

**Design Projects and the Capstone Design  
Sequence for ChE/Lab Experiments for ChE's**

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**Introduction**

Important elements of the undergraduate chemical engineering curriculum are the design course sequence and the laboratory sequence. Each of these sequences have particular goals in the context of the undergraduate curriculum.

The goals of the design sequence are to bring together the diverse elements of science and engineering introduced in earlier courses with some specialized ideas and skills so that the student can learn to apply basic ideas to develop designs of actual equipment and processes; learn to perform an optimized economic evaluation of the result; and recommend, on a sound basis, whether to proceed or not.

The goals of the laboratory sequence are to introduce the student in a hands-on fashion to the equipment, methods, and materials that chemical engineers must deal with in their professional work life. They must learn to plan efficient and effective experimental programs, evaluate experimental error, evaluate operations for safety, document experiments properly, and prepare reports summarizing the results obtained and recommendations to be made.

**Design**

In the design sequence, students perform homework to develop the basic skills being taught. However, the major part of the work is in the group and individual projects they must do. These projects bring together multiple skills needed to evaluate the projects. Thus, the students are forced to see the consequences of making errors in the application of basic knowledge. Furthermore, they are compelled to confront their own weaknesses in preparation. This is a highly enlightening exercise for many of them.

A number of skills are required to be able to perform effective design work. Students must be able to effectively recover information from library resources and the internet; they must

consider market analysis; they must be able to choose appropriate (and hopefully optimal) unit sequences; individual pieces of equipment must be correctly designed, sized, and costed; regulatory requirements must be considered; safety and health considerations must be taken into account; and a systematic economic evaluation and optimization must be done.

A major improvement in design tools is now available to engineers which they must learn to use. These are powerful process flowsheet simulation programs. This type of software makes it possible to screen many more cases than previously and it reduces the amount of "experience" required, while not altogether eliminating the need for experience.

An important task is to force the student to be highly specific in clarifying what assumptions they are making in their calculations. Often, students make implied assumptions of which they are not even aware. It is important to force these out in the open so they can decide if their assumptions are truly appropriate for the case at hand.

Another important issue for students to realize is that a design can be technically correct and technically successful; yet it can be an economic failure. The sooner this is recognized, the better.

The goal of the design course projects is to bring all these issues out in the open so the students can see for themselves what must be considered. Of course, competent execution of calculations goes without saying.

By forcing students to participate under the strict rules of the AIChE National Student Design Competition, they come to realize why the preparation in their earlier courses was necessary. Further, since the problem is made elsewhere and not in our department, they see that their curriculum is really necessary.

### **Laboratory**

In the laboratory sequence, students are exposed in a hands-on way to equipment, materials, and methods they will encounter in their work life. An important task of this sequence is to train the students in systematic methods for evaluating and handling equipment and materials. The hands-on aspects of the lab cause the students to realize that actions have consequences and that they can apply their scientific training to correctly predict the outcome of alternative actions. One example is to use laboratory data taken by the students to design commercial scale equipment. Students are forced to consider experimental design methods to minimize the time required to obtain key data. They are required to consider error, both random and systematic, in measurements and what to do about it; they are required to document properly, and systematically their work in laboratory notebooks; they are required to consider the safety and health aspects of their experiments, both for themselves and others; and they are required to report the results of their work and make final recommendations.

While the laboratory cannot cover all the equipment students may see in their work life, it can provide them with strategies for handling virtually any situation they may encounter.

## **Conclusions**

The design and laboratory sequences are key aspects of the chemical engineering curriculum. They have been upgraded and are highly successful in preparing students for the working world. Because of technology changes, constant attention to these areas is required to insure that education is appropriate and up-to-date.