

DIVERSIFIED AND SPECIAL PROGRAMS in Undergraduate ChE Education

R. A. KEPPEL, R. W. FAHIEN AND M. TYNER
University of Florida
Gainesville, Fla. 32601

About six years ago, the Chemical Engineering Department at the University of Florida began redesigning the undergraduate curriculum to introduce more flexibility and diversity into the student's educational experience. The considerations leading to the decision to do so and a description of the program which was developed have been reported.* The present paper is intended to provide conclusions about the value of the program and its acceptance by students.

EVOLUTION OF SPECIAL PROGRAMS

The curriculum, prior to 1965, was quite rigid (as were most ChE curricula). Although it was contemporary—students were required to take courses in transport phenomena, reaction kinetics, process control, economics and computer programming—there was little or no opportunity for development of the special talents or career objectives of the student. If he wished to sample the fruit in another orchard or to discover frontiers in other fields he was forced to take such courses as an overload. But few students could do this since loads were already high and the chemical engineering curriculum is noted for its difficult requirements.

In 1965 the faculty was inspired to develop a curriculum which treated each student as an individual—one whose interests, talents and career objectives could be expressed through selection of an option program. Each option program was formulated to represent high level work in a particular area which the student elected to study. A comparison over the past seven years of the credits allotted to electives and options is summarized below:

*R. W. Fahien, M. Tyner, and R. A. Keppel, Flexible Curricula Can Be Strong, *Chem. Eng. Ed.* 3, 154-56 (1969).

	Degree	Option Cr	Nontech. Elect.	Total Degree Cr
1964-65 Trimester Calendar	BChE	None	9	150SH(225QH)
1966-67 Trimester Calendar	BChE*** BChE	22* 6	7 7	140SH(210QH) 140SH(210QH)
1967-68 Quarter Calendar	BChE*** BChE	16** 16	6 6	142SH(213QH) 142SH(213QH)
1968-1970	Little change from 1967-68.			

*10 credits specified to be from ChE offering

**4 credits specified to be from ChE offerings

***This designation was used for the Practice Options.

It has been dropped but the options are available under the BChE degree designation.

The considerations underlying the development of the option program may be recapitulated as follows:

1. The chemical engineering curriculum should provide broad education and professional training, and allow for differences in student goals and talents and treat him as an individual.
2. All programs should contain those fundamental, core courses required for the practice of chemical engineering. No program should be considered an easy path to a cheap degree.
3. Option programs should not entail more than 10% of total degree requirements so that students would not be unduly penalized if wrong choices were made.
4. Choice of option should be deferred until the senior year in most cases.
5. Substitutions for a few courses in the option program should be permitted when the student has a sound reason.
6. Residence requirements and credits should not be increased beyond the four-year program already established by the college

and generally found to be favored by students, educators and employers.

THE CURRICULUM FOR 1971-72

Pre-Engineering

Florida students are not enrolled in the College of Engineering during their first two college years. Instead, they may enroll in any of the thirty or more junior colleges or in University College. This procedure has necessarily led to the development of pre-engineering curricula which are not under the administration of the College of Engineering. In most cases however, the lower division colleges strive to meet the standards of preparation which have been negotiated with University College. The credit hour requirements in various subjects are listed in Table 1.

Deficiencies in any of the subject areas are made up after transfer to the College of Engineering, in which case the student is required to earn more credits than the minimum shown for the BSChE degree. In some cases, the student has acquired credit such as organic chemistry which may be transferred to upper division.

TABLE 1. PRE-ENGINEERING CURRICULUM

Comprehensive English	
American Institutions	9
Humanities	12
Analytic Geometry and Calculus	20
Elementary Differential Equations	3
General Chemistry	12
Physics With Calculus (Including Lab)	12
Engineering Graphics	2 OR MORE
Engineering Concepts and Studies	1
Physical Fitness, ROTC, or Personal Development	6
Department Requirements and Elective	10
Total, QH	96

Upper Division Core Courses

Upon transfer to the College of Engineering the student reports to his departmental advisor and a program for the next three quarters or more is laid out based upon his state of preparation. Generally, this will involve courses identified as 300 level although some 400 level courses such as physical chemistry and thermodynamics must be taken as pre-requisites for senior ChE courses. The core courses for all chemical engineering students are given in Table 2.

