

A Course on

THE STRUCTURE OF THE CHEMICAL PROCESSING INDUSTRIES*

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THIS COURSE WAS INITIATED at the University of Delaware by J. Wei and an early description is available in *Chemical Engineering Education* (Fall 1973). Jim was motivated to develop the course by his experiences with Mobil which he claims he wasn't able to put in the proper perspective until he attended the Advanced Management Program at Harvard Business School and accepted an assignment in Mobil's Corporate Planning Department. In Jim's own words: "Had I understood the "Big Picture" more thoroughly in my early years, I would have done many things differently; would have been much more effective and would have been much more positive about the value of my work."

Jim Wei taught the course largely by the case study method in 1972 and 1973. He asked me to sit in and comment on the course in 1974 and I was impressed enough with the approach to join him teaching the material in 1975. This was the year one of our better graduate students, Mike Swartzlander decided to take the course and he became interested enough to join us first as a teaching and research associate in 1975 and as a junior author in 1976. In August of 1977 we presented our material and methods of teaching at the ASEE Summer School for Chemical Engineering Faculty in Snowmass, Colorado. An enthusiastic group of some seventy faculty and industrial colleagues from some sixty different schools and a dozen industrial firms attended our

*This paper is based on a presentation of a new course made at the 1977 Summer School for Chemical Engineering Faculty by J. Wei, T. W. F. Russell and M. W. Swartzlander of the University of Delaware. H. J. Taufen a vice president of Hercules and T. Baron, president of Shell Development, helped the Delaware group describe the course by presenting two very good case studies. This article tells how the course was developed, what topics are covered and how the course is taught.

T. W. F. Russell is a Professor of ChE and Director of the Institute of Energy Conversion at the University of Delaware. He obtained his bachelors and masters degree from the University of Alberta and after working as a design engineer with Union Carbide, Canada for three years, he obtained his Ph.D. from the University of Delaware. Professor Russell is a coauthor of "Introduction to Chemical Engineering Analysis" (J. Wiley 1972) and "Structure of the Chemical Process Industries—Function and Economics." (1978)

TABLE 1
Course Outline

- 0 Reader's Guide
- 1 Introduction
- 2 Basic Economics
- 3 Basic Accounting
- 4 Input-Output Analysis
- 5 Products and Companies of the CPI
- 6 Specific Chemical Products
- 7 Specific Companies
- 8 General Characteristics of the CPI
- 9 International Aspects of the CPI
- 10 Future Prospects: Threats and Opportunities

sessions. I taught the course alone in 1978 and 1979 since Jim decided to become Head of Chemical Engineering at M.I.T. and Mike started to work full time with Union Carbide in 1976. As a result of the Summer School some twenty schools in Canada and the United States used our text in manuscript form in 1977 and 1978.

Our course development activities were put in text form and the book is now available "The Structure of the Chemical Processing Industries: Function and Economics" McGraw-Hill, 1978. An outline of the course based on the text is shown in Table 1.

A key feature which makes the text unique is the initial chapter entitled "Readers Guide". This chapter serves three functions:

(i) It provides a way for the reader to enrich and update material by using the current literature and supplementary sources of information.

(ii) It outlines how to use the book, current literature and supplementary information for

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self-directed study.

(iii) It provides an instructor's and student's guide for those teaching from the text.

The course is designed to achieve the following goals:

1. To expand the mental horizon of the chemical professional beyond science and engineering and to show the economic purposes of the chemical process industries (CPI) and how the CPI benefit society.
2. To help chemical professionals understand how their work relates to the goals of their company and society.
3. To develop in the chemical professional an appreciation for the potential impact of new developments in technology, marketing, finance, politics, or international affairs as threats and opportunities.
4. To teach the chemical professional how to influence an organization to move in new directions by making fact-filled, comprehensive, and convincing economic studies.

The preparation and planning of this course differ from those of most engineering or science courses. Much of the material discussed needs to be current (no one today knows which problems will be the crucial issues tomorrow). Our course contains the relatively timeless fundamental economic and accounting principles, examples of economic analysis, and a detailed discussion of the structure of the CPI in the United States. Experience has shown that one can develop a lively, interesting, up-to-date, and effective course by expanding upon and adding to the textual material in a number of ways.

