THE CHEMICAL ENGINEERING CURRICULUM 1985

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THE AMERICAN Institute of Chemical Engineers, Education Projects Committee, has surveyed the chemical engineering undergraduate curricula since 1957 [1-6]. The most recent survey was initiated in the summer of 1985. The information provided by the chemical engineering departments in the United States was to be based on the curricula in effect as of the fall term of 1985. The survey is based on responses from ninety departments resulting from a mailing to all departments listed with AIChE in the summer of 1985. The questionnaire will be reviewed in an effort to consolidate questions without loss of valuable data. It is hoped this will result in a greater response to future surveys.

The data received were entered into a LOTUS 1-2-3 worksheet for ease of analysis and review. The questionnaire was unchanged from previous surveys in order to allow for easy comparison with data reported from those surveys.

A comprehensive historical data summary is not possible since the computer systems are incompatible. However, some comparisons can be drawn and trends indicated.

The semester hours for the degree appear to be

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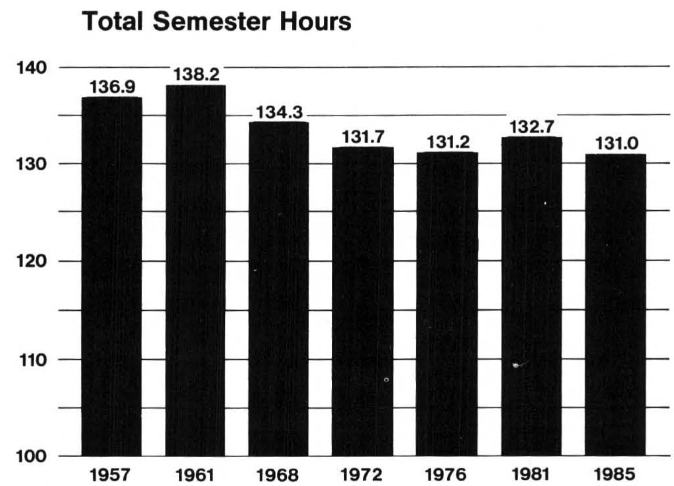

FIGURE 1

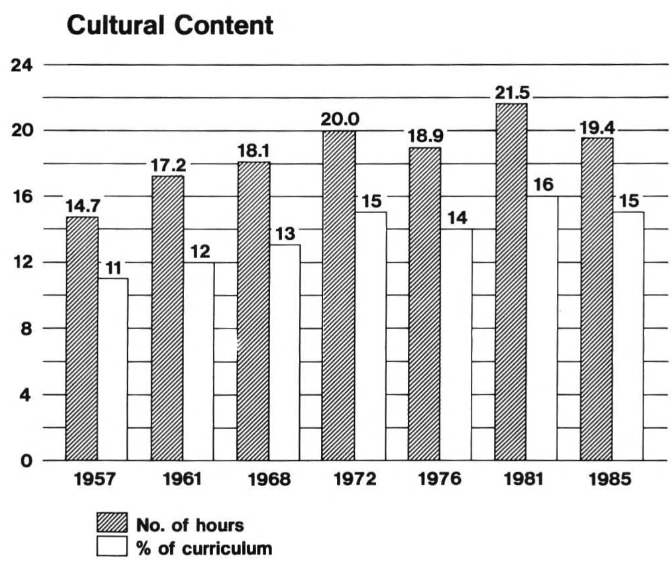

FIGURE 2

Very little unanticipated change has occurred. The design component has finally reached 100% of the schools reporting. This is probably a result of the accreditation effort in that area. The disappearance of analog computation . . . would be anticipated. Transport theory increased and now seems stable at 83%. . . . An increase can also be noted in equilibrium stage calculations.