There are many details of the core program which could be discussed but perhaps the above listing is sufficient to show that essential subject

TABLE 2. CORE COURSES IN CHE CURRICULUM

A. Engineering & General Subjects		
(Common to most Dept.)		QH
Computer Model Formulation (Incl. Programming)		3
Introduction To Electrical Engineering		5
Engineering Mechanics 1 (Statics & Dyn.)		5
Engineering Mechanics 2 (Dyn. & Strength)		5
Engineering Statistics		3
Materials Of Engineering		3
Seminar		1
Nontechnical Electives		9
		<hr/> 34
B. Chemistry (After General Chemistry)		QH
Organic Chemistry		8
Physical Chemistry		7
Physical Chemistry Lab		2
Instrumental Anal. Lab		2
		<hr/> 19
C. Chemical Engineering		QH
1. Process Operations Analysis		
Introduction To CHE (Mass & Energy Bal)		5
Measurements Lab		1
Systems Analysis		2
Analog Computer Lab		1
Fluid Flow Operations		3
Heat & Mass Transfer Opns.		3
Staged Systems Operations		3
ChE Operation Lab 1		3
ChE Operation Lab 2		3
Process Control Theory		3
Process Control Lab		1
		<hr/> 28
2. Thermodynamics And Rate Processes		QH
Seminar in CHE Thermodynamics		1
Molecular Phenomena In CHE		3
CHE Thermodynamics		3
Chemical Kinetics		4
Kinetics Lab		1
Elementary Transport Phenomena		3
Transport Phenomena Lab		1
		<hr/> 16
3. Economics And Design		QH
Cost Est. Of Process Design (Case Studies)		3
Process Design		3
		<hr/> 6
4. Technical Electives In Option areas		QH
Total (Including 10 Cr. Previously Noted		24
Which May Be Taken in U.C. or J.C.)		127
Total Credit For BSChE Degree, QH		213

matter has not been left out in order to make room for the option program.

The Option Program

The option that most closely resembles the current concept of chemical engineering curric-

... the faculty was inspired to develop an option program which treated each student as an individual ...

ula is called the **Process Option**. The subject matter specified is given in Table 3.

The option is designed for the student who feels sure that he wants to stay in chemical engineering and that he should prepare himself to accept career employment in the chemical industry or to undertake graduate work in chemical engineering.

The **Systems Option** and the **Science Option** are quite similar in course listings and involve replacement of one or two courses (Polymeric Materials and/or Advanced Design) by Matrix Methods and another math or science course. The Systems Option is designed for the student who wishes to apply computers and mathematical modelling to automation of chemical complexes. The Science Option is primarily for the student definitely planning to do graduate work leading to a career in research and/or teaching.

The **Interdisciplinary Options** were introduced because it was felt that chemical engineering problems were to be found in a variety of industries not ordinarily considered to be the domain of chemical engineers; e.g., problems of reaction kinetics in rocket propulsion, problems involving interfacial transport phenomena in microelectronics, and problems relating to mass, momentum and heat transfer in human organs.

TABLE 3. PROCESS OPTION COURSES

Multidimensional Transport Phenomena*	3
Polymeric Materials*	3
Reactor Dynamics And Design*	3
Advanced Process Design*	3
Mathematical Methods In CHE	3
Technical Electives	9
Total, QH	24

*Second level courses in subject area.

TABLE 4. BIOMEDICAL OPTION COURSES

Intro. Zoology Lab (Includes Anatomy and Physiology)	4
Principles Of Animal Biology	5
Embryology	5
Cellular Physiology	5
Tissue And Organ Physiology	5
Total, QH	24

The **Bio-medical Option** (Table 4) was developed with the cooperation of the counselor for the pre-med students. The courses listed are from

his recommendations and assurances that a chemical engineer having this option with good overall grades could gain acceptance to most of the leading medical schools of the country.

In addition to the relationships with established disciplines a new graduate program in Environmental Engineering was being developed

TABLE 5. ENVIRONMENTAL OPTION COURSES

Water Supply Engineering	4
Water And Waste Water Analysis	4
Treatment of Waste Water	4
Environmental Engineering	3
The Chemistry Of Water Treatment	5
Electives	4
Total, QH	24

at the University of Florida which needed a supply of students with undergraduate training closely allied to chemical engineering. It was felt that the problems of air and water pollution abatement should be solved through the application of chemical engineering principles and that the chemical engineer who also has studied Environmental Engineering is ideally qualified to do so. This program is shown in Table 5. Another option introduced in the fall of 1971 is **Computer and Information Science**. Several other engineering departments at the University of Florida are also offering this option which will specify courses offered by the newly created CIS Department.