In almost every class, we discuss or at least mention some item from one of the periodicals. We have subscriptions to most and have developed the habit of clipping articles for discussion. Some are brought to the attention of the class immediately, and some are filed until a particular topic is covered.

USE OF CASE STUDIES

Case studies are a particularly effective way of meeting the objectives of the course and developing the student's skills. Case studies also serve as examples, good and bad, of how a problem should be handled. Critical analysis of case studies helps develop the student's ability to detect weaknesses, flaws in logic, and inappropriate interpretation of facts and events.

A comprehensive listing of published case studies is available in the "Intercollegiate Bibliography [of] 1974, Selected Cases in Administration." We have used the following case studies with some success.

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- Industrial Chemicals, Inc. This Harvard Business School case examines research and development in a company by studying the personalities of the key people involved, how they interact with each other, and their career progression. This case study is well done and relatively timeless.
- Mobil Chemical Company. This Harvard Business School case is somewhat outdated, but it shows the student what sort of information management and technical personnel need in order to embark on a new business.
- Reichhold Chemicals, Inc. This University of Alabama case study deals with waste-water treatment problems of Reichhold's Tuscaloosa plant. Emphasis in the case study is on methods of treating waste water with a passing reference to some process improvements.

There is no central index of case studies prepared by industrial concerns, many of which are prepared for internal use and not made public. Frequently, however, material can be presented in lectures by guest speakers from industry, who can discuss the case effectively.

Many topics suggest themselves as one teaches a course and although it is not a trivial matter to do so, an instructor can prepare short case studies with the help of term papers and class assignments. If a research effort accompanies the classwork, one can prepare case studies of a sufficiently high quality to meet the thesis requirements of the master's degree.

SPEAKERS FROM OUTSIDE THE UNIVERSITY

THIS ESSENTIAL AND rewarding part of the course allows students to hear and question people who are actually involved with the issues dealt with in the text, the supplementary sources, or the case studies. About 10 to 15 percent of the lecture time should be devoted to outside speakers. Industrial concerns and government agencies are most cooperative, especially if you talk to people at the highest level. The speaker and topic must be chosen to fit into the course structure. The instructor should request background material from the speaker in the form of handouts or published articles and make sure that the students are well read before the presentation. Time for questions and answers should be provided.

TABLE 2
Typical product Assignments

Precipitated calcium carbonate	Caustic soda	Carbon dioxide
Titanium dioxide	Ammonia	Nitrogen
Carbon black	Sulfuric acid	Oxygen
Yellow iron oxide	Nylon	DDT
Penicillin	Polyester fiber	Pesticides
Aspirin	Rayon	Herbicides
Vitamin C		

ASSIGNMENT OF STUDENT SPECIALISTS

AFTER 2 YEARS OF experimentation, we have found that the following procedures greatly enliven class discussion, allow the more reticent student to participate more easily, and provide an effective means of motivating the students to become familiar with the basic references and to gain practice in researching the economic literature of the chemical industry.

Product Specialist Assignment

THE PLAN IS TO HAVE each student be the course specialist on at least one chemical industry product and to prepare a comprehensive term paper. The products must be carefully selected by the instructor, who should have a plan for class discussion utilizing the detailed information collected by the student.

Typical product assignments used at the University of Delaware are shown in Table 2.

Company Specialist Assignment

THIS ASSIGNMENT REQUIRED each student to become a class expert on a CPI company and to prepare a comprehensive term paper. The student was expected to provide both statistical and qualitative information on the company.

Development of Supplemental Materials

EACH STUDENT IS GIVEN a package of material at the start of the course which contains the following:

- Facts and Figures issue of Chemical and Engineering News.
- Two company reports and 10-K forms.
- Case studies. Plan on three.
- Reprints from current periodicals.
- Statistical Abstract of the United States
- Reprint of Barbara Lawrence. Preliminary Project evaluation: Any Technologist Can Do It, CHEMTECH, November 1975.