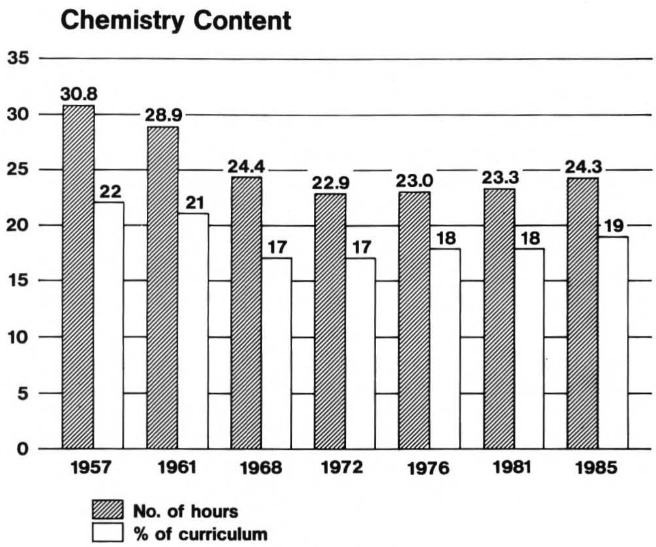

FIGURE 3

stabilized in the low 130's, as shown in Figure 1. It is interesting to observe from the more detailed information on the spreadsheet that the range is from 96 to 144 SH. It is difficult to determine if this is an anomaly of the individual school's credit system or a true reflection of the classroom hours of the student. Further detailed study would be needed to determine the curricular implications of these numbers. It should be noted that the vast majority of the schools lie in the range 125 to 135 SH.

The data in Figure 2 indicate a stabilization in the cultural content of the curricula after a significant rise during the early 1960's. The content level is now well above ABET requirements. The chemistry content, shown in Figure 3, went through a significant drop in the same period and his stabilized or is possibly rising slowly. The present level is 18.7% of the average curriculum.

In contrast to cultural and chemistry content, it is interesting to observe the communications requirements displayed in Figure 4. After a substantial drop in the percentage of schools which include communications in the curriculum, from 98.8% in 1957 to 77% in 1976, a rebound has occurred. In 1985, 93.1% of the schools included communications in the curriculum. Several responses commented that this was addressed in the senior design course. I feel certain this increase is in response to observations by industrial recruiters on our campuses and recognition by the faculty who deal with senior reports.

A summary of chemical engineering subcategories is shown in Table 1. This includes the three most recent surveys. Very little unanticipated change has occurred. The design component has finally reached 100% of the schools reporting. This is probably a result of the accreditation effort in that area. The disappearance of analog computation from the curricula would be anticipated. Transport theory increased and now seems stable at 83% of the reporting schools requiring this subject. An increase can also be noted in equilibrium stage calculations. A significant increase occurred in the number of schools requiring process control. A modest increase in the number of schools offering chemical engineering electives is gratifying.

The table suggests that the options are disappearing. This is inferred from the decline in schools reporting biomedical, polymer, nuclear and environmental options. However, the options are in fact diversifying. This is reflected in the increase in the number of schools providing chemical engineering electives in the program. Further detailed study of the questionnaire suggests the decrease in options is an anomaly of the questions. Many of the schools still retain the specific listed areas but provide several alternatives. As a result they now show up in chemical engineering electives.

The departments listing electives show diversity not reflected in the general statistics. An attempt will be made in the next questionnaire to break out this data. It can be qualitatively reported that depart-

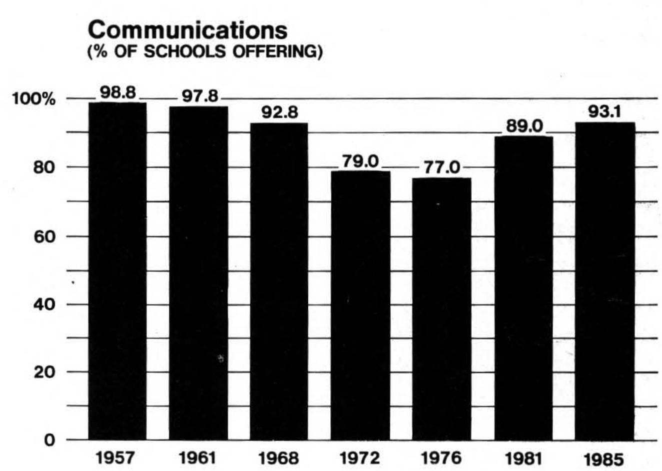

FIGURE 4

ments with electives include polymers, environmental, and computer applications. It is apparent from the comments that many departments are examining the inclusion of some nontraditional curricular opportunities such as biochemical, materials, electronic component processing, etc. Local options exist in biomedical, paper processing and others on an individual basis. This suggests that the departments are responding to the diversity available to chemical engineers without abandoning the fundamentals.

