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 internships 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.

THE EXPERIENCE FACTOR

Internships Through the Eyes of Students and Industry

Typically, the voice heard in these contibutions is the faculty or industrial mentor who supervised the internship. While the mentor is present in this article, the dominant voice is that of the student who experienced several internships and has reflected on the value of his experiences and what he has learned from them. Therefore, although this "Learning in Industry" contribution is somewhat different than the typical article in this series, I think you will find it useful and interesting.

Bill Koros, Editor

Clearly, there are many motivations for industry to involve students in programs as side-by-side workers with degree-holding engineers. This article describes a special example of such a program, titled INROADS,[1] aimed at injecting bright minority students into the professional world of engineering. The tone of the article differs a bit from other "learning in Industry" contributions, but its emphasis on the student perspective of such programs should be useful to those more interested in "outcomes" rather than in formal requirements as a measure of education. One outcome of a successful intern experience is the establishment of a link between the student and his or her mentor that extends well beyond the period of the formal internship.

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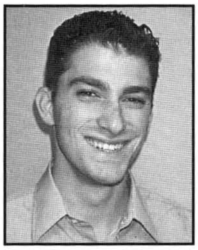

Damián Gumpel *received his BS in chemical engineering from the University of Texas at Austin in 1997 and is beginning his career at Andersen Consulting. While at UT he served as President of the school chapter of AIChE. He is an alumnus of the INROADS program and is a recipient of the INROADS Spirit of Excellence Award.*

A short industrial perspective is offered first, followed by a description of the formal INROADS program. Finally, there is a personal commentary of how the industrial commitment and private efforts like INROADS impacts a minority student seeking to explore the industrial world of engineering as a career option.

An Industrial Perspective of Internships

by Bill Campbell, Apache Corporation

Summer internships are extremely valuable, both to the student and to the recipient company. In experiencing the daily operation of industry prior to leaving the classroom, the intern can avoid some of the many "rude awakenings" that lurk outside of the college environment. For example, there are fewer days to sleep late or to take off, there are work assignments that have significant monetary impact on the company, and there are numerous opportunities for social interaction. Some other benefits to the student are:

- The internship provides the invaluable experience of "teamwork." Regardless of one's intelligence, GPA, or work ethic, working with other professionals in a team environment is a fact of life in today's corporate America. Functioning as an integral part of a team is critical in the business world and is a highly regarded skill that can be gained through work experience.

- The internship gives the student a chance to answer some "gut-level" questions, such as: Do I like working in this industry? Would I enjoy working for this company? Am I more suited for office or field work? What position would I like to attain in the future?
- The internship gives the student confidence to compete in today's business world. The intern soon realizes that he or she not only can meet the demands of corporate America, but can also exceed them. This kind of success allows the individual to raise his or her own self-esteem in order to pursue a particular study and chosen career.

The company benefits from internships by having someone who can go forward with projects that have been put on the "back burner." Most companies in the 90s have some low-priority projects that need to be attended to but which cannot be immediately completed due to current staffing levels. Another benefit is that interns can provide additional technical support through computer applications that are taught in today's classrooms but which are not readily available to the seasoned professional. The intern also provides a preview of his or her work habits prior to the company extending an offer of permanent employment. Additional considerations of internship are that the student often gives the professional a new perspective in regard to completing job assignments and enlightens the professional as to what is being taught in today's classroom.

In summary, the relationship between the intern and the company can be described in 90s terminology as a "win-win" situation. That is, both parties benefit from the arrangement.

The INROADS Program • The internship experience described here resulted from a program that is now over 25 years old, titled INROADS, which provides a unique vehicle for students from under-represented groups to enter the business world.

Specifically, INROADS is a private, nonprofit organization with the mission "to develop and place talented minority youth in business and industry and prepare them for corporate and community leadership." Frank C. Carr founded the program in 1971 in Chicago. What began with just a handful of high-school students from the Chicago barrios has now expanded to fifty affiliates across the United States, Canada, and Mexico. Currently, there are 6,000 interns, 913 sponsoring companies, and 6,500 graduates of the INROADS program from Hispanic, African, and Native American backgrounds.

The program involves more than just an internship to occupy the student's time during the summer break. The interns benefit from tutoring and academic support, from training workshops in seven skill areas (communication, self-management, business sophistication, management, valuing diversity, academic/technical, and community involvement and leadership), from coaching on career goals, and from networking with ambitious students and professionals who have similar goals. In the performance evaluation, the interns and their business coordinators meet at the end of the summer tour to review and provide feedback on the intern's performance.

Student Perspective of Internships

by Damián Gumpel

Having just graduated from high school and with college looming on the horizon, I wasn't sure I had made the right choice in accepting a summer internship. At that point in my life, I wondered if the best thing to do with my summer might be to put the word "school" in my brain's archives and just rest, or maybe get a job that required no thought. Fortunately, I had already made the commitment, and I felt I had to keep it. So thoughts of packing my bags with sandals and sunscreen and heading off to "Bumville" for the next three months died on the vine. The resulting intern experience was not only valuable but also came at a key time in my life. My first summer internships were at Apache Corporation as part of the INROADS program, and my most recent internship was with 3M Corporation, which I believe I received as a result of my previous intern work experience.

