of engineering technologists and technicians. Employment interest in them has not been fully developed. As it becomes fully developed, there probably will be an increasing effort to have engineers work in the fullest professional sense as engineers. Engineering technologists would be ready to handle operational functions. If engineering technology does affect our work as suggested, there indeed will be fewer engineers hired but probably at much higher salaries and with much higher professional input to their jobs. That calls for better and even more demanding programs. That more intense professional development in itself could provide a strong governor on enrollment.

No one truly can predict what lies ahead relative to what we have done in the past. Engineering obviously will have to help in meeting all national priorities and in keeping the country moving. Whether it will do its work more efficiently than in the past is our problem, and really that is the total crux of what engineering will be like ten years from now and what enrollment levels will be. □

A fourth control on the growth of ChE enrollment could be found in careful examination of predicted employment opportunities.

Too Many Departments!

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THE CONTINUED HEALTH of our profession demands that the production of baccalaureate graduates in ChE be limited. A natural such limitation results from the acceptance of a simple premise, but it is nonetheless one that educators in ChE somehow still find to be debatable. The premise is simply that education in ChE at whatever academic level must be developed and presented by professors who are themselves active participants in the growing edge of the profession. And this is true for professors in all of the professions. For example, I cannot imagine the apprentice surgeon learning his skill from a master who himself does not practice surgery. Certainly also the young surgeon who aspires to be the creator of new techniques—to invent the heart transplant, as it were—will want to work with the best-known experts of the day. So it is also in ChE.

It is not enough merely to admonish our students to go out and be honest and apply common sense to this or that ethical situation. We must provide intellectually demanding exercises and exposure to the great ideas and thinkers of Western Civilization.

This participation by faculty at the growing edge of the profession is heavily dependent upon graduate students, for the neophytes are an extension of the personality of the major professor. In fact, to a marked degree, the reputation of professors is heavily dependent upon the quality of the graduate students that we have attracted over the years. It appears that our economy can absorb about 400 new PhD level ChE's per year. At a nominal rate of one new PhD per year per faculty member, this implies a total faculty in the universities of the country of about 400. Or, correspondingly, the need of our society for about 1000 MS graduates per year implies a faculty of about 500 if we take a production rate of about two new MS graduates per faculty member per year. Using this larger number, and with a critical density of about 15 faculty per department, this suggests that we need about 35 departments. A faculty of 15 could readily produce a baccalaureate group of 70 per year or a national production of about 2500 BS graduates per year. The numbers in this sort of nominal scenario are approximately the degree production that seems to fit our national requirements for new ChE's. However, the institutional structures for educating these new practitioners of our science and our art have expanded beyond all reason. We compare the above projections with the curent listing of 123 accredited departments in the United States with almost 1500 faculty members—and growing. The academic profession then is functioning as an excellent absorber of ChE talent that could be

more productively utilized elsewhere. Innumerable variations on this theme are, of course, possible—the above exercise is merely typical—but the essential message of the analysis is that we have too many ChE departments. The excess capacity seems to be about a factor of two or three.

FEWER DEPARTMENTS

MOST IMPORTANTLY, fewer departments would produce a much more professional orientation than we now seem to impart to our students. And this new status would characterize our graduates at all three academic levels. One might well counter that it is not professional status that you achieve at all, but rather a snobbishness borne of exclusivity. This exclusivity does personify the elitism of our profession; but it also changes the point from which the new entrant into the profession views himself and his potential for contribution to our society. The change I propose does not atttempt to change a person's perspective on professional issues, rather it changes the point from which the perspective originates. It is not ideas that determine our professional status, rather it is our socio-economic status that determines our professional ideas and our self-perceptions. My discussions with many ChE's from all over the country produce a disappointment and a sadness by the self-perception of so many ChE's who see themselves as highly skilled technical employees of some great corporation. Yet the ChE is not merely a skilled employee of duPont—rather he *is* the duPont Company. And without his presence, the company could not exist. Attitudes and self-perceptions are enormously important. We will continue to have large numbers of our ranks who have technician-like perceptions of themselves and their work as long as the universities continue to inculcate such values. The greatest unmet task of our ChE departments is that of elevating the views and raising the expectations of our students. Although thermodynamics is an essential tool, it cannot be applied with professional character except from a background of values. It is not enough to merely admonish our students to go out and be honest and apply common sense to this or that ethical situation. We must provide intellectually demanding exercises and exposure to the great ideas and thinkers of Western Civilization especially in those areas that emphasize human values and ethics, and this attitudinal development is also enhanced by the vision of chemical engineering as a very special profession.

