U.S., 10 from Australia and 2 from New Zealand. The group included engineering professors, education researchers, graduate students, faculty developers and learning technologists, all of whom had a specific interest and expertise in elearning. This special issue is meant to capture some of the discussions at this meeting, as well as to expand the conversation to the broader elearning engineering education community.

The journal articles contain a range of different contexts for elearning (introductory materials science, dynamic systems and control, a range of civil engineering courses, Introduction to Electronic/Electrical Component Behavior, and Mechatronic Automation), a range of techniques for implementing elearning (games, technical and team simulations, clickers), and a range of different tools and methods for reporting on the work.

The methods used in the papers also differ, ranging from traditional quantitative surveys and analysis of usage logs to scholarly—and relatively innovative within the engineering education literature—guided practitioner reflection. The former may be most powerful in convincing skeptics of the value of elearning in engineering, while the latter reads like a discussion with an experienced colleague describing how to best implement elearning. Taken together, these articles give a sense of the possibilities, challenges, opportunities and limitations of these approaches. Through this process we have discovered that

- **All elearning is still first and foremost *learning*.** While engineering faculty may initially focus on programming and refining the technology, they quickly find that attention to student behaviors, attitudes and use become a priority. Further engagement with learning theories and educational researchers will help us to make the best use of elearning technologies.
- **A complex set of circumstances determines what will "work" for elearning.** It usually takes several iterations or academic terms to optimize these conditions. Again, learning theory can help target the most influential factors, assessment evidence can guide improvements, and the articles in this special issue also include practical advice for scaling up.
- **eLearning serves to support, augment, and complement traditional lecture formats.** For example, Pinder-Grover et al. found a statistically significant relationship between industrial engineering majors' access of lecture screencasts and their final grades in the course, reasoning that elearning supplements bring the greatest benefit to students with the least prior experience with a topic.

These papers present a broad spectrum of what can be done and what should be done in engineering elearning, and of the various ways in which elearning can help your students reach their learning objectives. However, there is much more that can be done. There is still a tendency for engineering educators to think of technology in terms of how it can accommodate activities initially designed for the classroom. Advances in information and communication technology can have a transformative effect on access to learning resources, educational tools, and social support structures. Traditionally, educational practices using networked (or non-networked) technologies have for the most part trailed progress in technology. Therefore, the development of well-defined theoretical frameworks centered on the use and adoption of elearning has great potential to forge new directions in the field of engineering education. Engineering education is not contributing as much to this literature as it could be—new theoretical frameworks that explore how engineering education research and practice are affected by the significant impact of elearning need to be developed.

In closing, the editors would like to thank the U.S. NSF for funding the workshop through grant DUE-0810990 and University of Adelaide colleagues who hosted us on their campus. We hope that this selection of papers is useful to you as engineering educators, and that you enjoy reading it as much as we did putting it together for you.

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Euan Lindsay is an Associate Professor in Mechatronic Engineering at Curtin University of Technology, in Perth, Western Australia. His research interests include engineering education (in particular remote laboratories), artificial neural networks, and mobile robotics. Dr. Lindsay's work in Remote and Virtual laboratory classes has shown that there are significant differences not only in students' learning outcomes but also in their perceptions of these outcomes, when they are exposed to the different access modes. These differences have powerful implications for the design of remote and virtual laboratory classes in the future, and also provide an opportunity to match alternative access modes to the intended learning outcomes that they enhance. Dr Lindsay was the 2010 President of the Australasian Association for Engineering Education. In 2005 he was named as one of the 30 Most Inspirational Young Engineers in Australia.

Krishna Madhavan is an Assistant Professor in the School of Engineering Education at Purdue University. Prior to his arrival at Purdue, he was an Assistant Professor with a joint appointment in the School of Computing and the Department of Engineering and Science Education at Clemson University. Dr. Madhavan served as a Research Scientist at the Rosen Center for Advanced Computing, Information Technology at Purdue University where he led the education and the educational technology effort for the NSF-funded Network for Computational Nanotechnology (NCN). He was the Chair of the IEEE/ACM Supercomputing Education Program 2006 and was the curriculum director for the Supercomputing

Education Program 2005. In January 2008, he was awarded the NSF CAREER for work on learner-centric, adaptive cyber-tools and cyber-environments in engineering education. He was one of 49 faculty members selected as the nation's top engineering educators and researchers by the US National Academy of Engineering to the Frontiers in Engineering Education symposium.