This column provides examples of cases in which students have gained knowledge, insight, and experience in the practice of chemical engineering while in an industrial setting. Summer interns and co-op assignments typify such experiences; however, reports of more unusual cases are also welcome. Description of analytical tools used and the skills developed during the project should be emphasized. These examples should stimulate innovative approaches to bring real world tools and experiences back to campus for integration into the curriculum. Please submit manuscripts to Professor W. J. Koros, Chemical Engineering Department, University of Texas, Austin, Texas 78712.

MAKE SUMMER INTERNSHIP A LEARNING EXPERIENCE

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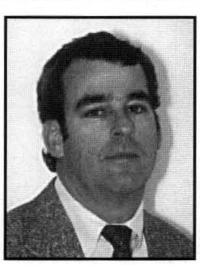
Many engineering undergraduates have the opportunity to work on one or more summer internships before they graduate. In principle, the students are paid to spend the summer learning how engineering projects are carried out in the real world.

Time out for a reality check. Without significant planning by faculty, the chances of an undergraduate summer intern actually learning something useful are not very good. Unlike graduate students, who usually receive projects consistent with their research expertise, undergraduates are often simply parceled out to various plants or R&D facilities. Rarely are faculty members involved in site or project choices; no one really knows what the students will end up doing, and there is rarely any follow-up to find out if they learned anything of substance.

Let's review how this process often works. Sometime around March or April, someone on the faculty starts phoning industrial contacts—usually research directors or plant managers—with questions like "How many kids can you take this year?" "Can't you squeeze just one more slot out of the budget?" The director comes up with a number and the faculty advisor jots it down and continues to make calls until the available slots match the number of students wanting internships that summer.



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On the industry side, a hand-off then takes place. The logistics of getting the students in, getting non-disclosure agreements signed, arranging something with Accounting and so forth is passed to the Human Resources Department. Around the first or second week of May, the HRD calls the director (or whoever) to inform him or her that everything is set and that 2 (or 4 or whatever) students will be arriving on June 5.

Now the real planning starts. The director immediately begins scanning a list of technical persons, identifying likely candidates to supervise a summer intern. The scientists chosen are requested to submit, by Friday at the latest, a description of The Project.

On Wednesday afternoon, the about-to-be intern supervisors earnestly look for a gas chromatograph and a discarded 286. Being experienced industrial scientists, they are well aware that any engineering student can be safely and harmlessly occupied for at least three months so long as The Project entails one of two activities:

Project #1, Description

Optimum functionality of our proprietary XLR34 Recombinant Distillation Process requires a complete understanding of the quaternary splits of all components throughout the column internals. The summer intern will be used, as suggested by our Total Quality Management Life Cycle Engineering guidelines, as a resource to speed up the analysis of tray-to-tray hydrodynamics in the XLR34 downcomers. The data will be used to build a simulation (see The Project #2) of downcomer flow stability needed for optimum economic ROI.

Translation

I'm going to have the kid stand in front of that old GC for three months injecting samples and recording peak areas. Aside from stabbing himself with the needle, there is virtually no way the student can get hurt and I'll never have to deal with the safety people or do any of their paperwork. Plus, he'll have an enormous pile of numbers to plot and try to make sense of which will keep him out of my hair for three months and give him at least six overheads to present in the project review in August.

Project #2 Description

The Economic Viability Indices for our proprietary XLR34 Recombinant Distillation Process are very dependent on downcomer hydrodynamic functionality. In order to maximize the R&D Investment Index, as suggested by our Total Quality Management Life Cycle Engineering guidelines, it is critical that fluid dynamic computations be carried out to model the flow striations previously described in our Project Monthly dated 2/9. A suitable computer system has been procured for use by the summer intern. Our goal will be to develop a proprietary computer simulation to describe these striations. In future communications, this program will be code-named Program XLRC to minimize the potential that in-kind competitors recognize our activities.

Translation

We found an old 286 that nobody was using and set it up in the corner of the high bay. Since any program has to be written in QuickBasic to run on this thing, it should take at least three months to get anything working. Aside from eye strain, there is virtually no way the student can get hurt and I'll never have to deal with the safety people or do any of their paperwork. Plus, there will be an enormous pile of code to write and try to debug, which will keep this person out of my hair for three months and give him or her at least 6 overheads to present in The Project Review in August. Best of all, by September 10, nobody on earth will remember what XLRC means, and I can bury the whole business and get on with my life.