. . . fewer departments would produce . . . a much more professional orientation than we now seem to impart to our students . . . would insure the stimulation of high quality colleagues in other related disciplines, and facilities that are not thwarted by the critical mass phenomena.

Fewer departments would insure the stimulation of high quality colleagues in other related disciplines. Departments of chemical engineering are parasitic in a sense, for we feed off of the departments of chemistry, other departments of the college of engineering, and increasingly the departments of biochemistry and microbiology as well and even several departments of the college of medicine. Excellence in essential supporting departments is also relatively rare, and yet a ChE department cannot really thrive unless, for example, the chemistry department is also excellent. This co-existence of strengths exists on relatively few campuses, and yet this co-existence and this synergism is essential to insure the continued expanding ChE domain.

Fewer departments would insure faculties that are not thwarted by the critical mass phenomena. Just as ChE personifies synergism with other disciplines, so also is this the case within its own areas of specialization. A faculty of about ten seems to be on the lower bound of criticality, for a survey of the work of departments reveals that smaller ones are either just weak, or, if strong, that strength will be in a very few special areas of ChE. It is essential that students be exposed to ChE's who might be characterized as applied physical chemists and it is equally important that they see ChE's who exemplify the more engineering orientation. The strength of our profession is this dual character of the ChE as both scientist and engineer—and our faculties must be of sufficient breadth to provide models of both extremes, and at several points in between. Those students who are graduating, at whatever the academic degree level, from departments that do not have this character are not receiving the vision of the profession nor the attitudinal structure that they need for optimum professional practice.

ECONOMIC ADVANTAGES

THE FINANCIAL position of ChE's is clearly enhanced by this control on numbers that we seek. ChE services are required, persons with such skills are few, and therefore the price for such services will be high. Professional licensing by the states could protect the public against imitators. A graduate in biology can read a few books on the physiology and diseases of dogs, but state licensing protects the public against this individual unilaterally declaring himself a veterinarian and opening a pet clinic. So it could be in ChE.

As is the case with most organizational structures, attitudes, philosophies, and ambitions, the major obstacle to this (or any other) more professional orientation is our desire to make the change. Many self-proclaimed leading departments will not be interested, for they mistakenly feel that they have nothing to gain. The sleepy departments will not be interested for concerns of self-preservation, for they would see themselves going out of business. Yet we are all the healthier—just as the NFL is healthier—if we maintain only as many teams as can be supported in first-class style and be maintained at more or less comparable strengths.

How might it be done, for departments are not likely to vote themselves out of business. Certainly the advantages to the individual faculty member of consolidating two or three departments could be made compelling. The combined department would be more attractive in terms of quality of faculty, quality of facilities, and numbers and quality of students. The economics of consolidation would be attractive to state legislatures and boards of trustees, and certainly the long-term economies of scale could be used to extract short-term incentives to promote and to initially capitalize this new epiphany of ChE education. Certainly those deans who lose their ChE department would breathe a sigh of relief, for the ChE's are widely recognized as the nemesis of all deans of engineering.

Perhaps the dismal science of economics may yet push us to this more professional status but curiously from the motivation of the happenstance corollary of cost effectiveness. That would be a very positive result, but it certainly would not reflect the wisdom of the ChE community. We seem to know so much about the economies of scale; it is curious that we continue to ignore those ideas in our own business. □

Can We Limit Enrollment By Professional Society Action?

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IT IS QUITE clear that the demand for engineering graduates is difficult if not impossible to predict. User surveys have not proven successful and it seems doubtful that we will ever be able to make forecasts adequate enough for individuals, universities, industrial and government sectors to do reliable planning. Some engineers think that the answer is to limit enrollment at some number below the most pessimistic forecast and thus assure that those accepted into the profession have an opportunity to practice it. There are two ways to limit enrollment:

- **limit number of accredited colleges**
- **limit number of studnts in accredited colleges.**

The Engineers Council on Professional Development already limits the number of colleges and any discussion of this issue must consider tighter criteria for accreditation. The question of limiting the number of students has not received as much attention and this problem is considered here.

ENROLLMENT LIMITING PROCESS

FIGURE 1 ILLUSTRATES the enrollment limiting process and shows what information is needed to consider the question. The capacity by discipline of each engineering college needs to be known and the number of graduates capable of being produced in each discipline in any one year must be known. This later information depends not only upon number of students which can be graduated, but also upon raw material supply of high school or transfer students. Demand forecasts for at least four years in the future must be available for each discipline. A comparison can then be made between supply and demand and action initiated (Figure 2).