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TABLE 3
Planning schedule

MONTHS BEFORE COURSE BEGINS	PHASES TO BE COMPLETED	COMMENT
12-10	Collect articles which will expand upon and complement text; decide on reprints students should have	Begin to rough out in-class course schedule
6-4	Order text	Not knowing class registration can be troublesome; class enrollment should have an upper limit to ensure adequate class discussions and interaction
4-2	Order reprints, Facts and Figures issue of Chemical and Engineering News, case studies, company reports, etc.	
2	Decide upon companies and products to assign to student specialists; make a list in order of importance	In-class schedule should now be fairly well decided
1½	Invite outside speakers	The last bit of information needed to firm up the class schedule
1	Prepare package of supplemental material	

PLANNING

TO PREPARE FOR A course we try to follow the planning schedule presented in Table 3. In the three-credit (42-h) course all 10 chapters can be adequately covered with time for guest speakers, case studies, and discussion of current problems of interest to the CPI. A flexible inclass schedule is shown in Table 4.

TABLE 4
Class schedule

CHAP.	HOURS	CHAP.	HOURS	CHAP.	HOURS
1	1-2	5	1-2	9	2-4
2	5-7	6	1-2	10	2-4
3	1-3	7	1-2	Guest speakers	3-5
4	2-4	8	4-6	Case studies	3-5

CONCLUSIONS

The course has been well received by our students at the graduate and senior level. For the last four years we have limited enrollment to thirty students and the class is always oversubscribed, in excess of forty-five students have tried to register each year. A short form of the course has also been given as part of the AIChE today series and to date has been taught in Houston twice, once in New York and once in Philadelphia.

ChE books received

"An Introduction to Industrial Organic Chemistry," 2nd edition, Peter Wiseman, Applied Science Publishers Ltd., London, 1979, 366 pages (paperback) \$16.80.

The organic chemical industry is subject to a high rate of technological change. This second edition text attempts to update the presentation on how organic chemistry is applied in society.

"How to Succeed in Organic Chemistry," J. E. Gordon. John Wiley & Sons, New York, 1979, 594 pages (paperback) \$8.95.

This is a Wiley Self-Teaching Guide designed as a supplement to an organic chemistry text or as a guide for self-instructional study or review. This practical book in 21 units presents a streamlined step-by-step method for learning organic chemistry.

"What Every Engineer Should Know About Product Liability," J. F. Thorpe and W. H. Middendorf. Marcel Dekker, Inc., New York, 1979, 104 pages, \$9.75.

The growth of technology has led to an increasing interaction between engineering and society's expectation of the new products. This book shows how the process of designing safer products is a natural extension of traditional engineering aptitudes and procedures.

"Industrial Hazard and Safety Handbook," R. W. King and John Magid. Newnes-Butterworth, 10 Tower Office Park, Woburn, MA 01801, 1979. 793 pages, \$67.50.

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This book is an attempt to identify and warn of the main hazards found in industry and to provide appropriate references for further study. It was written for safety specialists, representatives and students, for managers and engineers in industry as well as insurers and lawyers whose work is concerned with industrial accidents and their consequences.

"Introduction to Macromolecular Chemistry," 2nd ed., Hans Batzer and Friedrich Lohse. John Wiley & Sons, New York, 1979, 297 pages, \$34.50.

The chemistry of macromolecular compounds is presented under the topics of synthesis and isolation; characterization and identification; and physical properties and technical processing of macromolecular substances. It will be a valuable aid to students who wish to become acquainted with the problems in this field.

"Structure of Crystalline Polymers," Hiroyuk Tadokoro. John Wiley & Sons, New York, 1979. 465 pages, \$35.00.

Understanding the properties that distinguish one polymer from another requires knowledge of structure at the molecular level. X-ray crystallography and vibrational spectroscopy are the richest sources of structural data on macromolecular substances. This book gives a basis for understanding the current literature on polymer structure as it is revealed by x-ray analysis, infrared and Raman spectroscopy, and energy calculation. It is recommended both for students and research workers in this area.