INTERNSHIP IN CHEMICAL ENGINEERING DESIGN

T. W. F. RUSSELL
University of Delaware
Wilmington, Delaware 19898

H. E. TURNER
E. I. du Pont de Nemours & Co., Inc.
Wilmington, Delaware 19898

THIS IS A REPORT on an experimental program to test the concept of training students at the Master's level by a combination of formal university graduate courses and an on-the-job (industrial) internship in lieu of a formal MChE research project. The objective of the internship is to introduce the student to the "art" aspects of chemical engineering to complement the engineering science aspects of the classroom. The program could be likened to the medical internship whereby the graduate supplements his academic training with real-life experience and training under the guidance of experienced practitioners.

The program is a closely cooperative joint effort of the Department of Chemical Engineering at the University of Delaware and the Chemical Engineering Consultant Section of the Engineering Service Division of the E. I. du Pont de Nemours & Company. The organizations are close geographically and there has long been strong interaction through personal and professional contacts. In fact, it was in 1967 during initial contacts between the authors during implementation of a Washington University type of Design* that the basic idea for the Internship Program originated. It was then largely a matter of incubation, detail development, and proposal selling to the two affected organizations until the program was agreed to in March 1974. Two candidates were selected from applicants responding to publicity released in the Fall of 1974, and the program commenced in June 1975. (The University of Delaware has just recently completed arrangements with the Union Carbide Corporation at Bound Brooks, N.J., to start an Internship Program at that location. Two other companies in the Delaware Valley have responded quite favorably to proposals to initiate Internship Programs with Delaware.)

The ChE Consultant Section of the Engineering Department was considered to be an attractive place in which to test the Intern concept because of the problem-solving nature of its work and the availability of senior ChE specialists to "buddy-up" with the interns and guide their work. Table 1 shows a schematic outline of the section's activity. The first-listed group undertakes many conceptual design problems for the Design Division of the Engineering Department and for Du Pont industrial departments. These problems are relatively well-defined and therefore very suitable for use with the interns. Mass transfer and fluid flow were chosen as the areas for the

*Chemical Engineering, May 6, 1968.

T. W. F. Russell is a Professor of ChE and Associate Dean of the College of Engineering at the University of Delaware. He obtained his bachelors and masters degree from the University of Alberta and after working as a design engineer with Union Carbide, Canada for three years, he obtained his Ph.D. from the University of Delaware. Professor Russell is a coauthor of "Introduction to Chemical Engineering Analysis" (J. Wiley 1972) and Structure of the Chemical Process Industries—Function and Economics" (McGraw Hill, in press).

Howard E. Turner, manager of chemical engineering in the Engineering Service Division of DuPont's Engineering Department, joined the company in 1940. He has worked at the Edge Moor, Del., plant and the East Chicago plant and in Wilmington in the Engineering Service Division of the Experimental Station. He has served as a field section manager at the Newark, Del., office, as director of maintenance engineering and engineering materials section, and as head of the ChE section and later, the mechanical energy processes section. Mr. Turner attending the U. of Minnesota and received a B.S. degree and a M.S. degree, both in ChE. Mr. Turner is a fellow of the AIChE.

TABLE 1
Du Pont Engineering Department

Design Division
Construction Division
Engineering Research & Development Division
Engineering Service Division
- **Field Engineering**
- **Chemical Engineering Consultants**
  - **Heat, Mass and Momentum Transfer**
  - **Reaction Engineering & Chemical Processing**
  - **Engineering Evaluations**

two interns, one working in each area. We selected from among the dozen or so specialists in these areas, two of our senior consultants to act as the adjunct professors on the intern program; and they are so listed in the University Directory. The specific consultants were chosen not only for their technical competence but especially because of their teaching ability demonstrated in in-house continuing education courses and other teaching experiences. One of the consultants had taught an Industry-University Partnership design case study at Delaware for three years.

