Educating Engineers. Designing for the Future of the Field

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This book aims very high and calls for a complete restructuring of engineering education by focusing this education on what engineers do in practice. The authors make strong arguments that this restructured education would result in a superior education for new engineers. Unfortunately, *Educating Engineers* doesn't show how this complete restructuring can occur.

Part 1 explores the historical basis and shortcomings of engineering's current engineering-science based curriculum. Then the next four parts (15 chapters, approximately 140 pages) describe what the authors learned by extensive visits to 11 electrical and mechanical engineering programs at six engineering schools. The authors selected electrical and mechanical engineering because over half of engineering graduates are in these two fields. [The vast majority of the observations also apply to chemical engineering.] The four parts are: 2. engineering science courses, 3. laboratory, 4. design, and 5. the development of engineering professionalism and ethics. If a reader is not familiar with how engineering science, laboratory, and design are usually taught and some of the best practices in teaching these courses, then these parts will be of interest. Unfortunately, the authors often name schools or professors that use a method instead of citing readily available sources (*e.g.*, line drawing as an ethical method.)

Part 5, in particular Chapter 16, "A Foundation for Professional Practice," is an eloquent description of the need to inculcate the core professional and ethical values in engineering students, including chemical engineering students. If you look at no other part of this book, go to the library, check out this book, and read the six pages of chapter 16. Although the authors' argument clearly points out that ABET's criterion for ethics should include behaving in an ethical fashion, this conclusion is never stated. Reading chapter 16 may encourage you to read the remainder of Part 5 that strongly supports the need for professional education throughout students' studies.

Part 6 on changes in engineering education is meant to be the message and heart of the book. This part is in agreement with other studies that engineering education needs to change. Chapter 21, "Usable Knowledge," my second favorite chapter, is a succinct and useful review of learning principles. It reinforces the point that students will learn engineering science better if it is imbedded in engineering practice that can be, but often is not, brought to the fore in laboratory, design, and professional courses. The authors explain how service learning can help provide links to engineering practice, but miss the opportunity to discuss in detail the obvious advantages of co-operative education and internship programs that closely link industrial practice to the undergraduate curriculum.

Chapter 21 also compares the changes needed in engineering education to the ongoing changes in medical education. Exploration of these similarities is useful and probably novel for most readers. Unfortunately, the differences between medical education, which is a graduate-level program for a licensed profession, and engineering education, an undergraduate-level program for an essentially unlicensed profession, are not delineated. Information from the learning sciences on how people learn shows that people learn complicated activities such as engineering by doing. The authors advocate a "cognitive apprenticeship" that would have repeated cycles of: 1. modeling, 2. scaffolding (providing support), 3. coaching with feedback, and 4. fading (removing support).

Chapter 22 proposes an integrated, spiral curriculum, but the authors cite no examples and were apparently unfamiliar with chemical engineering examples of spiral curricula (*e.g.*, at WPI). The core of the proposed curriculum is professional practice of engineering. Chapter 23 briefly discusses approaches and pitfalls to development of this new curriculum. Unfortunately, the well-entrenched faculty-reward structure at research universities that rewards research and research contracts much more than pedagogical innovations and teaching the professional practice of engineering is essentially ignored.

What could be done to make the second edition a *tour de force* that shows not only that restructuring is needed, but also shows how restructuring can be done? First, follow Boyer's lead in Scholarship Reconsidered (a Carnegie Foundation book that did remake the academic landscape) by including hard data in addition to observation data. Since engineers eat and drink hard data, its inclusion will make the book more convincing. Second, explicitly discuss the scalability of pedagogical methods. Third, delineate necessary changes in accreditation and other constraints. Fourth, address the enormous barrier to change caused by the current reward structure at most universities. Finally, consider if the public would be better served if engineers had to have a graduate degree before meeting required licensing requirements. ❐