CHEMICAL ENGINEERING EDUCATION FOR THE SEVENTIES

Symposium

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The decade of the Sixties has brought about technological change at a continuously increasing rate. Computers have become a household word; exploration of the moon is taken for granted; and the fashion world flourishes with an abundance of brightly colored synthetic fabrics designed to stretch, conform or tear away depending on their mission. But more important than these technological advances is the dawning of an awareness of the impact that technology can have on our earth where we are attempting to accommodate millions of additional human beings each year. Yesterday's solutions have become today's problems. Pesticides, fertilizers, detergents, throw-away containers plus a multitude of other products, all with a market and a mission at the time of their development have caused problems as serious as those they were intially created to relieve.

ChE EDUCATION IN THE SIXTIES

Chemical engineering education has also undergone transformation in the past decade. A significant trend to shorten the undergraduate program to four years or 128 hours has been evidenced throughout the country. Transport phenomena has become a principal component of most curricula which used to be built around unit operations alone. At the beginning of the decade the Ford Foundation supported a major effort to introduce the computer into engineering education at The University of Michigan. The results of this experience were shared with engineering faculties across the country. Today the computer has become as close to the engineering student as was his slide rule in the Fifties. However, the computer has meant more than simply a high speed computational device to replace desk calculators and sliderules. It has resulted in changes in the mathematics content of many curricula as well as the introduction of new modeling and analytical courses within engineering.

During this same period it has been made increasingly apparent that the complexities of the society within which we live require that engineers emerge from universities with more than a mere technical competence in their chosen professional area. They must be exposed to course sequences in the social sciences and humanities which properly sensitize them to the citizen role which they must also fulfill in the future. Such courses have increased in the last decade while the total program has been contracting. Yet it should be recognized that a student of today receives more advanced mathematics, science, and engineering in fewer credit hours than did his predecessor ten years ago. This has produced frustrations in many of our students as they find it difficult to assimilate all of the material which is considered essential for the B.S. level engineer. As we look to the Seventies, we cannot ignore the lessons of the Sixties. We must assess our performance as educators at the present time as well as the challenges ahead to which we must address ourselves.

AGENDA FOR THE SEVENTIES

At the top of the agenda for the Seventies is the need to assess the environmental impact of our exploding technology and population. Of equal importance is the need to establish priorities for the use of our limited supply of natural resources, particularly our energy reserves. Though neither of these concerns will occupy only the chemical engineer in the decade ahead, he must assume a more prominent role if solutions are to be found. Chemical engineers are trained in the disciplines that relate directly to the cleaning up of our water, air and land. Separation processes and chemical reaction engineering form the basis of any attack on pollution and both have been a major component of chemical engineering curricula for years.

Though chemical engineers have not been primary contributors to the power producing industries, they have long played a primary role in the extraction, refinement and transportation of natural gas and crude oil resources. As such, they

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As a White House Fellow (1967-68) he worked in the office of Defense Secretary Robert McNamara. At the time of his selection as a White House Fellow, he was City Councilman and "mayor pro tem" of Ann Arbor, Michigan. Since then, Balzhiser has served on the White House Fellows selection committee.

have had a primary role in the fueling of power units all over the world. Today, as fossil fuel reserves are rapidly consumed, the need to develop alternate energy sources becomes more pressing. Safe, economic nuclear power requires continued effort to produce improved fuels and to develop reprocessing schemes for removing reactor poisons while recovering fissionable materials. The fusion process will continue to receive attention as will efforts to make greater use of solar energy for a portion of our total energy needs. As high quality fuels are consumed it will be necessary to develop methods that permit the use of marginal energy reserves, such as oil shale, in the future. The need to look to more remote parts of the globe for additional gas and oil will create new problems such as those currently encountered with the Alaskan pipeline. An angered public is already demanding assurance that oil-coated beaches and wildlife resulting from off-shore drilling accidents and leaking or ship-wrecked tankers be eliminated.

Water, present on the earth in a finite amount, is rapidly being polluted to the point where our fresh water sources may soon prove inadequate as an increasing population here and abroad places heavier demands on the available

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supply. This demand is focused in highly industrialized societies and those relatively arid countries of the world supporting substantial populations. Desalinization efforts are progressing; the cost remains high, but the prospects for further reduction are promising.

While air and water receive the principal attention because of their direct relation to the life processes, it is becoming increasingly apparent that we must make major strides as regards disposal and recycle of solid waste materials. Raw materials, such as ores, trees, oil and gas are also available in limited amounts. Failure to place a priority on their utilization is rapidly depleting known reserves. Meanwhile, waste accumulates in dumps and landfills producing visual pollution over increasingly large areas of our country. The separation and conversion processes necessary to recycle material are very much within the domain of chemical engineers.

The chemical engineer will continue to play an important role in feeding, clothing and housing an increasing population throughout the world, but hopefully one that he, along with others, can assist in bringing under control. The need for substitute and synthetic foods and materials will become increasingly critical in the years ahead. Though fertilizers and pesticides have improved the productivity of our lands immensely in the years past, today we recognize the need to refine these products and exercise greater discretion in their use if we are to avoid permanently degrading the environment. New fibers and plastics are certain to emerge which will provide new building materials, fabrics and, quite probably, new problems for society to adjust to.

