UNDERGRADUATE CURRICULA 1976

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THE EDUCATION PROJECTS committee of the American Institute of Chemical Engineers has carried out surveys of the undergraduate curricula in Chemical Engineering since 1957 [1,2,3,4]. A survey was also made in 1972 and the results were presented to the Department Chairman's meeting in Los Angeles. However, these data were never published, but are included in the present report. The present survey was undertaken during the Spring and Summer of 1976. The form used was similar to that used in the past three surveys. Modifications were made to reflect some of the changes in the emphasis in Chemical Engineering. The respondents were requested to use the curricula as of September 1, 1976.

The survey was carried out by mail and the form was sent to each of the schools listed in the 1975-76 "Chemical Engineering Faculties" (a publication sponsored by the Education Projects Committee of the AIChE).

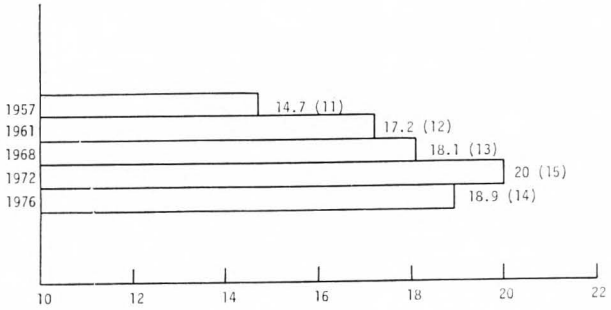


FIGURE 2. Humanities SH (% of curriculum).

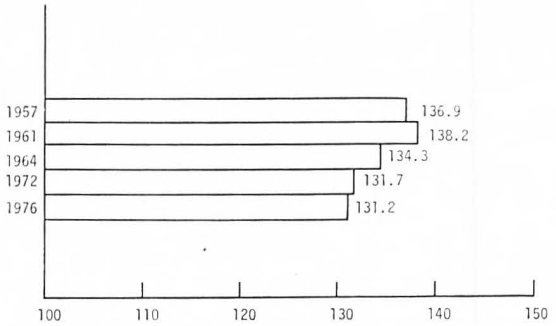


FIGURE 1. Total in semester hours SH.

Usable replies were received from 94 schools. The results were coded on IBM cards and analyzed using standard statistical procedures. The results of this survey are presented in the following tables. For purposes of comparison, the same format has been used as in the previous surveys. In this way, a comparison can be made of the changes taking place in the curriculum since 1957.

Table 1 presents the consolidated information under the categories shown in previous reports. This table is divided into three parts. The first set of columns showing the average number of semester hours offered including all 94 schools, the second section shows the percentage of schools offering the particular category and the third section shows the average semester hours considering only those schools offering the particular category.

There are a number of trends apparent in the undergraduate curricula and these are illustrated in Figures 1-4. Figure 1 shows the total semester hours offered. As can be seen in Figure 1, there has been a gradual reduction in net credit hours since 1957. It should be noted that these are net credit hours and that the gross credit hours has decreased much more than the net credit hours. This is caused by the de-emphasis on the military studies and physical education.

Figure 2 represents the changes in the humanities and social sciences. The present ECPD and AIChE minimum is one semester or 12.5 percent of the overall effort. The effect of the accreditation procedure is clearly evident. The figures in parenthesis at the end of each bar represent the percentage of the total devoted to humanities and social sciences. As can be seen

