ChE department

Each issue, we will feature a department of chemical engineering. We begin with a top-rated department that has produced numerous outstanding chemical engineering educators and scholars.

ON WISCONSIN

R. BYRON BIRD, *Chairman*

For many years the Chemical Engineering faculty at the University of Wisconsin has been split into three factions: the canoeists, the golfers, and those who steadfastly refuse to join either of the other groups. On most academic and administrative matters we usually have N + 2 opinions, when N is the number of professors (the extra "2" arises from the fact that several professors usually change viewpoints along the way). Because of this lively lack of unanimity it is sometimes remarkable that we can ever get our vectors lined up with a resultant component in the direction of progress. When we do, however, we are fairly confident that the concensus is workable. In what follows I shall attempt to outline very briefly our conclusions on a number of points related to chemical engineering teaching. Many of these reflect the strong leadership our department has had in the recent past, particularly that of Professors Hougen, Ragatz, and Marshall.

Research is teaching

There has been far too much talk about research VERSUS teaching. We feel strongly that research is a vital departmental activity and that the individual and small-group instructions involved in research is one of our important *teaching* activities. It also serves to keep the teacher alert by insuring that he is faced daily with new problems to which he does not know the answers, that he is required periodically to present and defend his ideas at technical meetings, and that he is obliged to know what is going on in his area of research in industry and other academic institutions. The teacher thus, in a sense, continually puts himself in the role of a student and thus can appreciate the problems that his own students have when they encounter a new situation. Nothing is more oppressive in an educational institution than a teacher who presides over a body of stagnant knowledge and demands that his students master the material obediently.

The flow of knowledge

It has generally been our policy that each undergraduate course is backed up by a graduate course, and that it in turn is backed up by a research program. In this way there is a continual flow of knowledge from the research laboratory into the graduate course; often the person doing the research also teaches the graduate course and he is then free to experiment on new ways to organize and teach the material. Once the material has been class-tested at the graduate level it can be moved down into the undergraduate program. The several undergraduate textbooks prepared in our department have been developed by this kind of procedure.

Attitude of "apartheid"

Our department has for many years gone on the record as being opposed to the "common core" idea in engineering education. We feel that such regimentation can possibly lead to a lack of flexibility and a lack of identity. Also, the strong chemistry background of our students is not made use of if they take common core courses in thermodynamics, fluid dynamics, materials science, etc. Furthermore, it seems to us that students should learn early in life the importance of making a decision and accepting the consequences. If a student makes the wrong curriculum selection and has to change his course of study, it may be that he will have profited from the experience in decision-making. Finally we feel that it is good for the students to identify themselves with an academic department early, for the purpose of developing *esprit-de-corps* and for advising purposes. This is particularly important in a large university. Our attitude of maintaining in-

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Importance of chemistry

The distinguishing feature of chemical engineering, as opposed to other engineering, is the strong emphasis on *chemistry*. We have maintained a substantial chemistry sequence in our curriculum, and our students are in the same courses as chemistry majors. We have not eliminated analytical chemistry, because we feel that the interface between analytical chemistry and process control is an important one for future development. We have tried to keep a strong chemical bias in all of our chemical engineering courses, emphasizing wherever possible those problems dealing with mixtures, chemical reactions, multiphase systems, molecular structure, polymers, interesting compounds, chemical separations, and ionic solutions. We are trying to make a conscious effort to stop talking about the famous compounds "A" and "B" and use examples involving real chemical systems. Our last six professional staff additions have been purposely made in such a way as to strengthen the chemical orientation of our department. We are not trying to imitate chemists nor are we trying to become totally dependent on chemistry as a source of inspiration and guidance; but we must not be oblivious to the great advances in chemistry in the last two decades (the *Westheimer Report*, an enlightening, easy-reading summary of the advances in chemistry since 1946, ought to be required reading for all ChE professors over 40).

Engineering emphasis

There seems to be misunderstanding in some quarters about the engineering orientation of our undergraduate curriculum. The publicity associated with the development of our transport phenomena course seems to have misled some people into thinking that we have abandoned all reason. We regard the transport phenomena course as a third semester of physics, made necessary by the fact that elementary physics includes almost no material on fluid dynamics, heat conduction, and diffusion. We still include in our curriculum two 3-credit lecture courses in unit operations, a 5-credit unit operations laboratory course, as well as courses in chemical reactor operation, process dynamics, and process design. In all of these courses the emphasis is very much on solving problems of engineering interest. The laboratory instruction in chemical engineering includes: transport phenomena, unit operations, applied electrochemistry, process control, and polymer processing; all of these except polymer processing are required. This laboratory instruction is quite substantial and we feel that this is essential in maintaining an engineering emphasis.

Importance of undergraduate instruction

Our department pays more than just lip service to the undergraduate instructional program. Almost every staff member participates actively in undergraduate teaching and advising. With an

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undergraduate enrollment of about 350, we have to devote a substantial part of our effort to course planning, instructional equipment, course notes, supervision of teaching assistants, and lecture preparation. We are also trying more and more to assign extra time when needed for course improvement. All undergraduate courses are given each semester, and enrollments in some courses are as high as 50 to 80. We have experimented with large lectures, small sections, and various "intermediate forms of instruction. We have found supervised problem-working sessions to be of value in some courses: in these, a portion of the homework is done under the guidance of a teaching assistant who circulates around the room and gives advice where needed. We have one standard curriculum for all students. However, those with a grade-point average of 3.5/4.0 may elect to replace any 6 credits of chemical engineering courses by 6 credits of any science or engineering courses. We do use quite a few teaching assistants (about 24 to 30 quarter-time graduate students) mostly for taking care of laboratories, problems sessions, and paper grading; occasionally they are given major lecturing assignments as well.