Simulation of body organs and functions by laboratory models, mathematical and experimental, is becoming increasingly common. The participation of the chemical engineer in artifical organ development, blood oxygenization and other areas closely related to the medical field is attracting increasing interest as well as many new demands.

Engineers in future years will have to consider design criteria other than profitability. The consumption of resources and the disposal problems related to the product and manufacturing cycles will enter into plans more often in the future. It seems that proprietary developments within the private sector will be subjected to increased scrutiny by federal technology assessment units or other regulatory agencies before products are marketed on a mass basis. While such practices are presently used in the food and drug industry, they are relatively uncommon for most products.

Concerns of these types are already apparent as we look ahead to the decade of the Seventies. We can't even begin to comprehend all of the concerns that will emerge before the decade passes. Certainly we will have to learn to adjust to shorter work weeks as a result of increased automation. Many adjustments will have to be made politically, socially, economically and educationally as the benefits and liabilities attributable to technology become better identified in the future.

CURRICULA TRENDS FOR THE SEVENTIES

The decade ahead will produce both structural changes in higher educational degree programs and content changes in curricula to meet societal demands. One can frequently predict what changes will occur at the undergraduate level by examining what has developed in graduate curricula in preceding years. Today change is occuring at such a pace that this natural process of curriculum evolution may be inadequate to accommodate to industrial and societal needs. However, one important point to be made is the continued importance and relevance of the heart of any chemical engineering program—chemical reaction engineering and separation processes. These two subject areas uniquely belong to chemical engineering and they must play a basic role in addressing the challenges listed earlier. Though chemical engineers are probably better trained today to deal with most environmental problems—air, water and land pollution included—we have failed to create sufficient visibility of these capabilities. Ironically most other engineering programs at Michigan have recently reduced chemistry requirements to one semester at a time when its importance is increasing rather than lessening in contemporary technology.

Chemistry of course, will remain at the heart of chemical engineering, though the specific content will likely vary. Analytical chemistry has virtually vanished from the curriculum. At Michigan the undergraduate of today takes 19-22 hours of chemistry offerings as compared to the 26-28 hours which had been part of the program since 1912.

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The trend of incorporating more engineering science in chemical engineering offerings will certainly continue into the Seventies. Courses in chemical engineering thermodynamics today include an appreciable amount of physical chemistry, particularly as it involves solution behavior and chemical equilibria. Though there is reluctance to reduce physical chemistry requirements, the pressures of the four-year program combined with the increased emphasis it receives in engineering courses will result in a change in the content and amount of physical chemistry taken by chemical engineers. I believe we must seek more microscopic treatment of matter from the physical chemist as we move more of the macroscopic content into our engineering courses. Kinetic theory, statistical and quantum mechanics as related to the prediction of thermodynamic and transport properties are becoming an increasingly necessary part of a chemical engineer's training. Such courses in combination with a properties course in chemical engineering should be designed to develop an engineering approach to property correlation and production which when coupled with the computer will open the way to process synthesis—another big advance likely to come in the Seventies.

The computer's impact on curricula has been dramatic in the past, but will be even more so in the future. Software development will evolve that will permit engineers to synthesize as well as optimize and control processes. The mathematical base has developed rapidly as has our ability to model increasingly complex systems for computer simulation of unit and process operations. The opportunities on this horizon seem limited only by our ability to understand and describe the nature of matter sufficiently well to develop computer programs that can generate the thermodynamic and transport prop-

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erties required in design. Methods of calculating viscosities, conductivities, free energies, activity coefficients, etc. for compounds and solutions given basic elemental parameters will be the objective of continued faculty and graduate research in the future. Equations of state formerly of academic interest only because of their complexity can now be programmed on computers and utilized far more extensively.

The academician must modify the content of many other courses, as well, if he is to optimize the assimilation of the computer into the educational process. Many of the complex procedures for sizing distillation columns and reactors are currently handled routinely by programs now available in corporate computing centers. Less time should be devoted to the drudgery of complex calculations and more to developing the student's ability to inferface with computers. This includes the ability to model processing units and systems in mathematical terms and to formulate the data packages needed for solution. He should be sufficiently educated in the logic and limitations of the computer to know when its use is justified.

The increased interest in environmental and bioengineering have already resulted in course additions to curricula. Many of these have been patterned after the technological courses of earlier years. They have served to give the necessary visibility as well as the state of the art to students with an interest in these areas. More quantitative treatments of this subject matter must be developed and extended to these fields of emerging importance. Chemical engineering is the logical engineering discipline to expand into this phase of "human systems engineering". These treatments will likely include more of the basic science in biochemistry, biology and ecology in future years. Courses in these basic areas will likely become required courses in the chemical engineering programs of the future.

SHIFTS IN ENGINEERING EDUCATIONAL PATTERNS

Structural changes in engineering programs will be as important as content changes in the next ten years; indeed, some of the changes in the latter will result from a restructing of degree programs. Though the current economic picture and governmental policy with respect to student support may alter the short range picture, longer range changes which will be more profound relate to less transitory phenomena than the economy or government policy.