STEERING THE COURSE

THE PROGRAM HAS been supervised by two steering committees. The structure and operation of the industrial problem-solving phase was supervised by H. E. Turner and H. S. Kemp of Du Pont and T. W. F. Russell of the University of Delaware. Progress and problems were initially monitored on a frequency of 2-4 weeks. The second steering committee supervised relations with and impact on the University. This committee was composed of A. B. Metzner, ChE Department Chairman, R. L. Pigford, M. M. Denn, R. L. McCullough, and T. W. F. Russell.

The interns are required to complete 24 credits of course work at the graduate level (eight 3-credit courses) as well as a 120-day intern assignment. The intern assignment is scheduled as follows:

June 1 - Aug. 31	**Internship.** **Students have a three-month period of full-time effort in the Engineering Department.**
Sept. 1 - Dec. 31	**Internship and Course Work.** **The student interns two days a week (Tuesday and Thursday) and takes four 3-credit courses in the ChE Department.**
Jan. 1 - Feb. 10	**Internship.** **The students complete their 120-day internship with five weeks of full-time effort.**
Feb. 10 - May 30	**Course work in thesis preparation.** **The students complete their course work and prepare their thesis under the direction of the appointed adjunct professors.**

The program takes twelve months, and some careful scheduling along with a good deal of effort on behalf of the interns is required.

In the first year of the program, publicity was limited and the intern selection was carried out by personally contacting each student who applied for MChE studies at Delaware. Approximately 20 phone contacts were made and as a result 14 students were invited for on-campus interviews. Seven from this group were sent to the Engineering Service Division of the Du Pont Engineering Department for further review. Two students were selected, one in January and one in April. In the second year no phone contact was carried out since ten out of the thirteen students who applied for MChE studies requested the intern option. The student applications were carefully evaluated by both the ChE Department and the Du Pont Engineering Department, and two offers were made. Both offers were accepted by mid-March 1976. As of this writing the first two interns have completed the program and received degrees in June 1976. The second two interns began their program June 1, 1976. The first two interns followed the schedule described. They completed their internship in February and finished their "thesis" write-up by April 30, 1976.

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A listing of jobs which includes the percentage of time spent for each job is shown below for both interns.

INTERN A — JOBS	TIME SPENT
1. HAFBOC Computer Program (Vapor/Liquid Equilibrium)	**50%**
2. Dimethylformamide Hydrolysis in a	**15%**

Distillation Column	
3. Dimethylformamide Extraction and Distillation	9%
4. Absorption Program	6%
5. Solvent Emission Control	4%
6. Bubble Cap Computer Program (Tray Design)	3%
7. Solvent Condensation	2%
8. Crude Dimethylformamide Distillation	2%
9. Turndown in a Distillation Column	3%
10. HCl Recovery	3%
11. Cooler-Humidification Evaluation	3%

INTERN B — JOBS	TIME SPENT
1. Perforated Pipe Liquid Distributor Design	7%
2. Open Channel Liquid Level Calculation	3%
3. Sizing of Vent Lines and Rupture Discs Associated with a Vaporizer	5%
4. Venting of a Two-Phase Mixture from a Reactor to a Collection Tank	3%
5. Pressure Drop in Piping Associated with Vacuum Crystallizer	3%
6. Analysis of an Expansion Joint	3%
7. Sparger Design for Injection of Steam into Slurry of Plastic Pellets	4%
8. Force Calculations at Elbows of Piping Systems	6%
9. Piping Analysis	24%
10. Vent Condenser Modification	10%
11. Quiet Mixer Design	2%
12. Process Vessel Pressure Reduction	16%
13. Analysis of Parallel Vaporizers	8%
14. Piping Modifications to Accommodate Increased Flow Rates through a Heat Exchanger	6%

The thesis for each intern consisted of a Project Summary, which described each job in a paragraph or two, and a detailed description of certain selected problems. The detailed description varied in length from 7 to 220 pages. The thesis write-ups were reviewed by the adjunct professors, who interacted with the interns on the following timetable.

