

SHOULD WE ABANDON CHEMICAL TECHNOLOGY?

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Several years ago, an article appeared in CHEMICAL ENGINEERING EDUCATION by Professor L. B. Anderson (1). Its title was "Is Unit Operations a Dirty Word?". His conclusions were that modernized concepts of unit operations would indeed be around for a long time. In the light of today's emphasis by many educators on engineering science, it would seem even more appropriate to ask the same question about technology, in particular, chemical technology.

Technology is defined herein as applied science. The prefix "chemical" simply denotes the application of scientific principles by engineers to solving the problems of the chemical industries. The net result is chemical engineering synthesis--the putting together of the many facets of science and engineering principles to guarantee performance in keeping the chemical industries in the forefront to meet human needs. This is chemical technology in its broadest sense. It encompasses research, development, design and systems analysis, manufacture, marketing and sales. All of the basic fundamentals learned in a modern chemical engineering curriculum are utilized to a degree, including chemistry, physics, mathematics, thermodynamics, kinetics, unit operations, and economics. In its narrowest sense, chemical technology can be archaically described as a highly descriptive tale of the birth, life, and often death, of many a chemical industry. It is obvious that there is a vast difference between these two extremes as to what constitutes chemical technology and therefore how it should be taught, if at all, to chemical engineering students.

If we accept chemical technology in the broadest sense, there should be no doubt in the educator's mind that this type of material must be taught to chemical engineers. The mechanics of teaching chemical technology have been debated for years. An earlier commentary on this subject has been given by Koffolt (2) in 1938 and by Withrow (5) as far back as 1911. Since chemical technology represents a synthesis concept involving a number of basic principles, we at Ohio State have long felt that it is logical to place an integrated chemical technology sequence in the senior year. This is supported by the recommendations of the Grinter report, p 14, issued in 1955 by an ASEE Committee on Evaluation of Engineering Education (2).

One of the chief questions is whether the student should vicariously experience this vast realm of chemical technology by studying in depth the patterns of numerous chemical industries or whether he should personally wrestle with several realistic and hopefully new problems of the chemical industries and arrive at his own solution. While there is less room for argument among chemical engineering teachers on this latter method, the study of industries is certainly controversial. It is our opinion that both methods should be used and integrated in such a manner that the case history--vicarious experience material is injected at the start of a technology sequence in a painless and interesting manner. This combination and timing works to good advantage in an over-all year's program of study in chemical technology.

Table 1 summarizes the course sequence in chemical technology at The Ohio State University. During the Fall Quarter, a comprehensive survey of the chemical process industries (Ch.E. 761) is introduced. This controversial teaching concept will be discussed in detail later. Coupled with the background type of course is Chemical Engineering Economy (Ch.E. 760). The principles of economic balances, time value of money, and profitability analyses are typical of the subject matter taught. The laboratory work in Chemical Engineering Economy consists of several comprehensive economic analysis problems, whereas in the process study course about 25% of the laboratory time is spent in plant visits and the balance in library research and reporting.

In the Winter Quarter, the process development course, (Ch.E. 770), is taught on an informal basis with the students given a typical chemical process study. The sequence includes library research, laboratory and pilot plant experimentation, preliminary process design, and economic analysis. Several methods are used, depending on the type of problems and size of class. The students work in groups of 3-5 on one of several related processes or as an entire group on one problem. In the latter case, an industrial research and development group is simulated with assignments rotated periodically throughout the quarter. This particular method develops management and communications skills as well as technical specialization since it is impossible for each student in a large group to follow completely the work of others in an over-all coordinated project.

Individual solution of the AIChE Student Contest Problem, Ch.E. 790, plus lectures on use of computers in optimization studies round out the Winter Quarter design sequence.