The Research Director, having received the project descriptions in a timely manner, passes them on to the faculty advisor. The advisor is quite pleased. These students will really learn something this summer! (Not!)

We have just described two very successful summer internships. I have personally witnessed dozens of them. From the standpoint of the Research Director and the company, the students came in, worked on something presumably useful to the company, and left without having been physically altered. Too bad no one thinks to ask the intern whether he or she actually learned anything useful.

To be fair, we should point out that many companies make an admirable effort to identify appropriate intern projects. In these companies, project ideas are solicited and reviewed by staff engineers (possibly a special committee) prior to intern assignments. Rarely, however, do professors take part in these reviews. While many companies conduct on-campus interviews for summer interns, the results may be undesirable since the professors, again, are left out of the planning process.

Unfortunately, few practicing engineers are able to assess whether a given project is appropriate for an undergraduate chemical engineering student. To test this, just ask a few industrial colleagues to submit problems for the sophomore mass and energy balance course. Don't be surprised if many of the problems are far too difficult for students at this level. We

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easily forget how hard those problems once seemed.

A BETTER WAY

Setting up meaningful summer internships for your students *is* possible. But, it takes commitment by the entire department and continu ing effort. If you really want your students to learn something useful, try following the route outlined below.

► *Establish Contacts with Engineers, NOT with Managers*

It must be very tempting, given everything else you have to do, to simply place that once-a-year call to the R&D Director. Unfortunately, many R&D Directors I have known don't have a clue on how to define a good internship problem. But if you make the effort to befriend the engineers who actually do the technical work, you can make dramatic progress toward the goal of finding truly excellent summer intern problems. The hard part is finding the right engineers. In addition to using whatever contacts you already have (alumni are excellent contacts), try scanning the programs from recent AIChE meetings for industrial participants who either wrote or co-wrote papers. Chances are good that a phone call and short pitch to these contacts will unearth a number of people interested in working with someone from the university.

Generally, engineers will not have the authority to grant internship funding. If their company is not in the habit of hiring summer interns, you may need to help the engineer outline for management the economics of sponsoring one or two interns. To do this, e-mail or fax the engineer a single page showing the approximate cost for having a student on-site for three months. It should include student salary, travel reimbursement, and housing if appropriate.

► *Sell the Program*

Once you have a commitment from the engineer, get the name and telephone number of the appropriate manager and place a call to that person. Be prepared to wait one to three months (or more) for management approval; virtually nothing is done in industry without having one or two meetings. Expect the manager to say something like, "Let me get together with Bob and some of the other engineers to discuss this first, and I'll get back to you later." Always get a firm date and time when the manager will "get back to you." If they don't contact you within a reasonable amount of time, and often they won't, get back to them. A certain amount of nagging can be productive.

Managers like to perceive benefits, tangible and intangible, for any and all money they spend. And, you are asking them to spend money on something they haven't been convinced they need or want. To this end, have a list of potential benefits handy. Mention such things as

- *Increased productivity without a fixed cost on the balance sheet.*
- *Students are well trained and might bring in new ideas and techniques.*
- *Students often accept positions after graduation with their internship sponsors. This can help hold down recruiting costs.*
- *Publications that result from internships reflect well on the sponsoring company and its management.*
- *The sponsoring engineer will have better access to the university and any technical or recruiting help the faculty might provide in the future.*

If it sounds like I'm telling you to "sell" internships, I've made my point. That is precisely what you are doing and exactly how you should approach the activity. It need not be a hard sell; the best sponsors, long-term, will be those who buy enthusiastically after a soft pitch. All you want is a commitment and a letter from that manager supporting the internships. Once you have this commitment in writing, whether obtained through the engineer or by directly approaching management, you are in a position to start defining the problems.

► *Defining the Internship Problems*

You will always know far more than your engineer-sponsor about the capabilities of the students and the types of problems that would be suitable for them. But, the engineer-sponsor knows far more about his or her process than you know and, therefore, presumably knows what the problems are. So, in this phase, you should have two goals:

1) ***Learn about the process so you can help define appropriate problems.***
2) ***Teach the engineer-sponsor what he or she needs to know to suggest appropriate problems.***

The first goal above should be a short-term activity. If possible, visit the plant or R&D center to learn about the process yourself; do not assume that the engineer-sponsor fully understands the process. Chances are there are many aspects of the process that are not considered "problems" simply because they aren't presently troublesome. I have never encountered a process that couldn't be improved in dozens of ways if someone simply paid some attention to the aspects that weren't "problems." Many such improvements could result from a three-month internship study. Since the cost of the internship is relatively low and the return on such improvements is usually rapid and measurable, it is easy for the company to justify the work. But, someone has to clearly point out potential improvements or they will continue to go unnoticed.