General Benefits of the Internships • Beside the obvious fact that an internship is a summer job that brings much-needed income to the coffers of a college student, it provides a plethora of intangible benefits and opportunities. As is true with just about everything else in life, however, what you get out of an internship is in direct proportion to what you put into it. Some of the skills that an internship can provide to a willing individual are:

◐ **Organization.** For the first time in my life, someone besides my parents was looking over my shoulder on a daily basis. As the number of tasks and their complexity increased, it became obvious that I had to develop a sense of organization and an awareness of my work area since I was the one responsible for knowing where everything was. I found I was more inclined to contribute ideas when everything was neat and tidy. By forcing myself to become organized, I developed a certain discipline that spread out and affected other areas of my work ethic. This skill was put to good use more than once in my journey through the demanding chemical engineering curriculum.

◐ **Communication**. Society clearly could not have evolved to its current complexity without efficient communication at various levels of subtlety and through various media. The same fact applies to work, where an ineffective communicator often does not advance through the ranks due to that deficiency alone. The ability to communicate involves more than just having a decent vocabulary; it is what you say and how you say it that can spell success or doom. There is a certain sense of professionalism that is prevalent within the confines of an office environment. Granted, the extent of this professionalism can vary greatly depending on the location and the prevailing culture, but it is up to the individual to know when and how to communicate in the most productive fashion. I have found that if I approach two different people for assistance in a manner that is unique to each individual, both instances will usually produce a positive result. But switching my approaches would result in a couple of blank stares.

This idea also applies to written communication, where the two most important rules are: keep it brief and get to the point. Gone are the college days of rambling essays (a definite blessing for most of us). I have noticed, however, that it is often harder to compress my thoughts than it is to expand upon them. For example, when I was first asked to draft memos to my boss, my mentor would find and mark superfluous material and return them to me time after time. I sometimes felt as if I could do nothing right, and it was tough for me to change, which leads me to the last skill, humbleness.

◐ **Humbleness.** The smartest, most talented students entering the business world can immediately look like sardines amid the sharks. More often than not, they find themselves surrounded by people who are at least half again as old as they are, who have considerably more practical experience, not to mention plain old life experience, and who most often hold a more advanced degree than the student. While some coworkers will try to put the student "in his/her place," most will extend a hand of friendship and assistance. As long as the intern doesn't acquire a reputation of being cocky, closed-minded, or brash, he or she is on the right track.

Apache Corporation Experience • Although my summer work at Apache corporation was not in the "traditional" chemical engineering fields, it was extremely beneficial in preparing me for industrial work in general. During my four years of summer internships at Apache Corporation, I worked on a wide range of assignments, ranging from trivial to important. On reflection, I realize that many of these tasks were significant. Listed below are some of my most important assignments, with a brief description of how my chemical engineering education was put to use in executing them.

• *Field Studies on Marginal Oil and Gas Properties.* This work is generally considered low priority for the professional, but it needs to be completed prior to the sale of any property in order to identify its value and to evaluate any remaining potential. Using my knowledge of unit operations, it gave me the opportunity to calculate such things as fluid flow, permeability, pressure loss, and static head.

• *Reserve Bookings on New Field Discoveries.* This involved applying the different terms and formulas used in an economic analysis (NPV, IRR, and discount rate) that I acquired from a chemical engineering elective on economic analysis and applications.

• *Preparing Material for Presentation to Management at the Quarterly Reviews.* This work is significant since these sessions are used to "showcase" the upcoming drilling opportunities to management and hopefully lead to their funding and ultimately to new discoveries. The training I got throughout the chemical engineering curriculum when I had to write lab reports and make project presentations stood me in good stead. One class in particular that helped was a technical communication class that stressed verbal and written communication skills.

• *Providing Technical Support to My Mentor with Regard to Computer Applications.* For example, I created a spreadsheet that evaluated three different methods used for volumetric calculations and selected the optimum for each particular application. I was able to do this as a result of a computer course designed to introduce the chemical engineering student to programming in applications such as Excel, Mathematica, and FORTRAN.

The internship also exposed me to some of the issues that Bill Campbell mentioned in the first part of this article. First, virtually all of the work was team-oriented. It involved participating in meetings with geologists, geophysicists, and managers who usually averaged at least fifteen years of experience on the job. This meant that I had to find my niche in the group in order to become an effective contributor rather than a burden. Also, since most of my day-to-day tasks involved working with Bill, I had to become acclimated to his work routine and style. This was the first time I worked alongside someone for an extended period since most projects I had been involved in at school were of a shorter length and did not require more than a couple of hours per day of interaction.