TABLE 1

CHEMICAL TECHNOLOGY SEQUENCE - SENIOR YEAR
CHEMICAL ENGINEERING DEPT. - OHIO STATE UNIVERSITY

<u>Quarter, Course Number and Title</u>	<u>Credit Hours</u>	<u>Lecture Hrs/Wk</u>	<u>Laboratory Hrs/Wk</u>
A. FALL QUARTER			
Ch.E. 760 - Chem. Engr. Economy	3	2	2 (computation)
Ch.E. 761 - Chem. Engr. Processes	3	2	2 (25% on plant trips)
B. WINTER QUARTER			
Ch.E. 770 - Chem. Engr. Process Development	4	-	12 (50% experi- mental)
Ch.E. 790 - AIChE Student Contest Problem and Systems Analysis	2	2 after 30 day period	100 hrs over 30 day period
C. SPRING QUARTER			
Ch.E. 772 - Chem. Engr. Process Design	3	1	6
Engr. Draw. 755 - Plant Design	3	1	6
Ch.E. 791 - Special Project Problems Investigations	5	-	15 (0-90% experimental)

A chemical engineering design sequence is given in the Spring Quarter. The process design course (Ch.E. 772) starts with a new problem for the purpose of teaching optimization methods of process design. Digital and analog computers are used to aid in the solution of a relatively complex problem where many basic scientific, engineering, and economic principles influence the results. The plant design course (Engr. Draw. 755) covers the principles of plant layout and auxiliaries design, again using another new problem.

The special projects problem (Ch.E. 791) is usually conducted as an individual assignment to the student by one of the professors. The scope varies widely and may run from a design project with little experimental work to the opposite extreme. The criterion in each case is to have the student solve some challenging problem.

In summary, the chemical technology sequence presents the students with five major situations which must be resolved on a professional basis. In addition, they have acquired a well-rounded knowledge of the chemical industries and a good foundation in the key area of economics. This sequence of courses would represent about 12% of the usual 4-year curriculum in chemical engineering. This percentage is within the proper scope as recommended by the Grinter report (2), page 22.

I should like to proceed next to the truly controversial technological background course as encompassed in Chemical Engineering Processes (Ch.E. 761). This type of course has (or had) many titles such as industrial chemistry, chemical technology, and chemical process industries--to name a few. The philosophy of our present course can be illustrated best by first giving some past history. Before a major modernization of our chemical engineering curriculum in 1959, this course had been taught for many years as a two-course sequence of three credit hours each in the last two quarters of the senior year. Two text-reference type books with a total of 2074 pages were used for study. Eight inspection trips were taken to nearby plants with reports to be prepared. Needless to say, the course was difficult to teach, even for professors with a great deal of prior industrial experience. The rearrangement of the technology sequence to the present scheme shown in Table 1 reduced the time allowed for acquisition of technological background to one 3-hour course at the start of the sequence. There was some debate as to whether this reduction in hours could be best absorbed by studying only a few chemical processes in depth or by taking a broad-brush approach. The latter was chosen principally because all of the other chemical engineering courses were quantitative in content and the broad qualitative viewpoint often needed by engineers for prospective was lacking.

A second reason for a wide look at the chemical industries was to incorporate and orient the students' background and preparation in chemistry. No other course in the chemical engineering curriculum can better accomplish this aim. In an analogous manner, the teaching of transport processes serves to utilize the students' formal training in mathematics and physics. The importance of

TABLE 2
CHEMICAL TECHNOLOGY OUTLINE SERIES
TABLE OF CONTENTS

- I. ORIENTATION
 - A. INTRODUCTION
 - B. CHEMICAL AND ENGINEERING LITERATURE
 - C. PLANT INSPECTION TRIPS
 - D. CHEMICAL INDUSTRIES FACTS AND FIGURES
 - E. GENERAL PRINCIPLES APPLIED IN STUDYING AN INDUSTRY
 - 1. Chemistry
 - 2. Thermodynamics
 - 3. Kinetics
 - 4. Chemical Engineering Unit Operations and Unit Processes
 - 5. Process and Mechanical Design
 - 6. Economics
- II. INORGANIC CHEMICAL INDUSTRIES
 - A. SULFUR AND SULFURIC ACID
 - B. FUEL AND INDUSTRIAL GASES
 - C. NITROGEN
 - D. WATER
 - E. ELECTROCHEMICAL
 - F. CHLOR-ALKALI
 - G. PHOSPHOROUS
 - H. NUCLEAR RAW MATERIALS
 - I. HIGH ENERGY CHEMICALS AND FUELS
- III. NATURAL PRODUCT INDUSTRIES
 - A. UNIT PROCESSES AS A STUDY BASIS
 - B. OILS, FATS, AND WAXES
 - C. SUGAR AND STARCH
 - D. PULP AND PAPER
 - E. PETROLEUM
- IV. SYNTHETIC ORGANIC CHEMICAL INDUSTRIES
 - A. PETROCHEMICALS - A FRAMEWORK FOR STUDY OF ORGANIC PROCESSES
 - B. CHEMICALS FROM C₁ ALIPHATICS
 - C. CHEMICALS FROM C₂ ALIPHATICS
 - D. CHEMICALS FROM C₃ ALIPHATICS
 - E. CHEMICALS FROM C₄, C₅ ALIPHATICS
 - F. CHEMICALS FROM AROMATICS
 - G. MISCELLANEOUS
- V. POLYMERIZATION INDUSTRIES
 - A. FUNDAMENTALS
 - B. TECHNOLOGY
 - 1. Thermoplastic
 - 2. Thermosetting
 - 3. Elastomers
 - 4. Fibers