Graduate courses

Most of our graduate courses have a strong science and research flavor. They are intended to be of interest primarily to the Ph.D. candidate, who is preparing himself for research. We have never developed a strong terminal MS program at Wisconsin and very few of our courses are suitable for those not seeking the doctorate. The number of graduate courses we offer is purposely kept rather small. We want the few courses we do offer to be well-organized and up-to-date. We encourage our students to take courses in the basic sciences or other engineering departments so as to bring new ideas into chemical engineering. We have no course requirements in chemical engineering for the Ph.D. We have quite a few small seminars in the department and auditing of courses is widespread. In summary, we oppose formal course proliferating in engineering at the graduate level.

Graduate examination procedures

Prior to the final thesis examination, we have three formal graduate examinations in chemical engineering. The *MS examination* can be an examination on an MS thesis. Otherwise it is devoted to the critical presentation of a recent article in one of four chemical engineering journals. This type of an examination hopefully encourages some familiarity with the technical literature and also helps to bring new work to the attention of the staff. Rather than being a teacher-*vs.*-student exam, it is more teacher + student *vs.* someone else's research. The *qualifying examinations* (beginning of third semester) are four 4-hour tests on basic undergraduate material: transport phenomena, thermodynamics, process dynamics, and chemical reactors and kinetics. These are intended to insure that we are not turning out students with poor foundations covered with a thin veneer of high-powered, science-oriented graduate material. The *preliminary examination* (beginning of fourth semester) consists of a report, about 100-200 pages, on specific plans for the Ph.D. thesis research, including basic theory, literature survey, detailed equipment plans, estimated costs, and time schedule. The purpose is to insure that the candidate has research potential and that the problem is realistic and of finite duration. I think most of us also feel that it is to some extent an examination of the major professor. Often some very good ideas come out of the two-hour oral presentation of the report.

Foreign language requirements

At Wisconsin the language requirements are left pretty much up to the individual departments. We currently require either the traditional minimal reading requirement in two languages or else advanced competence in one. We allow any languages to be used, recognizing that some want the competence as a research tool, whereas some may wish to train themselves for an overseas assignment. Still others may wish to capitalize on a foreign language spoken at home in their youth. There seem to be two major problems at the present. One is that the language departments have gone over to machine-graded tests which we suspect do not encourage the right motivation for language study. The second problem is that most undergraduate engineering curricula do not require foreign language study. We have recently made one change in our curriculum aimed at encouraging foreign language training: we allow students who have had two or more years of a foreign language in high school to continue that language during their freshman year in lieu of freshman English.

Professional staff

We believe that it is in the best interests of the students to provide for them a staff with widely varying backgrounds (in addition to golf *vs.* canoeing). For example, as regards the industrial experience of our professors we have a spectrum going from 0 years up to 15 years. We have some who specialize in research, others who specialize in teaching. We have some with strong ties to chemistry, but others with strong ties to electrical engineering, biomedical sciences, metallurgy, mechanics, etc. About 4/5 of the staff have Ph.D.'s (or Sc.D.'s) in chemical engineering, but 1/5 got their doctorates in chemistry or polymer science; we feel that having about 20 percent to 25 percent of the staff with their doctoral training in a related field can bring in many new ideas and viewpoints. But the one thing we require of all of our staff members is independence. We do our best to hire new professors in fields not already covered by the present staff so that the newcomer will develop his own niche. We want our students to have a diverse group of experts available to them as consultants.

The above items we seem to have reached agreement on. But, like all departments, we have a number of controversial problems as yet unsolved. One perennial problem is that of *report-writing*; everyone (students, T.A.'s, professors, and employers) agrees that there is a serious problem here and numerous remedies have been applied. Part of the blame possibly rests with the high schools, but much of it is doubtless a result of the unfavorable student-to-teacher ratio; expert writing is a result of long, careful tutelage, and I doubt that it can be mass-produced.

Another problem is that of *graduate-student support*. All departments face the annual job of matching fellowships with students. Inequities seem to be inevitable because of allowances for dependents, income tax regulations, tuition refunds, eligibility for supplementation, etc. About the only point we seem to agree on in our department is that no supplementation (aside from quarter-time teaching for NSF fellows) will be allowed for first year graduate students. We do not believe that supplementation, travel expenses, or other enticements should be part of the graduate recruitment activity. Students should select their graduate school on the basis of the program and the facilities.

Another problem is that of *postdoctoral research*. We get many letters from persons seeking postdoctoral appointments. We have to turn most of these down for lack of funding. In many instances the persons would do better to get industrial experience, but many of the requests are legitimate. A postdoctoral year is valuable for persons switching from industry to teaching, or from one teaching position to another. Postdoctoral research during a sabbatical year can be quite stimulating. Postdoctoral research in a department can often be used to spearhead a new area or to provide an extra push in a graduate research program. We certainly have not discussed this matter enough.

Of continual concern are the *potential new areas* of chemical engineering. I doubt if we do enough experimentation and exploration in trying to bring in new subject material and techniques into chemical engineering. We have been far too slow in emphasizing colloidal phenomena, polymer processing, catalysis, multiphase systems, and other subjects whose importance seems to be well recognized in industry. We probably do not spend enough time on this at the departmental level.

Needless to say the problem which concerns most of us is *time*. One wonders whether the leisure days in the ivy-covered halls ever really existed. The faculty member today has enormous demands put on his time: research, teaching, proposal-writing, continuing-education programs, industrial consulting, attendance at meetings, reviewing of research proposals, etc. We must in the near future seek new ways of insuring that staff time is being effectively utilized. Finally there should be enough time left over for the canoeists to convert the golfers, or to discuss the relative merits of making popcorn by transport phenomena methods or by the unit operations approach.