the preceding one. Eighteen out of 45 in the class selected the R & D Option. This represented a smaller proportion of the class than before and a group composed almost exclusively of higher-ranking students. The D & P group was composed predominantly of the lower-ranking students, but many of these were very good. Grade-point average for the two groups were 3.2 and 2.6, respectively. Although higher than the corresponding 1963 averages, they were further apart.

The 1965 class was similar in size and general characteristics to its predecessor and produced similar results. Only one of the R & D group missed ranking in the top half of the class, while the D & P group was quite heterogeneous — it contained both the third man from the top and the anchor man. Grade-point-wise, the two groups almost duplicated those of the previous year.

The future plans of members of the 1963, 1964, and 1965 classes at graduation time are summarized in Table III.

TABLE III. Future Plans of Graduates

	1963		1964		1965	
	D&P	R&D	D&P	R&D	D&P	R&D
Graduate School	1	9	4	10	3	8
Industry	16	5	18	7	26	6
Military Service	2	1	5	1	1	0

Similar trends were observed in each class. A majority of those in the R & D group planned to work on advanced degrees in chemical engineering, but a few planned to take graduate work in business administration. On the other hand, practically all of those in the D & P group planned to enter industry and the few exceptions who planned to enter graduate school were not continuing in chemical engineering. Two were contemplating post-graduate study in law, two in industrial engineering, two in business administration, and one in general science. Only one member of the 1965 D & P group actively sought admission into chemical engineering graduate school.

In general, the chemical engineering faculty at Iowa State is pleased with the way the two-option program has worked. Although the system provides two paths which are significantly different in content and objective, the teaching load has not increased appreciably and instruction efficiency has not suffered by having some classes too small and others too large. Most important of all, the needs and interests of individual students have been more nearly fulfilled.

The Rensselaer Program for Engineering Education

The Rensselaer Program for Engineering Education

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Engineering programs have undergone considerable modification in recent years in response to professional needs. However, the changes primarily involving the replacement of skill courses by basic and applied science studies appear to meet immediate rather than future requirements. At Rensselaer a planning committee has analyzed the long-range problem and has reached five conclusions (*2*):

1. The primary objective of the baccalaureate for the engineering student should be basic education of a broad character.
2. Pre-engineering education and professional engineering education should be recognized as separate phases. Admission to professional programs should be based on pre-engineering student performance which shows potential for the practice of modern engineering.
3. More emphasis should be directed to the development of the engineering approach in decision making, perspective, and attitude, and to the fostering of creativity.
4. The student's capacity to acquire specialized competence in his professional practice can be developed only through an experience of specialization in depth. However, such specialization must not be achieved to the detriment of breadth of education.
5. Programs of study in which specialization is to be acquired must be designed to meet the challenges of the future and must be sufficiently flexible to satisfy the demands of the evolving technology.

These conclusions, now in the form of five statements of principle, form the basis for the engineering program now being implemented and developed at Rensselaer. The new program is believed to be a significant departure from current engineering educational practices both in content and philosophy. All engineering students pursue a pre-engineering program for three academic years. At the conclusion of this phase the student must choose one of two paths to continue his education: (a) seek admission to the professional school in which the first-stage program of two academic years leads to the Master of Engineering as the first professional degree; or (b) complete a fourth-year program subjected to minimal curricular requirements, leading to the Bachelor of Science degree. At the conclusion of the first-stage professional program, students may pursue advanced studies leading to the doctorate with emphasis either in research or professional practice.

Prior to either of the bifurcation points (the end of the pre-engineering phase and of the Master of Engineering program), electives are permitted whereby the student may individualize his program in the light of his interests and long-range objectives. This opportunity must not be interpreted as an excuse for specialization at the pre-engineering level; this would be premature and out of keeping with the basic philosophy. The advantage of the elective opportunity is to remove from engineering education the curricular straightjacket all too often imposed on the student.

Although the educational concept has been determined and a prototype plan is now being implemented, additional development work is required. There are three phases of development: (a) the pre-engineering curriculum, (b) professional school programs, and (c) engineering perspective. Development of the pre-engineering phase requires identification of those science, mathematics, engineering science, and humanities and social science experiences which are basic to engineering endeavor and which will form the foundation for the professional practice of the future, say 10 to 20 years hence. In addition, it is necessary to determine the order and the manner in which these experiences are to be obtained. It will not suffice to seek the lowest common denominator of courses acceptable to the several professional specialties, nor would a compromise consisting of the most prized components of the specialties be adequate. What is necessary is a positive identification of the ingredients fundamental to meaningful engineering practice, not in today's framework but in that foreseen for the future.

