The National Teaching & Learning FORUM

Educating Engineers: Designing for the Future of the Field

By Sheri D. Sheppard, Kelly Macatangay, Anne Colby, and William M. Sullivan
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Reviewed by Matt Fisher, Associate Professor and Chair, Department of Chemistry, Saint Vincent College

Lee Shulman once described professionals as those who provide a worthwhile service in the pursuit of important human and social ends, possess fundamental knowledge and skill, develop the capacity to engage in complex forms of professional practice, make judgments under conditions of uncertainty, learn from experience, and create and participate in responsible and effective professional communities. From that perspective, there are a number of professions – medicine, teaching, nursing, accounting, engineering, science, and law are just some examples. The Carnegie Foundation for the Advancement of Teaching has spent several years looking at professional preparation in five fields, and this volume presents the results of their examination of engineering education. The study draws from national studies of engineering education, self-study reports from forty engineering schools, and observations/interviews at 11 engineering programs at seven institutions. Underlying this work is a model of professional education that involves three apprenticeships: a cognitive apprenticeship to learn to think like a member of the profession, a skills apprenticeship to learn the practices of that profession, and a moral apprenticeship to learn the ethics and societal responsibilities that come with membership in a particular profession. This model provides a powerful holistic lens to examine the particular practices through which a profession prepares future members.

As Sheppard and colleagues describe engineering education, there are four components involved: courses in the fundamental knowledge (math, science, engineering science) that engineers need to master, laboratory experiences, design, and ethics. The authors describe these as four linear components of the overall curriculum. Individual sections of the book, each composed of several chapters, are devoted to a close examination of each component – goals, actual practice, student and faculty observations, what goals are actually accomplished, and limitations. The analysis of each component is effectively connected both to the three apprenticeships as well as what research has shown about how people learn. The final chapters present a thoughtful argument for remaking the undergraduate engineering curriculum into one where the fundamental approach is "networking these components in ways that strengthen and connect them into a cohesive whole." Challenges and the roles of various stakeholders in such a change are also discussed. The thoughtful use of a variety of different forms of evidence – descriptions of observations, insights from published literature, quotes from students and professors – provide ample support for the conclusions and recommendations found throughout this volume.

The applicability of this study to readers of T*he National Teaching & Learning FORUM* involved in some way with engineering education is clear. But does this study have anything to say to those of us who teach in other fields? From my perspective as a chemistry faculty member, I would answer yes. Faculty members in the natural sciences work within curricula that share many of the same features as engineering – theory laden courses, laboratory experiences, problem solving in a very ill-structured environment (design or research), and ethical considerations. As a chemist, I found a great deal of similarity between what the authors describe as characteristics and limitations of engineering science courses and laboratory experiences and what chemical educators are confronted with. Reading the analysis in *Educating Engineers* helped me see parts of the chemistry curriculum from a new perspective, one where I could see both strengths and limitations that perhaps I had not noticed

before. In large part this ability to see aspects of the chemistry curriculum in a new light results from the thoughtful way that the authors have incorporated a rich set of evidence into their narrative. Reading the descriptions of observations or the comments from students and faculty helped me see more clearly and deeply the applications to and implications for undergraduate chemistry education.

What the authors have done in this volume is to take a "curriculum design" perspective on the question of how engineers should be educated. At the same time, they have avoided the trap of being stuck in generalities by providing a rich sense of the particulars to be found in the 11 engineering programs they examined. The result is a volume that will provide much to think about for any faculty member involved in undergraduate STEM education and concerned about the overall curriculum. Faculty who are interested in improving a single course will find some useful information, but it is faculty who are interested in improving the overall curriculum in their department who will really benefit from reading *Educating Engineers*.