Though industry, until recently, has readily absorbed the spectrum of graduates produced by our engineering programs, they have admitted with increasing frequency that many of the people they hire are really over-educated and overpaid for their needs. They get from the universities and colleges principally B.S. and Ph.D. level people, but seem to feel that technologists or someone nearer the M.S. level would better meet their needs. The desire to get outstanding people, particularly at the graduate level, has forced them to recruit Ph.D.'s, as the best have traditionally pursued that goal. However, in too many instances the student has reached a point of diminishing returns, as regards his initial value to a company, long before his thesis is completed. Though of some value to those planning academic careers, the degree seems to mean increasingly less in terms of preparing an individual for industry in relation to the time required.

A second factor of increasing importance is the rapidly rising cost of higher education today. This factor impacts in several ways on students. First, many are choosing to remain at home and study for two years in a junior or community college before embarking on an engineering program. Second, a student and his family must decide how much they can afford to invest in higher education before a payoff is realized. The Sixties produced a proliferation of graduate student support programs which are rapidly vanishing today. In the absence of this support from government, industry or universities, fewer stutents are likely to remain on campus for three to five years beyond a B.S. degree, particularly if fewer companies seem willing to compensate them for their incremental investment, which includes not only schooling costs, but the income sacrificed by remaining in school.

Pressures within universities to economize are mounting rapidly as well they should. Wage and salary increases in most sectors of the ecoomy are at least in part related to increased productivity. Had faculty salary increases been linked to such a factor in the last decade, I'm certain we'd be far worse off than we currently are. That is not to say that the typical professor in our department doesn't work 50-60 hours a

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week, but merely to point out he is doing it no differently than he did ten years ago. I sense a developing pressure to increase the number of common offerings across the engineering college in an effort to better control class sizes. This may in time lead to major organizational changes in engineering where departmental lines become subordinated to disciplinary affiliations.

Simultaneously, however, educators must reexamine the process itself. Can we increase our our productivity? Can we better motivate our students? Student frustrations seem to increase not only with society and Vietnam, but also with their academic experience. Professors expect more out of them in less time (128 versus 142 hours) than was true earlier. The increasing affluence of the last decade has caused many to factor salary and job security into their future plans less than was true of depression-raised students. Thus the demands of engineering seem to be too high a price to pay for many who see society's real needs as falling outside of the physical sciences and engineering.

Consideration of these factors suggests several likely changes in the years ahead. The number of engineering technology programs, both two and four year will increase, particularly in community colleges. The B.S. degree will gradually merge with the M.S. degree with a resulting five-year program which may well contain a two-year pre-professional program (which could be obtained in a community college). Fewer students will choose to pursue the Ph.D. as we currently know it, though some of these may choose to continue study beyond the first degree, but without the traditional thesis. Such a program would permit a project with greater breadth than the Ph.D. thesis, but quite relevent to societal and industrial needs. Continuing education programs will be developed by industry and universities, with likely competition from enterprising and innovative individuals who will quickly move into the area if universities fail to respond.

The advantage of a cooperative education program should not be overlooked. Many institutions are currently using such programs in cooperation with industry around the country to their mutual satisfaction. It not only provides the student with an opportunity to apply classroom material to engineering practice, but equally important today, it provides him an opportunity to earn while he learns. Certain institutions by virtue of their geographical locations are ideally oriented to move into cooperative education and should certainly explore the advantages that such programming provides.

It is essential that we not overlook innovative methods of instruction. Programmed learning where appropriate should be used; other audio and visual techniques should be investigated including the use of television, both live and tape, in an attempt to educate not only on campuses but also in corporations and homes across the country. Tapes and films as well as texts should comprise a portion of the faculty's scholarly effort in the future.

Certainly society, as well as the chemical engineer of tomorrow, faces not only the challenges cited above, but also others which remain undefined and in some cases beyond our comprehension at this point. Several predictions can be made with virtual certainty, (1) change will continue at an accelerating rate in the decade ahead, (2) criteria must be developed other than profit which will guide industry and the government in their future decisions and (3) as we experience continued population growth and consumption of our natural resources, technology, its application and direction, will become increasingly concerned with survival, not just convenience or return on investment. □

ChE news

ONE DAY SCHOOL FOR CHEMICAL ENGINEERS

A sub-committee of the Education Projects Committee of AIChE has organized a "One Day School" for chemical engineering faculty from colleges within the Metropolitan New York and Mid-Atlantic areas. This school will be sponsored by the FMC Corporation at their Princeton, New Jersey Research and Development Center. March 24, 1972 is the date and the theme of the program will be **Coal and Its Conversion to Higher-Value Energy Products.** FMC personnel will present papers on coal as a natural resource, fuidized-bed pyrolysis of coal, hydrogenation of coal-derived oil, and the Cogas venture. A tour of the FMC coal pyrolysis and hydrogenation plant is part of the program.

This program has been planned for the Projects Committee by R. E. White of Villanova, R. T. Eddinger of FMC, and C. W. Clump of Lehigh.