For the professional phase the task is to define a rationale for identifying sectors of professional practice worthy of advanced study, and criteria for judging the suitability of proposed study plans. Programs must not only be relevant to future professional needs but must also develop the student's capacity to specialize rather than to narrowly compartmentalize his thinking. Professional school specialization must be directed primarily at developing a particular competence for further growth. Detailed knowledge of current technology, while useful in initiating a career, is of lesser importance.

Development of sound engineering perspective by the student with regard to the professional objective of "seeking optimal means of exploiting nature for human purposes within the framework of relevant restraints" is the third goal. The engineering process can be divided into four major steps:

1. Problem recognition, formulation, and delineation into manageable components. Relevant restraints such as economics, reliability, safety, space, etc., must be identified. Information applicable to the particular problem situation must be recognized.
2. Conception of all reasonable alternative solutions to the recognized problem.
3. Analysis of alternative solutions with regard to feasibility, performance, etc.
4. Selection and implementation of the best possible solution.

The overall process is basically iterative. The conceptual phase may feed back to problem formulation or constraint definition. The analysis step may in turn suggest new alternatives or even a complete revision of the original problem statement. Even the final decision step may result in repetition of parts or all of the sequence. It is this engineering process, or its equivalent as put forth by others (1, 3, 4), that is the very essence of engineering practice. The whole purpose of education in mathematics, physical sciences, humanities, and social sciences is to provide the means by which this process can be executed with distinction.

It is proposed that the overall engineering process can be delineated into identifiable and manageable components and that the student can acquire competence in these components through planned experiences. A thread of general engineering will be provided throughout the program, starting with a sophomore level course followed in the third year by a year-long engineering laboratory. The thread will be continued in the first year of the profes-

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sional school with an advanced course in engineering in which the student will be guided through challenging assignments, and will culminate with a project experience on a worthy engineering problem as a requirement for the Master's degree. The project will serve as a capstone, for here the student's ability to discharge his professional obligation will be judged by an examining committee of faculty and practicing engineers of acknowledged reputation.

Sound and implementable programs for engineering education cannot be developed by a simple rearrangement of the blocks of knowledge and of analysis currently available. The knowledge must be organized into more basic elements and the subtle interrelationships that bring about new arrangements more suited to future needs must be identified. One must inquire as to the longevity of each particular element, its relationship to other elements, its role as a foundation for still other elements, its breadth of applicability, and its contribution as a base for future learning beyond a man's formal education.

The program for engineering education described possesses several features which may be viewed as advantages over current practice. The pre-engineering concept will insure that all students have had the opportunity to acquire the essential background in those fundamentals underlying engineering as a single field. The student's intellectual awareness of the unifying themes of nature will not be confined by the expediencies of current specializations. The graduate should be better prepared to meet the shifting challenges of the future.

Selection of those students wishing to pursue the serious practice of engineering will allow the fourth-year programs of professional school students to proceed at advanced levels and to probe more deeply into the subject area than is feasible now in a typical terminal year. Coherent programs leading to the Master's degree will eliminate the almost inevitable duplication of effort in much course work now encountered in the one-year graduate program following the baccalaureate. This feature suggests that a more effective utilization of the student's effort may be obtained even with a liberalization of the pre-engineering requirements.

Finally, the proposed baccalaureate program will produce men whose intimate awareness of modern science and technology in combination with a broader and more liberal perspective will permit meaningful and significant careers outside of engineering, per se, in a society markedly affected by technological consideration.

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Zak (*3*) and dynamic equilibrium by Wergang (*19*). Osburn has described a visual demonstration of fractional distillation (*15*) and a plug-board teaching aid for analog computer instruction (*16*).

Professor Hubert N. Alyea has reviewed all the demonstrations appearing in the Journal of Chemical Education, abstracted them, and grouped them by subject. Two series of abstracts appeared, the first covering the period 1924-56 was printed in J. Chem. Ed. from Vol. 34, No. 1, January 1957 through Vol. 37, No. 8, August 1960. The second series covered the years 1957-59 and was printed in Vol. 37, Nos. 2-8 (1960). Subjects of interest to chemical engineers, although largely physical chemical in nature, and the location of abstracts (in the first series only) describing demonstrations are given in Table I.

In the field of instrumentation or process control analysis, Larson and Heng (*10*) described a process dynamics experiment. In a series appearing in ISA Journal, descriptions by Balise (*4*) and Hubbard (*6*) are most useful. Major (*13*) described an instrumentation teaching aid.

Recently the National Science Foundation has sponsored a project of Professor Fred Landis, Department of Mechanical Engineering, New York University, New York 53, New