The ABET-AIChE distribution is a useful measure of the character of the curriculum. The figures are not immediately discernible from the survey forms but an effort was made to be as fair as possible in the distribution of reported credits. The results are combined with those of 1981 in Table 2. As was the case in the 1981 report, the average curriculum appears to conform very closely to the accreditation requirements.

It is unfair to draw conclusions from this limited data, but it appears that a tendency to "free" electives may be surfacing in the "other" category. Another perspective on the curriculum can be gained from Table 3. The breakdown is somewhat finer than the ABET classification and illustrates the range of diversity that can exist. Some of the diversity may be attributable to the data but certainly not the majority. Only two-thirds to three-fourths of the departments include mechanics or electrical engineering. Further, only one-half of the departments explicitly include materials or economics. The range of requirements is also striking. The mathematics average of 18.72 semester hours (including computing, deleted in ABET), with

TABLE 1.
ChE Curriculum; Sub-Categories

	% Offering			Avg. SCH when Offered		
	1976	1981	1985	1976	1981	1985
MATH						
Analytical Geometry	53	49	56	3.9	4.1	3.2
Calculus	89	93	100	8.6	9.3	8.4
Differential Eqs.	94	94	98	2.8	3.2	3.0
Linear Algebra	36	27	31	2.5	2.4	2.3
Advanced Calculus	20	18	32	3.4	3.1	3.1
Complex Variables	6	3	7	0.9	1.7	1.9
Partial Diff. Eqs.	16	10	14	1.4	2.6	1.8
Numerical Analysis	20	16	18	1.9	1.9	1.9
Dig'tl Comp/Progrmng.	79	74	75	2.1	2.3	2.7
Analog Computations	7	2	1	1.8	1.8	1.3
Applied Engrng Math	22	30	33	3.0	2.8	3.4
MECHANICS						
Statics	72	78	73	2.7	2.6	2.6
Dynamics	36	37	27	2.4	2.5	2.3
KINETICS						
Chemical Kinetics	60	59	67	2.0	2.1	1.8
Chem. Reactor Des.	73	76	84	2.5	2.6	2.2
UNIT OPERATIONS THEORY						
Transport Theory	68	84	82	4.4	4.8	5.0
Transport Lab	36	43	41	1.7	2.2	2.0
Equilibrium Stage	47	51	55	2.6	2.5	2.5
U.O. Theory	83	78	79	5.9	5.3	4.9
DESIGN						
ChE Design	93	98	99	3.6	4.1	4.3
Process Synthesis	33	31	24	2.4	2.4	2.1
INSTRUMENTATION						
Instrumentation	14	16	18	1.5	1.6	1.6
Process Control	64	70	89	2.3	2.5	2.4
Process Dynamics	34	40	42	1.8	1.8	1.5
OTHER						
Math. Modeling	14	11	14	2.6	2.1	2.1
Computer App in ChE	15	27	23	2.4	2.1	2.4
Biomedical Eng.	1	0	1	4.0	0	3.0
Polymer Processing	5	6	2	1.8	2.3	2.5
Nuclear Eng.	2	3	0	4.5	4.5	0
Environmental Eng.	5	5	2	4.1	5.2	2.6
Other ChE Required	34	36	26	2.3	2.3	2.1
ChE Electives	49	55	57	7.1	5.3	5.2

