Special Guest Editorial

Reframing Professional Development: A Systems Approach to Preparing Engineering Educators to Educate Tomorrow's Engineers

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The articles in this special issue present research on who engineering students are, how they learn, and what they need to know. The challenge to engineering education is that the answers to those issues are different now than they were just a few years ago, and they will inevitably continue to change. Due in part to the rapidly increasing power of technology, routine tasks that were traditionally performed by engineers are now performed by technicians using computers while engineers are called upon to develop innovative products and processes, exercise new and unfamiliar technical and professional skills, and function in an increasingly global environment. What it will mean to be an engineer in the twenty-first century and the incompatibility of current engineering curricula with that meaning have been the subject of many high-level studies. The debate so far has had little impact on engineering educators.

In view of the broadening and rapidly shifting scope of the engineering profession, it is imperative to shift the focus of engineering curricula from transmission of content to development of skills that support engineering thinking and professional judgment. Future engineers will need to adapt to rapidly changing work environments and technology, direct their own learning, broaden an understanding of impact, work across different perspectives, and continually revisit what it means to be an engineer. Traditional approaches to engineering education (chalk-and-talk lectures, individual homework, three years of "fundamentals" before an introduction to engineering practice) is incompatible with what we know from decades of cognitive and classroom research. Furthermore, research on student engagement has moved the boundaries of learning environments beyond formal classrooms to informal spaces such as student lounges, professional work spaces, and virtual community spaces. What remains crucial is the importance of social learning as students interact with others—e.g., peers, educators, campus administrators, and internship supervisors. As such, the teaching decisions engineering educators make can impact learning in and out of the classroom.

While these challenges may seem formidable, they present considerable opportunity for reframing what it means to be an engineering educator preparing tomorrow's engineers. Future engineering educators will have access to a variety of exciting new roles for enabling engineering education to dynamically respond to the evolving nature of the engineering profession:

- *Educational philosopher and provocateur:* Engage in the international dialogue about the content, skills, and values engineering graduates should be equipped with and how these should be addressed. Advocate new perspectives that challenge traditional views and enable innovative curricula, content and pedagogy.
- *Educational researcher:* Imagine educational and workplace environments as learning laboratories to delve into how, what, and why students are learning, and how engineers use this learning. Design experiments to develop, assess, and disseminate new instructional materials, methods, and learning environments.
- *Interdisciplinary educator:* Integrate engineering content with content from other STEM disciplines, economics and business, humanities, and the social sciences. Provide opportunities such as interdisciplinary projects for students to learn from peers in other disciplines.
- *Teaching leader:* Share effective instructional methods and materials with colleagues; help to adapt them for their own classes. Embrace opportunities to be a decision maker and change agent, build networks for making an impact, and have intellectually stimulating discussions with colleagues about good teaching practice.
- *Scholarly teacher and reflective practitioner:* Read the literature and attend education conferences to keep abreast of new education practices. Imagine links between research findings and teaching practice. Engage in collaborative and systematic reflection about what works and what does not (and why) as an essential part of life long learning and continuous improvement. These habits of mind might even be initiated as part of graduate training.

Engineering educators would not be expected to assume all these roles but gravitate to those they feel most comfortable, competent, and passionate; department heads would ensure that each role is filled by one or more faculty members. The idea is to encourage activities that facilitate greater synergy between being an *engineer* and being an *educator*. Ideally, all educators would assume a role of *scholarly teacher and reflective practitioner*.

How can we prepare engineering educators for roles that may not be part of their training or their experience? The inadequacy of current professional development approaches is abundantly clear. It is unfortunate and unnecessary that many new engineering educators have to figure out for themselves how to design syllabi and lesson plans and tests, motivate students to learn, teach effectively in small and large classes, help students who are struggling, and deal with classroom disruptions and cheating while at the same time building a research agenda, recruiting students, and meeting service responsibilities. Just as the education of future engineers must evolve to reflect new challenges within the profession, professional development must evolve to reflect new demands on engineering educators.

