INNOVATION WITH IMPACT

Creating a Culture for Scholarly and Systematic Innovation in Engineering Education

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Dear Colleague:

This report represents the culmination of a series of evolving conversations that began in the summer of 2004 within the American Society for Engineering Education and that progressively broadened to include hundreds of engineering faculty, chairs, and deans across the United States. The initial conversations focused on how the Society could and should contribute to the national dialogue on preparing U.S. engineers for the 21st century. As a consequence of those conversations, ASEE launched in June 2006 an initiative, "Advancing the Scholarship of Engineering Education: A Year of Dialogue," involving discussions within the Society on the role and importance of educational scholarship to ensure the long-term excellence of U.S. engineering education. A report based on those discussions led to this project, which began in October 2007 with support from ASEE and the National Science Foundation. The project sought to catalyze even broader conversations across the American engineering enterprise on creating a vibrant engineering academic culture for scholarly and systematic innovation to ensure that the U.S. engineering education enterprise keeps pace with changes in the engineering profession and in the world.

The project was conducted in two phases. Phase 1 involved the efforts of 68 volunteers who worked for more than six months to distill their thoughts and recent articles and reports into a set of critical issues and actions to advance U.S. engineering education. These were shared and discussed with another 37 volunteers at a meeting in November 2008 in Atlanta, Georgia. The advice and ideas from that meeting were incorporated into the report, "Creating a Culture for Scholarly and Systematic Innovation in Engineering Education," which was presented at the main plenary at the ASEE annual conference in June 2009 and posted on the ASEE website *(www.asee.org)*.

Immediately following that conference, Phase 2 was launched to seek additional advice and ideas from the broader U.S. engineering community on the critical issues and suggested actions in the Phase 1 report. The project's research team prepared and conducted a survey of a large sample of U.S. engineering programs to gather feedback and to establish a baseline on current practices in engineering education. This was supplemented by written feedback collected following the presentation of the report at a number of conferences and meetings over a two-year period. The feedback was analyzed, combined with the highlights of the Phase 1 report, distilled into seven recommendations and over 70 potential actions generated during the course of the project, and this final report prepared.

As reflected in the report title, we believe that there is an opportunity to foster a culture of innovation with impact. On behalf of all of those who contributed their time and energy to this project, we hope this report provides new ideas and timely inspirations to help make our world-class engineering programs even better—and to continue to evolve engineering education as a vibrant, high-performing, effective, efficient, collaborative, rigorous, and valued endeavor that is responsive to the changing needs of the profession and the world.

Sincerely,

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Ransburg Distinguished Professor of Electrical and Computer Engineering
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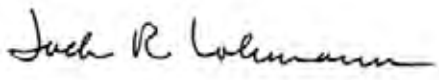

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01 | EXECUTIVE SUMMARY

As engineering careers have become increasingly collaborative, multidisciplinary, entrepreneurial, and global, and as the pace of change of technology has accelerated, the expectations for engineering education have expanded. To the foundations of mathematics, science, engineering fundamentals, disciplinary depth, and professional and ethical standards have been added interdisciplinary breadth; communication; teamwork; global economic, environmental, and societal contexts; critical thinking; ingenuity; creativity; leadership; flexibility (ABET, 2011; NAE, 2004; McMasters and Komerath, 2005) … and the list continues to grow. Although the American engineering community has a rich history of commitment to continually improve the U.S. engineering education enterprise (ASEE, 2009), there are major gaps between our reports and our curricula, our desire to graduate diverse talent and our ability to deliver, and our encouragement for educational innovation and our follow-

through to support it. At a time when local, state, and national resources for education are becoming increasingly scarce, expectations for institutional accountability and student performance are becoming more demanding. It is clear that "business as usual" will not ensure success in meeting the growing demands, much less a place at the forefront of the global engineering education community.

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If a "grand challenge" for engineering education is *"How will we teach and how will our students learn all that is needed to tackle the challenges of today and tomorrow?"* then the issue is *not* simply a need for more educational innovations. The issue is a need for more educational innovations that have a *significant impact* on student learning and performance, whether it is through widespread and efficient implementation of proven practices or scholarly advancements in ideas, methods, or technologies.

Several factors combine to limit the broad impact of our innovations. The dominant approach to engineering education innovation today is based largely on faculty intuition drawn from personal experiences as students and teachers. Seldom are engineering education innovations grounded in confirmed learning theories and pedagogical practices, and many innovations once implemented are not assessed for their effectiveness in achieving their stated objectives. Transfer of education innovations into practice falls prey to the same "valley of death" that challenges technological innovations. And neither educational innovation nor transfer or adoption of educational innovations has a firm place in the academic reward system.

Against this backdrop, the American Society for Engineering Education launched a two-phase project in October 2007, with support from the National Science Foundation. The Phase 1 report, *Creating a Culture for Scholarly and Systematic Innovation in Engineer-*

ing Education, was presented at the main plenary at the ASEE annual conference in June 2009 and posted on the ASEE website. The report, which drew on the understanding and insight of over 100 volunteers, developed a framework for tackling the issue of culture change in engineering education: that although there are many thoughtful reports on improving engineering education, most reports emphasize "what" needs to be changed, i.e., topics to cover, skills to obtain, or experiences to offer. "Who" should drive the change and "how" the change should be driven—both of which largely determine how quickly and how well change occurs and how it is sustained—are often not fully addressed. The Phase 1 report zeroed in on three key messages:

Who—While a quality higher education experience involves many stakeholders, the responsibility for the quality of the engineering educational experience rests with the engineering faculty and administration.