There are several other options available to students in the general area that we have called **Applied Science** in our catalog description. It does not seem necessary to give details of each of these. The important fact is that in each case an attempt has been made to get a recommended list of courses from counselors of the department involved so that the option represents more than introductory work in the field.

In contrast to the options discussed so far there have been three Practice options offered since 1966 and they are retained in the 1971-72 catalog. The **Business and Sales Option** has an attraction for many chemical engineers who might want to strive to become managers and directors of chemical complexes. They will need a technical background as well as advanced course work in management and/or sales. Some excellent students have chosen this option which is shown in Table 6.

The **Operations Option** (Table 7) is designed to expose students to practice oriented coursework such as corrosion, polymeric materials, management and process economics.

TABLE 6. BUSINESS AND SALES OPTION COURSES

Basic Technical Writing	3
Public Speaking	4
Principles Of Management	4
Principles Of Organization	4
Business Law	5
Process Economics (Advanced)	3
Total, QH	<hr/> 23

TABLE 7. OPERATIONS OPTION COURSES

Process Economics (Advanced)	3
Corrosion or Electrochem Eng	3
Polymeric Materials	3
Management Electives	14
Total, QH	<hr/> 23

The **Liberal Studies Option** has not so far been very popular with chemical engineering students. Only one student has chosen it. When the option was introduced it was thought that it might attract students who wanted to pursue two goals simultaneously; that is, a technical career and a broader knowledge of himself and society. The program has not been advertised and since its availability would not ordinarily be known to counselors in junior college or University College, it is probable that students are unaware of its existence. But it may also be that students who have chosen engineering for a career have not been interested in taking any more humanities or social studies courses beyond those required.

RESULTS AND EVALUATION OF THE OPTION PROGRAM

Student acceptance and use of choices which are made available to them are probably as good indicators of the value of the program as one can find. Statistics which have been compiled for the period June 1969 to June 1971 indicate a wide diversity in selection of options, (see Table 8).

Many students, of course, do not immediately find the type of employment which corresponds to the option they chose. But they are still prepared for chemical engineering work and only a few students in the lowest percentile standing have had difficulty finding employment. Thus far, all of our ChE graduates have found jobs.

It seems fair to conclude that the option program is doing what was intended—preparing students with a sound foundation in chemical engineering yet permitting them to branch into other fields if the opportunity arises and they are so inclined.

Since most of the option courses are taken outside the department, the curriculum has not led to a large increase in teaching loads. In fact some of the departmental courses were already being taught as electives, as articulation courses for new graduate students, or as service courses for students outside the department. Furthermore, since we have a faculty of nineteen it has not been difficult to find faculty to teach our courses without excessive teaching loads. Hence the cost of the flexible curriculum is quite small in proportion to its benefits.

These benefits include in addition to student satisfaction, a steady (or at times increased) student enrollment in contrast to decreases elsewhere and in the face of the competition among twelve engineering degree programs in the College of Engineering. While other departments have reduced their requirements to 202 QH, we have been the only department in the College to maintain 213 QH. It has so far seemed more important to our faculty to maintain a high quality but flexible program than to seek additional students through a reduction in hours.

TABLE 8. OPTIONS CHOSEN IN THE CHE BACHELOR'S DEGREE PROGRAM AT THE UNIVERSITY OF FLORIDA

OPTION	%
Process	19
System	6
Science	3
Interdisciplinary	
Environmental Engineering	18
Biomedical Engineering	10
Electrical Engineering	5
Food Science	3
Other (No Duplications)	9
Business and Sales	21
Operations	5
Liberal Studies	1
Total Chosen	<hr/> 100

The program has not been without some drawbacks. More time is needed for counselling students. There are some students who tend to defer making decisions, who would rather be told what to study than to assume any of that responsibility themselves. It sometimes takes several meetings between counselor and student to seek out an area that might be of special interest—one which might fire his imagination and motivate him to greater achievement. But experience has been that for the most part our flexible curriculum has succeeded in doing so. □