Second, the internship gave me the chance to explore the "gut-level" questions Bill raised. All students at one point or another ask themselves these questions, and the best way to find the answers is through experience on the job. The four summers I worked at Apache, along with this past summer at 3M, have been an enormous help in my personal search for the answers. I realized I wanted to work in an office environment that requires team interaction and some travel and that involves work in the energy industry. With this "road map" in hand, I was able to narrow my job search to those companies that included these characteristics. As a result, I found a match with Andersen Consulting and wound up accepting an offer from them.

The internships also helped reinforce my desire to pursue an engineering degree. When I began college, I chose to go into chemical engineering because I had enjoyed chemistry in high school and my father was an engineer. I did not have much else to go on, but as each summer passed, I was more and more certain that this was a field I could succeed in.

I would not be in the position that I am in today without the benefits of INROADS and my experiences at Apache and 3M. Although I realize that not all students find themselves in a position to intern every summer, they should be encouraged by their chemical engineering departments to seek out internship opportunities. It is surprising to see just how many industries are looking for chemical engineers today. The versatile knowledge base that a chemical engineer offers is unique and in demand. Faculty and advisors should make every effort possible to help expose chemical engineering undergraduates to this wide world of opportunity.

REFERENCES

1. Information relating to INROADS obtained from *1996 INROADS Annual Report* and "Train to be a Leader." Headquarters are in St. Louis, Missouri; phone 314-241-7488. ❒

Pneumatic Transport Studies

Continued from page 117.

parent 7-m long, 52-mm I.D. pipeline with a removable section, a regulated air supply, and a solid particle collector. The test section is made up of a 1.2-m long removable section in the middle of the 7-m long tube. At the end of the horizontal pipeline, a transparent T-bend is inserted so visualization of the bend behavior can take place. The solids collector was constructed from a 0.093-m^3 cardboard drum with an inlet of 100-mm I.D. The particles are separated from the air as the flow passes through a paper filter bag. Fine-particle collection was achieved with a double-paper filter bag assembly. For the saltation velocity of a single particle, a small slide valve was installed in the top section of the pipeline to feed the individual particles, allowing the behavior to be observed. In the three devices described, in-house construction was required, but a number of the items were purchased and incorporated into the overall design.

Pneumatic Conveying Loop

The pneumatic conveying system consists of a 14.5-m long, 50-mm I.D. horizontal copper pipeline with a 2.2-m long vertical section, a return line, T-bends, and several transparent sections placed along the pipeline. A regulated compressed-air supply provides the gas at the pressure necessary to convey the solids. A hopper placed on a scale and connected through flexible connections to the collector and feeder is used to continuously weigh the solids inventory. A solids collector consists of a paper filter bag placed at the top of the hopper. A gate valve is used to deliver the solids from the hopper, and different settings can provide various flow rates of the solids. The transparent sections allow visual observation of the flow patterns. Morris couplings are used to seal the connections and to keep the pipeline aligned (see Figure 4).

Wedge Construction

The wedge-shaped container was constructed of two pieces of clear Plexiglas (76-cm high, 74-cm wide, 0.4-cm thick). These were bolted to two steel supporting legs. Four bolts (1.27-cm diameter, 0.96-cm long), two to each leg, were used to attach each plastic sheet to the supporting legs. The front plastic piece was scribed so that it had a 1-by-1-cm grid network across the entire area. The grid network formed a convenient transparent graph for readily obtaining the position of the black marker beads in the bed. The width of the wedge, *i.e.,* the distance between the Plexiglas faces, was 1.61 cm. Two brass rectangular bars (83.0-cm long, 1.61-cm wide, 2.54-cm thick) were used to form the inclined surfaces of the wedge. The surface of the brass bar adjacent to the glass beads was machined to be flat, with a tolerance of ± 0.05 mm. The brass bars were taped to take eight brass screws (0.63-cm diameter, 0.96-cm long) on each side of the bar. These screws were used to fasten the bars to the Plexiglas at any desired inclination. A thin Plexiglas strip (76-cm long, 1.61-cm wide, 0.64-cm thick) was then placed on each machined brass bar surface to form the slide surface for the beads.

A vertical plastic disengaging section (6.35-cm high, 15.3-cm wide, 1.61-cm deep) was located at the bottom of the sloping sides of the wedge. The disengaging section was included to even out velocity gradients that could have been generated by the flow of beads through the slot located at the bottom of this section. The slot was adjustable and was made of two pieces of steel (17.0-cm long, 2-cm wide, 0.16-cm thick) that were attached by means of screws to the vertical front and back Plexiglas walls. The edges of the steel pieces that formed the slot were machined within ±0.05 mm to ensure perfect mating when the edges met. The slot opening was set with feeler gauges so that the opening was uniform to within ±0.05 mm across the width of the slot. The gate was closed with a piece of tape simply by attaching the tape to the front plastic wall. To start the flow of beads, the tape was removed and the gate fell open, permitting the solids to flow. The legs supporting the wedge had adjustable leveling screws mounted underneath them. These leveling screws were used to align the equipment vertically and horizontally. It had been shown that unless this equipment was perfectly aligned, it was impossible to obtain symmetrical velocity profiles.[4] ❒