TABLE 2.
Distribution of Course Work; 1981 and 1985

Curricular Area	AIChE Minimum (%)	1981 Avg.	1985 Avg.
Math. beyond trig.	12.5	13.6	12.7
Basic Sciences	25.0	24.3	25.4
(including adv. chem.)	(12.5)	(11.7)	(12.8)
Eng. Sciences and Design	37.5	37.3	37.2
Humanities/Social Sciences	12.5	16.1	15.0
Other Technical Courses		8.7	5.4
Free Electives			4.3
Other	12.5		
TOTAL PERCENT	100.0	100.0	100.0
TOTAL CREDIT HOURS		133.4	131.0

TABLE 3.
Summary of Categories

Category	No. of Schools	Average	Maximum	Minimum
Communications	84	5.53	12.00	0.00
Culture	91	19.36	30.00	11.00
Mathematics	91	18.72	35.40	12.60
Chemistry	91	24.28	31.30	15.00
Physics	91	8.75	14.00	5.40
Economics	55	2.89	6.00	0.00
Mechanics	71	3.23	7.00	0.00
Electrical Engineering	67	2.71	7.00	0.00
Materials	46	1.55	7.00	0.00
Required Chem Engr.	91	38.07	. 55.0	18.70
Elective Chem Engr.	52	5.19	12.00	1.00
TOTAL HOURS	91	131.00	144.00	96.30

a range from 12.6 to 35.4, is surprising.

The questionnaire also included noncurricular questions addressing staffing and foreign enrollment. The departmental average of faculty was 6.1 professors, 2.6 associate professors, 2.7 assistant professors and 1.5 others. Over one-half the departments reported 1.7 average faculty openings, ranging from 1 to 6. The undergraduate body was composed of 9.2% foreign nationals while the graduate students included 38.7% foreign nationals.

It appears that only minor changes have occurred in the curriculum since the 1981 survey. However, it appears from the comments (and considering recent changes in the AIChE accreditation requirements) that the survey scheduled for 1989 will show greater change. A detailed review of the questionnaire will be made prior to that survey and any suggestions for change will be gratefully accepted by the author.

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ChE book reviews

THE PICTURE BOOK OF QUANTUM MECHANICS

By Siegmund Brandt and Hans Dieter Dahmen
John Wiley & Sons, Somerset, NJ 08873, $29.95 (1985)

Reviewed by
Henry A. McGee, Jr.
Virginia Polytechnic Institute and State University

Models from our everyday experiences with balls and strings and sticks and springs are easily pictured in one's mind, and these pictures aid a study of classical mechanics. Wave mechanics has no such ordinary background of familiar pictures, and our learning is then wholly abstract and based upon complex equations. This new book utilizes computer graphics to provide pictures of wave forms, interferences, reflections, time developments, etc., to aid in the visualization that is missing from our everyday experiences. It is a significant step in the teaching of basic quantum mechanics. The book is wholly fundamental physics with no discussions of practical matters. A typical junior-level course in physical chemistry would be a minimum prerequisite to reading the *Picture Book.* The book is written by physicists, and the graphics that appear on about every other page aid basic physical understanding. For basic understanding, this book is excellent. Fortunately, this book does not have the kind of overpowering or intimidating character of most books on quantum mechanics that are wholly mathematical and abstract.

There is nonetheless little here of direct interest to the chemical engineer who is involved in research in applied chemistry. Chemical engineers would be better served by a study of semi-empirical molecular orbital schemes that have been so well developed over the last two decades. With these techniques, one can calculate heats of formation, structure, vibration frequencies, and the like, from input information that merely states which atoms are joined to which in the molecule. These techniques continue to be successfully used by even organic chemists to pursue practical matters. Even the rational design of drugs—a sort of quantum pharmacology—is viable. The semi-empirical quantum techniques can be well-used without the detailed fundamental understanding that is portrayed in the *Picture Book*, even as a mass spectrometer can be well-used without one having a detailed understanding of the electronic pulsing circuitry that makes it all possible. To be sure, whether in quantum mechanics or in mass spectrometry, a conceptual understanding of underlying detail is important. And, as always, the more detailed one's understanding, the better.

The title sounds tacky, but the book is well done. The writing and graphics are clear, and the text fills only two-thirds of each page, leaving much white space that makes for pleasant reading. ☐