CHAPTER FIVE
DESIGN-IMPLEMENT EXPERIENCES AND ENGINEERING WORKSPACES

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INTRODUCTION

In this chapter, we continue our discussion of the resolution of the second question central to the improvement of engineering education—*How can we do better at ensuring that students learn these skills?* In Chapter Four, we examined how the curriculum can be restructured and retasked, in order to strengthen the links between the disciplines and weave the necessary skills into the curricular plan. In this chapter, we will examine perhaps the most important device to meet the demands placed on an integrated engineering curriculum—the design-implement experience.

Design-implement experiences allow students to design, implement (build, write, manufacture) and test an actual product, process, or system, or some reasonable surrogate. Such experiences are sometimes called design-build, design-build-test, or design-build-fly. In software, students often design and then write code. Courses based on competitions have aspects of design-build-compete. In contrast with traditional "paper" design courses, the essential feature of such experiences is that students actually build the design and verify its effectiveness.

Design-implement experiences are a key feature of a CDIO program. Their importance is highlighted by the fact that:

- They have dual impact, that is, they teach students personal and interpersonal skills, and product, process, and system design and implementation skills, and at the same time reinforce disciplinary knowledge.
- They strengthen the learning of fundamentals, by being presented multiple times within a curriculum, first to introduce and motivate learning, then to provide opportunities for application.
- They involve both active learning—in which students manipulate, apply and evaluate ideas—and experiential learning—in which students take on roles that simulate professional engineering practice, as will be discussed in Chapter Six.
- They can be motivating and fun, attracting students to engineering and retaining them within the course of study once they have enrolled.

Because of this important role in engineering education, design-implement experiences should not be optional, but should be carefully integrated into the curriculum. Students should be engaged in at least two cycles of design-implement opportunities in order to best support their disciplinary and skills learning.

An important complementary aspect of a CDIO program is that it provides workspaces to facilitate hands-on project-based learning. This need not be new space, created for this purpose, but can be retasked space, previously used for classroom or traditional engineering laboratory exercises.

This chapter discusses the main educational means for planning and conducting design-implement experiences. We have drawn examples from the collective experiences of programs participating in the CDIO Initiative. The workspaces, or learning environments, that enable these design-implement experiences are also discussed. Descriptions include key attributes of effective workspaces and suggestions for modifying existing facilities to accommodate design-implement experiences.

CHAPTER OBJECTIVES

This chapter is designed so that you can

- recognize the importance of design-implement experiences and supporting workspaces in an engineering education
- outline the requirements for design-implement experiences and their appropriate learning spaces
- give examples of design-implement experiences in different educational contexts
- discuss the benefits and challenges of design-implement experiences
- adapt existing facilities and resources to improve design-implement experiences and CDIO workspaces

DESIGN-IMPLEMENT EXPERIENCES

A design-implement experience is a series of events in which learning takes place through the development of a product, process, or system. The key criterion for such an experience is that the object created is designed and implemented to a state at which it is operationally testable by students. In this testable state, students verify that the product, process, or system meets its requirements. Then they identify possible improvements.

The meaning of design-implement experience

We use the term *design-implement experience* to signify a range of engineering activities central to the process of developing new products, processes,