The second goal (training engineers to define good internship projects) is a long-term investment in your program. After expending considerable time and energy to develop sponsors, you would like to retain them for many years and, as quickly as possible, reach a point where the engineer-sponsors can suggest suitable problems without your assistance.

Good internship problems have certain distinguishing attributes:

❑ *The problem can be approached by a junior or senior chemical engineering student and solved (or good progress can be made) using skills that students at that level can be expected to have or to easily acquire.* The analysis or design of a single unit operation is usually appropriate. As an example, suppose a plant has a rotary dryer that uses preheated air for drying, but there is no recycle of the exhaust. How much money could be saved by recycling some of the hot exhaust air? Would the product quality be the same if the dryer is operated at a higher humidity? Would productivity suffer? How much capital investment would be required? Should this change be made? Even though the dryer performance is currently "acceptable," the operation might be wasting a substantial amount of energy. An analysis of this dryer would make a great three-month intern problem. The solution requires mass and energy balances, understanding relative humidity and psychrometric charts, basic equipment cost estimation, and basic economic-return calculations. Some experimentation might also be needed, but chances are, old company reports will have drying curves for the product at different conditions of temperature and humidity. The student will then also get some practice in doing an internal literature search.

❑ *The problem can be completed (or really good progress can be made) during the time allotted to the internship.* Don't minimize the importance of this attribute. Students quickly become demoralized if they begin a project and then discover they cannot possibly complete it. They find it embarrassing and often discouraging to have to give the customary end-of-internship talk to the technical staff on a half-completed project. For example, an analysis of the entire heat exchanger network in a large plant cannot be carried out by anyone in three months, but an intern could analyze the performance of one small network of heat exchangers (three or four) in that time.

❑ *The sponsor should have already obtained any needed data that cannot be collected in the first month of the study.* For example, the analysis of a batch polymerization reactor might sound like a good project, but chances are that the sponsor does not have the necessary kinetic data for the analysis. (If the data existed, someone would have already done the reactor analysis.) If you assign this problem without reviewing the available data, you may doom the student to a miserable summer. The intern may spend the entire summer waiting for analytical equipment to be delivered or, worse, spend the summer trying to get an ancient GC working that never will.

❑ *The project should test and stretch the student's engineering skills.* Does the project require mass and energy balances to be written and solved? Is statistical analysis of data required? Does the project require the student to learn some new chemistry? Are periodic written progress reports required? Is a literature search needed? Beware of project ideas that begin with "We could sure use some help getting the data we need on Project GruntWork...."—it is a sure bet that your student will spend three months standing in front of some infernal apparatus testing one sample after another. The intern learns NOTHING from this type of activity. If a company just wants some data taken, it should hire a temp. You can do better for your students.

❑ *The intern should be safe while working on the project.* Most engineer-sponsors will go to heroic lengths to guarantee the safety of their interns. Nevertheless, you should, if at all possible, look over the sponsor's shoulder on this issue. Ideally, your program teaches industrial safety as an integral part of the chemical engineering curriculum and your students are capable of auditing their own work environments. Give your students practice before turning them out by assigning safety audits as part of your unit operations and design courses.

► *Complete the Cycle*

Defining appropriate projects will be far more time-consuming than arranging internships. Clearly, one or two faculty members cannot do all the work. One good way to spread the work load is to get the students involved. Once given a set of guidelines like the ones above, there is no reason that small teams of students (three or four to a team) can't work with engineer-sponsors to draft lists of potential projects. If possible, involve yourself in the review process. By observing the ability of your students to assess the project ideas, you will quickly find out whether they have learned the material you've been teaching.

In this way, you can help each class identify new projects and problems for the classes to follow. In addition to learning to identify those "hidden" process improvements described above, your students will be learning teamwork, proposal preparation, communication skills, salesmanship, and, hopefully, a bit about obligations to future generations.

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