TASK	TO BE COMPLETED BY
Preparation of the Project summary by interns	February 13
Selection by adjunct professors of the projects for detailed write-up	February 18
Detailed outlines for each project by interns	February 23
Review of outlines and approval by adjunct professors	February 27
Complete write-up of specific projects by interns	March 26
Review by adjunct professors and revision by interns	April 7
Typing and final preparation	April 30

Finished copies of the theses were read and commented upon by the department chairman and the University Intern Steering Committee.

During the year the interns reported on their work twice. The first presentation occurred early in the 1975 Fall Session at a special seminar in the ChE Department. Both interns described a problem they completed over the summer. The two adjunct professors described their experiences and the overall program was reviewed by H. E. Turner and T. W. F. Russell. The seminar was well-received by both students and faculty. Early in 1976 both interns described another problem in detail to the regular graduate seminar. The interns completed all work including courses and the internship in a twelve-month period. This is designed to be and is a difficult program. The interns worked very hard and had to meet some rather severe deadlines with no vacation and only normal industrial holidays.

PROGRAM COSTS AND IMPACT

THE PROGRAM IS designed for 120 intern days. These are "working" days. All thesis preparation is done outside this time as are all requirements for the course work. Our first year's experience showed that the interns spent about 20 to 30% of their time in review or questions and about 70 to 80% in problem solving, of value to those requiring engineering service. Each intern is thus worth about .70 x 120 x \$150 = \$12,600 if their time is billed at \$150 per day.

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The interns require a certain amount of time from the adjunct professor that is educational to the intern but unproductive to the job at hand. An estimate of this time based on our first year's experience is 15-20 days total for the two interns. This cost must be charged to the program. Management time spent on the intern program must also be charged against the intern's total value to a firm. Substantial management effort is required initially, but at the steady state a

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reasonable charge is 10-12 days per year for the total program. Interns are paid the same stipend as graduate students in the traditional program. For 1975 this was $4800 per year. Tuition for 1976-77 amounts to $2264 per year (out of state). Costs would vary with location, but the program should break even. A summary of costs is given in Table 2.

There is no question that the interns have had a very worthwhile experience. They have an opportunity to integrate their graduate course work with problems in a "real world" engineering environment. This integration is enhanced and made most effective by the one-to-one relationship that is developed with the adjunct professors. The interns spend more time with their adjunct professors than students in the conventional program do with their thesis advisors. This is due partly to the need for immediate action on some problems and partly due to the greater number and variety of problems dealt with.

Table 2
Cost Analysis

INTERN BILLING	$25,200
COSTS	
Adjunct Professors	15-20 days
Management	10-20 days
Intern Stipend	$ 9,600
Intern Tuition	$ 4,600

Because of the nature of the consultant-like operation carried out by the adjunct professors, the interns were also exposed to types of problems that they would not normally encounter on their own until they had accumulated much more experience.

The University gains in a number of ways:

- **Class discussion is enlivened and often takes a different tack because of the presence of the intern.**
- **Graduate student seminars are improved because some industrial problems and real solutions are described in addition to the conventional graduate level work.**
- **Informal discussions regarding course work and research work take on a different tone when there are interns as well as students in the conventional program.**

These and other effects of the intern program are sometimes difficult to measure and quantify. There is no question, however, that the faculty feels the program adds needed variety and insight and they have become very enthusiastic.

The industrial organization gains the services of a very capable chemical engineer with Bachelor's level education for 120 days. The program is highly selective and the intern is in the top 10% of his class and always from a quality school. Having an intern in the course work also provides some flow of new knowledge from the university to the industrial group. The need to explain problems to the intern also tends to focus on matters in more detail and sometimes additional insight is gained by the adjunct professor. Both management personnel and the adjunct professors have gained a good deal of satisfaction in helping young people grow and develop as engineers, and in advancing the education process. □