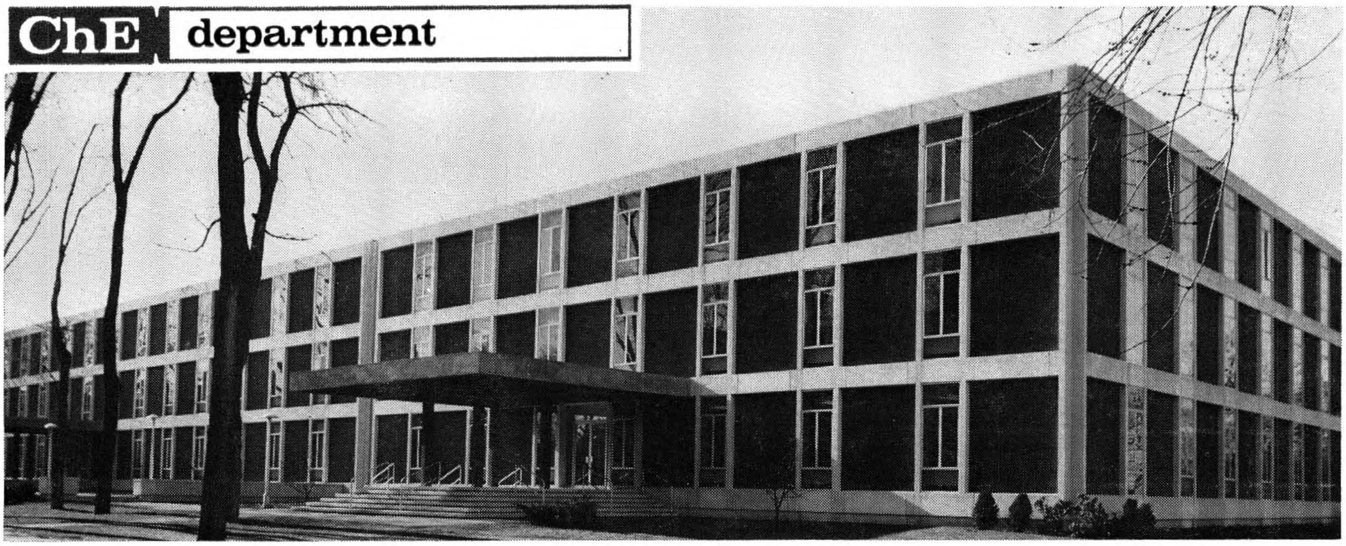

RENSSELAER

CEE features a school which incorporates a new Master of Engineering degree into a dual administrative structure.

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Chemical engineering education at Rensselaer has in recent years been strongly influenced by two major decisions of the School of Engineering. The first, taken in 1963, was to adopt a new structure for engineering education which departs significantly from the traditional pattern; while the second, taken in 1967, was to reorganize the administration of the School of Engineering.

In the educational structure, all engineering students pursue a pre-engineering program equivalent to three academic years during which emphasis is directed to the foundations of engineering by providing broad background in the natural sciences, mathematics, humanities, social sciences, engineering science and engineering. At the end of this phase the student may elect either to pursue a fourth year of study to a Bachelor of Science degree or to seek admission to the Professional School of Engineering and if qualified to undertake a coherent two year advanced study program to the Master of Engineering in a field of engineering. Students achieving either degree objective can continue their formal education either in engineering or in some other discipline or seek direct entry into a career.

The rationale of this educational structure originates with five principles: 1) the objective of a baccalaureate program should be basic education of a broad character, 2) professional engineering education should be based on a broad pre-engineering core, 3) the students' ability to resolve engineering problems must be developed and creativity should be fostered, 4) specialization in depth is necessary not only for career entry but also for developing ability to acquire new competence, and 5) programs must be flexible and responsive to individual needs.

These principles have not only influenced the educational programs but also played a fundamental role in the reorganization of the School of Engineering. The most pronounced feature of the new administrative structure is its dual character in that responsibility for research, advanced study and personnel administration is assigned to seven Divisions of Advanced Study while responsibility for all phases of programs up through the master's degrees is given to twelve Curriculum units, including the pre-engineering curriculum. Faculty members are associated with that division whose scope includes their individual fields and with those curriculum units reflecting their professional interests. From a curriculum point of view, this structure provides for an emphasis on educational development and makes available the whole faculty as a teaching resource.

THE PRE-ENGINEERING PROGRAM

The full implications of the pre-engineering program, Table 1, cannot be appreciated without an intimate awareness of the course content and philosophy. On the surface, it may seem to be a typical product of the trend towards unification of phases of engineering programs noted in recent years. However, such unification is frequently achieved as a lowest common denominator of the needs of all of the engineering specialties on which consensus can be obtained. In this instance, this program, which is under the direct control of the pre-engineering curriculum unit, is designed to provide the educational base upon which to superimpose professional study in depth without preoccupation with the specifics of the professional fields involved. In this context, subject matter represents not only a basis for further education of a professional nature but also a foundation for intellectual growth for a future whose details are in the main unperceived. The selection of knowledge must be based on appropriate criteria of value such as its longevity, range of application, contribution to future growth, relevance to the individual field of study and relevance to other subject areas. In addition, a balance must be obtained between prerequisites for areas of specialization, liberal education from a technical as well as nontechnical vantage point, and the opportunity for students to individualize their plans of study.

