CHAPTER FOUR
INTEGRATED CURRICULUM DESIGN

WITH K. EDSTRÖM, S. GUNNARSSON, AND G. GUSTAFSSON

INTRODUCTION

We have now reached a transition point in our discussion. In Chapter Two, we posed the two central questions that any approach to improving engineering education must address:

- *What is the full set of knowledge, skills, and attitudes that engineering students should possess as they leave the university, and at what level of proficiency?*
- *How can we do better at ensuring that students learn these skills?*

As discussed in the previous chapters, there are compelling reasons for university engineering programs to educate students in a broad set of personal and interpersonal skills, and product, process, and system building skills, as well as to instruct them in the technical disciplines. We argued that the best way to accomplish this is to stress the fundamentals, and to set the education in the context of conceiving-designing-implementing-operating products, processes, and systems (the essence of CDIO Standard 1); that students are expected to achieve a comprehensive set of learning outcomes, as defined by the CDIO Syllabus; and that learning outcomes should be comprehensive, be consistent with program goals, and be validated by program stakeholders (the essence of Standard 2). The first three chapters have laid out a process to answer the first of the two central questions.

The next three chapters discuss the resolution of the second central question—*How can we do better at ensuring that students learn these skills?* Engineering programs need to provide an education that is better at teaching not only disciplinary fundamentals, but also personal and interpersonal skills, and product, process, and system building skills. In almost all cases, we need to do better within the resources allotted. In order to reach these goals, a program retasks the available resources to get more out of them—it retasks the curriculum and the workspaces, and restructures the learning experiences. This chapter will discuss how a CDIO program is built around an integrated curriculum that incorporates an introduction to engineering. Chapter 5

explains how a program also incorporates experiential design-implement exercises, often in a modern engineering workshop. Chapter 6 describes how the CDIO approach incorporates active learning, as well as integrated learning activities that simultaneously teach disciplinary knowledge, personal and interpersonal skills, and product, process, and system building skills. Therefore, as we begin this chapter, we transition from the *what* implied by first central question to the *how* implied by the second.

An integrated curriculum is characterized by a systematic approach to teaching personal and interpersonal skills, and product, process, and system building skills. In general, an integrated curriculum has the following important attributes:

- It is organized around the disciplines. However, the curriculum is retasked so that the disciplines are shown to be more connected and mutually supporting, in contrast to being separate and isolated.
- The personal and interpersonal skills, and product, process, and system building skills are highly interwoven into mutually supporting courses, relieving the potential tension between technical disciplines and these skills.
- Every course or learning experience sets specific learning outcomes in disciplinary knowledge, in personal and interpersonal skills, and in product, process and system building skills, to ensure that students acquire the appropriate foundation for their futures as engineers.

Said another way, the integrated curriculum forms an *educational system* that has an impact greater than the sum of its parts, The educational system is coordinated, with well-understood and mutually supporting elements—each element taking on a well-defined function. All of the elements work together to enable students to reach program learning outcomes. An important part of an integrated curriculum is an introductory course in engineering, which excites students about engineering; teaches some early key skills; creates a set of concrete engineering experiences on which students can base subsequent learning; and suggests the framework of the education to follow. As with any well-defined system, the curriculum must be designed with the appropriate balance of flexibility and efficiency, It would be a grave error to design a curriculum that leads to precise learning outcomes, but leaves students little choice or flexibility.

This chapter describes the curriculum design process developed and implemented in the CDIO Initiative. The process respects pre-existing conditions and available resources that characterize each individual program, but suggests approaches and alternatives to curriculum design that better support the intended student learning. The first part of this chapter underscores the importance of an integrated curriculum, as defined in Standard 3. It is followed by discussions and examples of systemic approaches to curriculum design, The second part of this chapter discusses the task of introducing students to engineering, and gives examples of how to do this in an introductory course, as defined in Standard 4, Design-implement experiences and pedagogical aspects of integrated learning are discussed in Chapters Five and Six, respectively.