chemistry is pointed out by the AIChE Committee on Dynamic Objectives for Chemical Engineers in their report (5) from which I quote: "In the past, the education of chemical engineering undergraduates has been unique in that there has been extensive training in the parent science of chemistry. Many forces are now tending to eliminate this feature of chemical engineering, but this committee believes implicitly that instead, it ought to be carefully preserved and enhanced." What better place for the enhancement of chemistry than in the teaching of chemical technology?

A third reason for the over-all viewpoint was to help the students solve their five technology problems during the senior year with some background as to what others had done in the past. This is much the same idea as a research chemist doing a literature survey before making final plans for his own research program.

As anticipated, we were unable to find suitable texts for such a short course which meets for a 10 minute quiz plus a 40 minute lecture twice a week for eleven weeks. To streamline the study program, only the important features of each chemical process industry were to be covered, not the complete details. A set of notes was prepared in essentially outline form to achieve this aim. The table of contents is listed in Table 2. Each industry was discussed in the topical manner listed next:

1. Physical properties of raw materials and products
2. Consumption pattern
3. Methods of production
 - . Chemical reactions
 - . Process description with flow sheet
 - . Major engineering problems including thermodynamics, kinetics, process and equipment design, corrosion.
4. Economics

In general, only one or two important processes from an industry were developed in detail. One industry was assigned for study each lecture period.

These notes were nearly completed with many sections being sent to appropriate industrial companies who have graciously offered comments for revision. With this concise and direct study approach to each industry on the list, the student's time is not diluted in trying to get details via the more expansive reference book approach. Even with this new format, the student cannot possibly absorb all of the material with its implications. However, the results of obtaining a broad viewpoint of the approach to problems in the chemical industries have been gratifying in performance achieved throughout the remainder of the technology sequence. An added advantage accrued in giving the student a better sense of balance in interviews and a final choice of jobs.

Teaching in this style was easier and more interesting. With the knowledge that the students had studied the fundamental points in the outline guide of a particular industry assigned for that day, the instructor felt free to discuss in class some new innovation or recent engineering break-through related to that industry.

As a result of streamlining the study of chemical technology background material, additional time is available for individual project problems. One assignment is doing library research and reporting on two new processes. One of these processes is often carried on into process development the following quarter (Ch.E. 770). Another part of the laboratory requirements of the course is to make three chemical plant inspection trips as a group and then write up individual reports.

The course is further used as training in the methods of communications. Report writing and public speaking were removed from the new curriculum in order to substitute more mathematics and humanities. Consequently, written reports in the Ch.E. 761 course are severely graded and oral presentations are given with the aid of a tape recorder for speech training.

SUMMARY

The definitions and teaching of chemical technology have been presented in a broad, yet penetrating and modern style. The learning of necessary background material to orient the students in a chemical technology sequence has been streamlined to make an up-to-date, fast-moving, and interesting approach to this study of the processes and problems of the chemical industries.

When we consider that over 80% of our B.S. degree men go directly to the chemical industries where they immediately encounter many phases of chemical technology, why not prepare them in advance with a mature and seasoned approach to their new problems? This is the aim of a full year of integrated coursework in chemical technology. This is the reason we should never abandon nor even decrease our teaching efforts in chemical technology for the lure of engineering science per se. If we do, we will soon give up the heritage our predecessors have so stoutly made for us in best serving mankind through the combining of chemistry and engineering.

REFERENCES

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4. "Report of the Committee on Evaluation of Engineering Education," L.E. Grinter, Chairman; ASEE, Urbana, Illinois, (June 15, 1955).
5. "Dynamic Objectives for Chemical Engineering," CEP, 57 (10), 69 (1961).