What—A more efficient and effective educational enterprise could be achieved if the engineering curriculum and its instruction and assessment were deployed in programs perceived by students to be personally rewarding, socially relevant, and designed to help them succeed.

How—Higher levels of performance in any field are achieved by continual innovation that is motivated by the desire to solve important problems and that is addressed systematically in tight interplay with research and proven practices. This time-tested model, widely practiced by engineering faculty in their disciplines but largely untapped in engineering education, lies at the heart of transforming the culture in engineering education.

Building on this "who/what/how" framework, Phase 2 of the project set out to understand the current "state of the culture" by conducting a survey of faculty committees, chairs, and deans. Narrative and quantitative responses from 110 departments representing 72 colleges provide insight into current views and practice in teaching and learning, faculty preparation and engagement, and infrastructure and support for engineering education innovation. In a nutshell:

- While faculty committees report that active and engaging pedagogies such as cooperative learning are being used more than may be fully realized by the engineering community as a whole, most of those pedagogies, as well as their educational innovations,

are largely directed to long-standing learning environments such as laboratories and research experiences. Newer learning environments, such as international, entrepreneurship, or service-learning experiences, are not as warmly embraced.

- While there is increased interest in making engineering programs more engaging and relevant, there is much less emphasis or attention to making them more welcoming, especially to groups traditionally underrepresented in engineering.

- Engineering programs are quite comfortable and routinely interface with industry and employers, but they are much less engaged with just about everyone else on campus or across the full spectrum of the American educational system.

- There is substantial support for career-long faculty development in teaching and learning, beginning with doctoral students aspiring to faculty careers. However, more specific development opportunities, such industry experiences or graduate study in educational scholarship, are of much less interest.

- Not too surprising, there is a strong desire for more supportive policies, practices, and physical and fiscal resources for educational innovation. Indeed, there is agreement among faculty, chairs, and deans that the top three challenges for improving educational innovation are: resources, workload, and the reward system.

- Engineering education innovation remains largely focused on departmental curricula viewed through the lens of "teaching," and much of the current infrastructure for educational innovation (e.g., conferences, journals, funding), inside and outside engineering, appears largely unknown.

- The gap between what is valued and what is practiced across several areas of pedagogy, learning environments, and faculty preparation speaks to the divide that exists between innovation and impact.

Besides providing a baseline on the current "state of the culture," the survey also provided a basis for developing seven recommendations to address the question of how we can build a stronger foundation for our engineering education enterprise, taking advantage of the creativity and innovation that exists throughout our enterprise, but looking especially to those elements that will ensure impact. In the report appendix, these broad recommendations are accompanied by specific actions that faculty, chairs, and deans; ASEE, the National Academy of Engineering, and professional engineering societies; funding agencies; ABET; and industry can take to get started on a transformation of engineering education.

WHO

Recommendation 1—Value and expect career-long professional development programs in teaching, learning, and education innovation for engineering faculty and administrators, beginning with pre-career preparation for future faculty.

Recommendation 2—Expand collaborations and partnerships between engineering programs and (a) other disciplinary programs germane to the education of engineers as well as (b) other parts of the educational system that support the pre-professional, professional, and continuing education of engineers.

WHAT

Recommendation 3—Continue current efforts to make engineering programs more engaging and relevant and especially expand efforts to make them more welcoming.

HOW

Recommendation 4—Increase, leverage, and diversify resources in support of engineering teaching, learning, and educational innovation.

Recommendation 5—Raise awareness of the proven principles and effective practices of teaching, learning, and educational innovation, and raise awareness of the scholarship of engineering education.

CREATING A BETTER CULTURE

Recommendation 6—Conduct periodic self-assessments within our individual institutions to measure progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation—innovation with impact—in engineering education. *Recommendation 7*—Conduct periodic engineering community-wide self-assessments to measure progress in implementing policies, practices, and infrastructure in support of scholarly and systematic innovation—innovation with impact—in engineering education.

While we can be proud of the international stature of our engineering programs, we also should not be complacent and assume that what has worked in the past will continue to work in the future. The rich history of U.S. technological innovation and its entrepreneurial collaboration between scholars and practitioners across many fields has served us well. We need to adopt and adapt this time-tested model for U.S. engineering education innovation. "Innovation with impact" and "creating a culture for scholarly and systematic innovation in engineering education" are mutually reinforcing: practices grounded in scholarship are more likely to be effective in achieving their desired objectives, and scholarship driven by important problems is more likely to produce results with potential for meaningful impact.

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Addressing the challenges we face will not be easy but tackling them provides targets of opportunity in which engineering programs, industry, government, and engineering-affiliated organizations can work collaboratively to significantly advance U.S. engineering education. While the engineering profession has become a critical component in our national capacity for innovation, the same cannot be said for engineering education. A key to maintaining our technological preeminence is to ensure that we educate many more young people with imagination and passion as engineers. Just as the engineering sciences transformed the curricula content in engineering education in

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the 1950s and 1960s, so the "Sputnik moment" for the current generation pivots on a transformation in the processes used to educate engineers to meet the challenges of our time. This demands innovation in educational approaches that boost the effectiveness and the efficiency of engineering education for both undergraduate and graduate students. Thus, we hope this report and its recommendations will ultimately earn U.S. engineering education a "seat at the table" as a complementary peer companion with engineering research in advancing the nation's capacity for innovation with impact in all domains of engineering and technology. ■