Two features of the program are worthy of note. First, the electives in the third year allow the student to plan a program suited to his interest subject to the limitation that his intended field of specialization may identify a maximum of two prerequisites. Most students oriented to chemical engineering elect a year of physical chemistry and courses in heat and mass transfer and thermodynamics emphasizing chemical and phase equilibrium. On the other hand, individual students can have unusual educational interests which may suggest rather different elective patterns and still meet the needs of the chemical engineering curricula either in the fourth year program or the two year Professional School program.

The second major feature is the engineering design stem which is a structured sequence of experiences intended to develop the student's perspective toward engineering,[1] The sequence is initiated with Engineering I,[2, 3] in which the elements of the engineering process, i.e. problem formulation, conceptualization, analysis and decision making, are developed through loosely defined engineering problems which will yield to analytical solutions under proper assumptions. The Engineering Laboratory courses continue this theme through engineering problems which require experimental information. The next stage occurs at the senior level or in the first year of the professional school program in an advanced course in which the students address more substantial problems oriented to their field of specialty and is concluded by an engineering project or thesis in the second year of the master's program. It should be observed that this sequence is aimed at developing the students' ability to resolve problems and to apply knowledge out of the context in which it has been learned. While a broad interdisciplinary flavor is maintained at the first two levels, a strong orientation in the specialty discipline can be obtained in the latter portion.

TABLE 1 — PRE-ENGINEERING CURRICULUM

Freshman Year	
Mathematics I	Mathematics II
Chemistry I	Chemistry II
Physics I	Physics II
Engineering Science I	Engineering Science II
Humanities Elective I	Humanities Elective II
Sophomore Year	
Mathematics III	Mathematics IV
Physics III	Physics IV
Engineering I	Thermodynamics I
Mechanics I	Mechanics II
Social Sciences Elective I	Social Sciences Elective II
Junior Year	
Fluid Mechanics	Materials
Circuit Theory	Engineering Laboratory II
Engineering Laboratory I	Mathematics Elective
*SES Elective 1	SES Elective 3
SES Elective 2	SES Elective 4
Humanities or Social Sci. Elective	Humanities or Social Sci. Elective

*Science or Engineering Science Elective

CHEMICAL ENGINEERING CURRICULA

The structure of the programs of specialization to be superimposed on the pre-engineering program was dictated by two major factors. First, of the students electing an engineering education, an increasing number have career objectives other than a direct commitment to engineering *per se*. For these students, an engineering education with its focus on technical and quantitative subjects can be a liberal education eminently suited for the diverse needs of our society so strongly influenced by and dependent on technology. Second, for those students who would practice engineering in a modern sense, an unusual degree of competence and flexibility to deal with problem areas not yet perceived using skills, tools and knowledge not yet discovered must be developed.

In order to meet these goals, the new educational pattern provides two curricula in each field or discipline, i.e. a one-year program to the Bachelor of Science degree and an integrated two year program to the Master of Engineering degree. In addition, since accreditation requirements as applied to the baccalaureate program would have severely limited flexibility, accreditation was obtained for the Master of Engineering as the first professional degree.

TABLE 2 — MASTER OF ENGINEERING

First Year	
Separation Process	Process Design
Organic Chemistry	Chemistry Elective
Chem. Engrg. Calculations	Chemical Engrg. Kinetics
Chemical Engineering Lab	Chem. Engineering Lab
Elective 1	Elective 3
Elective 2	Elective 4
Second Year	
Advanced Fluid Mechanics	Heat or Mass Transfer
Chemical Process Dynamics	Masters Project or Thesis
Master Project or Thesis	Elective 7
Elective 5	Elective 8
Elective 6	Elective 9

In addition to the requirements shown above, the students' plan of study must include a one-year sequence in Humanities or Social Science and courses in Thermodynamics and Engineering Economics.

For the Master's program, Table 2, course sequence and content is designed on the basis of an integrated two year program and some of the courses taken in the first year, including electives, are graduate courses. It may be noted that students apply for admission to the program in their junior year and are judged by the same admission criteria applied to graduate study. By allowing these students to take graduate courses during what would have been their senior year, in-depth study which can include advanced courses previously accessible only to doctoral students can be obtained. Although, the elective freedom is reduced by the general requirements of a one-year sequence in humanities or social science, courses in thermodynamics and engineering economics, and one year of physical chemistry if not taken in pre-engineering, this normally leaves the student with five electives which he can sequence in the first or second year to follow a diverse number of minors or specialty sequences such as transport phenomena, systems engineering, polymer science and engineering, management, etc.