Reframing the professional development of engineering educators from a complex systems perspective could move the community beyond short term, quick-fix solutions towards longer term, proactive, integrated, adaptive, and relevant solutions. From a complex systems perspective, engineering education involves the engineering profession, the society it serves, educational institutions, educators, and students. The question becomes how to design for *intentionality*—to change the existing situation into a preferred one? One way is to consider educational institutions as learning organizations that focus on building a culture of innovation and continual learning, and emphasize the importance of systems thinking, dialogue, and reflective practice.

A particular challenge of conceiving higher education as a learning organization is finding ways to leverage academic freedom of the individual within the organization while maintaining a collective goal of quality of an education. The question of assessing and evaluating professional development is also a challenge at the individual and organizational level. How might the maintenance of competence and expertise be a joint responsibility of the individual professional and the organization? Providing accredited, award-bearing programs in higher education or including professional development outcomes in accreditation policies may create a system for continual development at the organizational and individual level. This might provide mechanisms for improving alignment between academic roles and academic rewards or incentives.

There are also implications for enabling synergistic cycles of research informing teaching and teaching informing research. Engineering educators do not typically read engineering education journals. A challenge for engineering education researchers is to find ways to communicate their work for use in practice and to respond to educator and practitioner needs to ensure they are conducting rigorous and relevant research. A challenge for education practitioners is to find ways to help form research agendas and provide feedback on research-informed instructional practice.

This volume delves into questions about who is an engineer, how they learn, how they come to identify as engineers, and what they need to learn. From a complex systems perspective, there would be parallel questions about engineering educators: who are they, how do they learn, how do they come to identify as engineering educators, and what do they need to learn? Finding answers to these questions is a substantial research agenda and requires creativity and serious scholarship. For example:

- *Becoming an engineering education professional:* What motivates continued professional development, what are deterrents, and how do they interact? What can stimulate a broad segment of the engineering faculty community to partake in professional development programs, participate in education-related professional societies, and engage in the scholarship of teaching and learning? What role might graduate education play in initiating this professional development?
- *Engineering education thinking:* What do engineering educators find convincing about existing education research and what informs their decisions about teaching? How do beliefs about teaching and learning co-evolve as engineering educators acquire expertise, and how does this impact an understanding of what constitutes engineering knowledge?
- *The engineering education culture:* What can promote better alignment between academic roles and academic rewards? What are strategies for integrating all the facets of academic careers—research, teaching, academic leadership—with personal life goals? What are the pros and cons of engineering-specific instructional development delivered by experts in both engineering content and engineering pedagogy, as opposed to interdisciplinary programs delivered to faculty from all STEM disciplines by experts in general pedagogy?
- *Theories to guide professional development of engineering educators:* What are exemplar models of professional development for supporting experienced, new, and future engineering educators (e.g., workshops, seminars, continuing education, mentorships, learning communities)? How much emphasis should be placed on general theories of pedagogy and learning, the scholarship of disciplinary teaching and learning, and practical tips on good teaching and assessment? What are implications of established teaching and learning theories for informing the professional development of engineering educators; what new studies should be undertaken?
- *Assessing and evaluating professional development:* What are ways to assess and evaluate professional development? What are approaches that integrate assessment with life-long learning (e.g., action research, critical learning communities, development of portfolios, and recording of life histories as emerging forms of research that incorporate reflective practice)? What role can engineering education programs or departments play in designing and assessing professional development programs for engineering faculty?

The challenges facing engineering education—globalization, increased blurring of traditional disciplinary boundaries, rapidly accelerating growth in the capabilities of technology in general and instructional technology in particular, and shifting college student demographics—are here to stay. Finding and evaluating new approaches in the face of a rapidly changing environment is nothing new in our field—it is what successful engineers have done and continue to do every day. Engineers appreciate complexity; they thrive on challenge and a passion to make an impact. Embracing the challenges as well as new roles for engineering educators is the ultimate opportunity to impact who becomes an engineer, how they learn engineering, and what they need to know to be tomorrow's engineers.