

COFFEE ON DEMAND

A Two-Hour Design Problem

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In the capstone design class, most chemical engineering students experience one, or maybe two, design projects. It is helpful when students are able to have additional design experiences. We use a simple two-hour problem at the beginning of the second semester of our design program, giving our students another design experience and helping them “restart” after winter break.

This design problem is constructed to meet multiple objectives. It provides the students with an experience where they can look at the design process microcosm. They can reflect on this experience as, in later lectures, we discuss how design problems can be approached. In a short period of time they have to organize their group and carry out the project.

The problem is designed to introduce the complex nature of a design project in a relatively quick exercise. The problem includes analytical and creative elements, engineering design, and economics, and it clearly has multiple solutions. In addition, it is a problem that most students enjoy. (It is nice to show the usually complaining chemical engineering seniors that they can actually enjoy their discipline.) Finally, we hope this little exercise will help build our students' confidence.

Figure 1 is a copy of the problem statement, which we give to our students. In our case, it is handed out in a two-hour problem session (approximately 15 students). It is given during the first week of the second semester of process design. At this point the students have had basic engineering economics and all the technical courses they need to analyze the problem. The problem could easily be adapted to other situations.

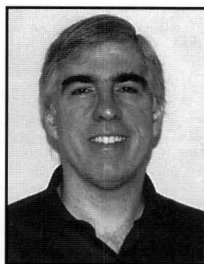
SETUP AND EXECUTION

The class is divided into groups of five to eight members who are given the problem statement to read. They are encouraged to wander the building as necessary and use whatever resources are available—calling suppliers, talking to other faculty and shop personnel, and using the department's collection of catalogues. The instructor usually

brings several basic references to help the students in their design project (*e.g.* Perry's, Peters, and Timmerhouse, etc.). Then the instructor can simply sit back and watch the group dynamics as they emerge, learning a lot about the students in the process. The instructor also provides an occasional nudge to encourage the groups to consider the problem more fully, or to get moving if they are wasting too much time to be able to complete the problem.

The students easily understand the problem and they usually relate to it well. Different groups may need encouragement at different points. For instance, it will be necessary to encourage some groups to divide the problem and break into subgroups to tackle the different parts. It is often helpful to encourage them to do a “market survey” to learn what the various faculty members might want. (In our department they discover that one-third of us are not coffee drinkers.)

The problem includes an interesting open-ended conceptual design issue. “How do I keep the coffee in the lines fresh?” In addition, our department is located in two separate areas of the building and the students must decide if they should install one system or two. There are some very concrete practical considerations. The length of the piping is one of these considerations and the project includes an economic analysis. Finally, a key learning area is project management. They must decide how to divide



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up the task in order to get it done quickly.

One of the benefits for an instructor is watching the groups carry out this last task. Who emerges as a leader? How do they cooperate? How do they move to a solution? I often find that I refer to these sessions when writing student recommendations. The process is concluded with brief oral reports. We have not required any additional reporting, but are considering adding a written design summary and critique.

PROJECT DESIGN RESULTS

The result of this exercise is a wide range of solutions and, often, of cost estimates. Students have come up with recirculating systems, hot-water delivery systems with local brewing, and local thermoses filled at scheduled times during the day. There have been both pumped and gravity-fed systems. One group even proposed an out-source scheme where faculty members call the campus coffee bar to deliver the coffee.

STUDENT RESPONSE

The student response to this project has been good. They become involved quickly and it is a very active class. It is quite easy to lead a discussion follow-up in the next lecture. In order to get a more detailed student response, the most recent class to experience this exercise completed a short survey and participated in a discussion of the value of the project. The survey and discussion were conducted late in the semester, about two months after the design project.

Students were uniformly positive about the project in the informal discussion. One student noted that, although he was initially frustrated with the project because it seemed so poorly defined, he soon realized that latitude for creativity was one point of the exercise. Many students noted that it helped them get going after a long winter break. Others noted that this design project required that they make a lot of quick assumptions and estimates—a valuable lesson in preliminary design.

Their written comments included

- “Overall, it was quite a challenging problem for two hours after my mind had grown used to disuse over break.”
- “Knowing that it was a very short-term assignment, I was enthusiastic and willing to be creative from the start.”
- “...A fun group project where we got to be as creative as we wanted but had to meet the goals.”
- “...It made you think creatively and practically.”

Table 1 shows the student responses to the six quantitative questions that were asked on the survey. Students clearly enjoyed the problem and saw the multiple positive answers. The project seems to have met its major goals.

SUMMARY INSTRUCTOR'S VIEW

This project allows students to experience a complete design project in a short period of time. It illustrates many important design issues and allows the instructor to observe first-hand the student group dynamics and skills.

The project performs the important function of actively involving students with the material. They show significant enthusiasm, even at the beginning of the semester when they are not quite ready to get into their work. The project is diverse and large enough to involve all students and allows them to have impact on the final result. The project can be easily adapted to new situations. □

Conceptual Design of Coffee Delivery System for Chemical Engineering Faculty

Central management is considering installing a centralized system to deliver coffee on demand to each of the chemical engineering faculty offices. You have been assigned the task of completing a conceptual design for the process, including a flow sheet, approximate equipment and piping sizes, an order-of-magnitude cost estimate, and a scope package. The scope package should be a listing of “other” issues in the design, including health and safety concerns, environmental concerns, and utilities availability. You must consider the quality of the product your system will deliver. Please compare your OOM estimate to the cost of purchasing a coffee maker for each faculty member and hiring student assistants to operate the coffee makers. Your preliminary design and cost estimates are due in an hour and a quarter for a major management meeting. You may postpone the detailed HAZOP until later.

Begin your time by quickly outlining with your group the major issues you need to deal with, a basic plan of attack, and the division of responsibilities within your group. Note that three other groups are designing systems and management has a keen eye on which group will come up with the best design. Patents are being considered, so keep your design proprietary. You may leave the room to gather information, but please be back in time to assemble your ideas for presentation to management at 2:30 p.m. Your group will be expected to give a five-minute summary presentation at that time. You are encouraged to prepare visuals on the blackboard in advance. Good luck.

Figure 1: This is the problem statement that the students are given.

TABLE 1
Responses to Quantitative Questions on Student Survey
(The following table indicates the distribution of student responses to the six questions using the scale below.)

<u>Statement</u>	<u>1</u> Strongly Agree	<u>2</u> Agree	<u>3</u> Somewhat Agree	<u>4</u> Somewhat Disagree	<u>5</u> Disagree	<u>6</u> Strongly Disagree	<u>Mean</u>
1) Completing this project built my confidence that I could complete conceptual design projects in the future.	9	4	1				2.4
2) Completing this project increased my understanding of design projects.		10	4				2.3
3) I gained experience organizing a design project.	1	9	4				2.2
4) I could see that a problem had multiple solutions.	11	2	1				1.3
5) We used a blend of analytic (calculation) and creative approaches to complete this project.	3	7	3	1			2.1
6) I enjoyed the project.	5	8	1				1.7