The required courses in the program include the obvious topics for chemical engineers, namely, Separation Processes, Process Design, Kinetics and Engineering Economics. The remainder of the core, Chemical Engineering Calculations, Thermodynamics, Advanced Fluid Mechanics, Process Dynamics, and Heat or Mass Transfer, is a structured sequence of graduate level courses in which the topics are presented in a framework of modern mathematical analysis. The stage for this treatment is set by the Chemical Engineering Calculations course in which an intensive study of operational calculus is undertaken permitting this sequence to be focused on truly general and fundamental concepts. The overall core requirements are intended to develop the knowledge, understanding and skills required not only to initiate a career as a contributing member of an engineering group but also because of the depth of study to promote the students' potential for a creative engineering practice and to minimize the risk of obsolescence.

The Bachelor of Science curriculum for chemical engineering majors, Table 3, assigns approximately one-half of an academic year to the major field. In view of the elective opportunity in the junior and senior years, students wishing to emphasize subjects relating closely to chemical engoineering can follow plans very similar to strong traditional four-year programs. However, in the absence of accreditation requirements, students may use this elective opportunity to obtain educational experiences uniquely suited to advanced study outside of engineering or to a broad spectrum of careers for those who do not choose to practice chemical engineering *per se.*

TABLE 3 — BACHELOR OF SCIENCE

Separation Processes	Process Design
Organic Chemistry	Chemical Engrg. Kinetics
Chemical Engineering Laboratory	Engineering Economics
Humanity or Social Sci. Elective	Chemical Engineering Laboratory
Elective 1	Humanity or Social Sci. Elective
Elective 2	Elective 3

Because there is widespread concern that common core approaches tend to drive chemistry from engineering curricula, it is worth noting the following about the Rensselaer program. Every chemical engineering student takes a minimum of two years (4 courses) in chemistry beyond the general chemistry required of all engineering students. If he so chooses, and most chemical engineering students do, the student may elect additional chemistry. Indeed the flexibility of the curriculum permits a student to arrange a sequence in chemistry that would take him through to the most advanced graduate courses. Chemistry has not disappeared and is not disappearing from the programs of study of chemical engineering students at Rensselaer.

DISCUSSION

Although these brief descriptions of the program and organization can serve only to indicate some of the highlights, the experience to date suggests some conclusions.

The pre-engineering concept has focused the attention of the students, and the faculty involved with them, on their identity as engineers first and as specialists second. With subject matter that is in fact basic to engineering practice, a more enlightened and perceptive treatment is promoted. Engineering faculty members involved with this program have shown an increased awareness and concern for the rationale of course structuring, content and philosophy. The economics of providing new specialties is eased and a sound basic education is assured. With the pre-engineering curriculum recognized as an administrative entity, more viable and aggressive concern for the character and the quality of this phase of the program has been obtained.

From a chemical engineering point of view, the dual opportunity at the specialty level has increased significantly the ability of the student to follow a program particularly suited to his interests. Rather more diverse educational goals suited to the broad spectrum of career opportunities can be met. In addition, the integrated two year Master of Engineering program permits students to achieve considerably more advanced study in depth than under the alternative four plus one arrangement.

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LETTERS (Continued from page 55)

agreed with Professor Henley about the futility of advertising. . . .

At a high school Career Day recently, I sat next to a faculty man from the Physical Education department. "Hey kid," he said, "we have the highest paid college graduate this year — O. J. Simpson."

Professor Henley states that "we are not attracting the sons and daughters of college graduates." With only 3% unemployment in the United States, job opportunity is not much of an incentive to today's college student. But it has always been hard to attract rich kids to the more difficult curricula. The adage "shirtsleeves to shirtsleeves in three generations" has been around for a long time.

If Professor Henley encounters only "bread and butter types" among his students, I suggest that he is not getting across the glamour and importance of chemical engineering. And we can do without the "hippie types." The philosophy of the hippies, it seems to me, is to live only for today. The hippie takes whatever pleasures he desires when he wants it caring not a whit for the consequences of his actions on himself or on others. If he has any brainpower, he will addle it with "pot." Chemical engineering philosophy on the other hand, might well be defined as "leaving the world a little better than you found it."

Chemical engineers don't like to advertise. . . . The increase in enrollment is the result of advertising, pure and simple. Not meaningless platitudes, but getting the story to the high school students. Do you know what a high school Career Day is really like? Thirty to fifty different fields are represented and the most successful graduates are pictured as typical. The poor high school student can visit only three or four fields in the time available. At the last one I attended, Chemical Engineering got six visitors, Psychiatry got eighty-seven. When even the university president (ours) suggests that all BS degrees ought to contain the same number of credits and require the same number of courses, can you blame the high school kid for thinking that one BS degree is about as good as another and thus picking that which is the easiest?

Specifically, what do we do at Montana State? We give the widest possible publicity by means of poster announcements to all the State high schools to the industrial interest in chemical engineering as expressed by their forty-five $250 cash scholarships to freshmen. We follow this with newspaper publicity for each winner.

We show the students that chemical engineering does make a major contribution to man's problems. The population explosion and its accompanying pollution problems, if solved, will be done by "applied chemistry on a large scale." That's a pretty good definition of chemical engi-