TABLE I
B. Ch.E. Curriculum
1957, 1961, 1968, 1972, 1976

		Avg. Number of SH					Schools Offering, %					Avg. SH when Offered				
		1957	1961	1968	1972	1976	1957	1961	1968	1972	1976	1957	1961	1968	1972	1976
6.	Gross Credits, SH	147.0	146.2	136.8	133.1	132.5	-	-	-	-	-	-	-	-	-	-
7.	Net Credits, SH	136.9	138.2	134.3	131.7	131.2	-	-	-	-	-	-	-	-	-	-
8.	NON-TECHNICAL STUDIES															
9.	Written Communication	6.5	5.9	4.9	3.5	3.3	98.8	97.8	92.8	74.0	72.0	6.6	6.0	5.3	4.8	4.5
10.	Oral Communication	1.1	1.0	0.8	0.6	0.7	43.2	45.6	28.9	25.0	30.0	2.4	2.3	2.7	2.6	2.3
11.	Subtotal Items 9-10	7.6	6.9	5.6	4.3	4.0	98.8	97.8	92.8	79.0	77.0	7.7	7.1	6.0	5.4	5.2
12.	Humanities, Required	4.0	5.4	4.9	4.9	5.1	63.0	72.7	66.3	57.0	62.0	6.3	7.6	7.5	8.5	8.2
13.	Social Studies, Required	3.1	2.7	2.5	2.9	2.8	59.1	55.4	39.8	44.0	38.0	5.9	4.8	6.2	6.6	7.3
14.	Other Req. Soc-Hum.	1.3	1.5	1.5	1.5	1.2	22.2	20.7	22.9	21.0	20.0	5.7	7.3	6.7	7.4	6.1
15.	Non-technical Electives	6.4	7.6	9.8	10.2	9.1	76.5	82.6	79.5	79.0	77.0	8.3	9.2	12.3	12.8	11.8
16.	Subtotal, Items 12-15	14.7	17.2	19.1	20.0	18.9	100.0	100.0	100.0	100.0	100.0	14.7	17.2	19.1	20.0	18.9
17.	Physical Education, etc.	1.8	1.9	1.2	0.9	0.8	50.6	51.6	44.6	36.0	33.0	3.5	3.7	2.8	2.6	2.5
18.	Military Studies	3.1	2.9	0.8	0.4	0.0	48.1	49.0	18.1	5.0	1.0	6.5	6.0	4.4	7.7	2.0
19.	Other non-technical	0.3	0.3	0.4	0.5	1.1	23.5	14.1	19.3	14.0	28.0	1.3	2.0	2.2	3.4	4.1
20.	Subtotal Items 17-19	5.2	5.2	2.0	1.9	1.5	84.0	77.2	54.2	44.0	43.0	6.2	6.6	3.7	4.5	3.5
21.	Total Items 11, 16, 20	27.5	29.6	25.8	26.0	25.0	100.0	100.0	96.4	100.0	100.0	27.5	29.6	26.8	26.0	25.0
22.	MATHEMATICS, CHEMISTRY, AND PHYSICS															
23.	Intro. & keview Math.	4.4	2.6	0.2	0.1	0.2	79.0	53.3	6.0	4.0	5.0	5.6	4.9	2.8	2.3	3.1
24.	Anal. Geom. and Calc.	11.6	11.7	11.3	9.9	9.8	100.0	100.0	100.0	100.0	100.0	11.6	11.7	11.3	9.9	9.8
25.	Diff. Eq. & Other	1.3	3.6	6.3	7.3	8.1	44.4	81.5	98.8	95.0	100.0	2.8	4.3	6.3	7.6	8.1
26.	Subtotal Items 23-25	17.3	17.9	17.7	17.9	17.9	100.0	100.0	100.0	100.0	100.0	17.3	17.9	17.7	17.9	17.9
27.	General Chemistry	8.0	7.8	7.4	7.1	7.3	100.0	100.0	97.6	99.0	97.0	8.0	7.8	7.5	7.2	7.6
28.	Physical Chemistry	8.5	8.1	7.7	7.1	6.7	100.0	98.9	97.6	99.0	96.0	8.5	8.2	7.9	7.2	6.8
29.	Organic Chemistry	8.5	7.8	7.4	6.6	6.8	100.0	98.9	98.8	98.0	99.0	8.5	7.8	7.5	6.7	6.9
30.	Quantitative Analysis	4.2	3.5	1.2	0.8	0.7	98.8	94.6	36.1	31.0	29.0	4.2	3.7	3.3	2.6	2.3
31.	Qualitative Analysis	1.3	1.3	0.6	0.4	0.2	44.4	39.2	25.3	15.0	13.0	3.0	3.3	2.3	2.3	1.9
32.	Other Chemistry	0.3	0.5	0.5	0.7	1.5	9.9	9.8	18.0	20.0	32.0	3.3	5.5	2.8	3.3	4.6
33.	Subtotal Items 27-32	30.8	28.9	24.1	22.9	23.0	100.0	100.0	98.8	100.0	100.0	30.8	28.9	24.4	22.9	23.0
34.	General Physics	10.8	10.2	8.5	7.3	7.3	100.0	100.0	98.8	95.0	90.0	10.8	10.2	8.6	7.6	8.1
35.	Modern Physics	0.2	1.0	1.4	1.3	1.1	8.6	38.0	38.6	34.0	26.0	2.6	2.7	3.7	4.0	4.1
36.	Subtotal Items 34-36	11.1	11.3	10.5	9.0	9.1	100.0	100.0	100.0	99.0	98.0	11.1	11.3	10.5	9.1	8.9
37.	Total Items 26, 33, 36	59.2	57.9		49.7	49.0	100.0	100.0	85.5	100.0	100.0	59.2	57.9	52.2	49.7	49.5
38.	ENGINEERING GRAPHICS															
39.	Total Graphics	4.7	3.8	2.0	1.6	1.3	97.5	94.6	67.5	59.0	50.0	4.8	4.0	3.0	2.6	2.6
40.	ECONOMICS, BUSINESS LAW, BUSINESS ADMINISTRATION ALLIED															
41.	Economics, Princ. of	2.2	2.1	1.5	1.1	1.0	55.6	58.7	39.8	33.0	32.0	3.9	3.5	3.9	3.2	3.1
42.	Economics, Engineering	0.7	0.5	0.6	0.7	0.8	23.5	22.8	27.7	29.0	36.0	2.8	2.2	2.0	2.2	2.2
43.	Bus. Law, - Admin., etc.	0.5	0.3	0.1	0.2	0.3	18.5	8.7	2.4	4.0	10.0	2.9	3.0	4.5	4.1	2.7
44.	Total Items 41-43	3.4	2.7	2.2	1.9	1.8	70.4	68.5	55.4	53.0	52.0	4.8	4.1	3.9	3.5	3.4
45.	MECHANICS OF SOLIDS															
46.	Mechanics	3.7	3.9	4.1	3.0	1.8	97.8	97.5	90.4	78.0	72.0	3.8	4.0	4.5	3.8	2.5
47.	Mechanics of Materials	3.1	2.5	1.4	1.1	1.1	97.5	80.4	47.0	41.0	40.0	3.2	3.1	3.0	2.7	2.8
48.	Total Items 46-67	6.8	6.4	5.1	4.2	4.0	100.0	97.8	90.4	85.0	84.0	6.8	6.6	5.7	4.9	4.8
49.	ELEMENTARY ELECTRICAL ENGINEERING															
50.	Elementary El. Eng.	4.7	4.0	2.8	2.4	2.2	98.8	93.5	77.1	73.0	66.0	4.8	4.3	3.6	3.3	3.6
51.	Elementary Electronics	0.3	0.9	1.5	0.8	0.7	9.9	38.0	49.4	28.0	26.0	2.6	2.5	3.0	2.8	2.6
52.	Total Items 50-51	5.0	5.0	4.3	3.2	2.9	100.0	95.7	88.0	79.0	74.0	5.0	5.2	4.8	4.1	3.9
53.	NATURE AND PROPERTIES OF MATERIALS, CATEOGORY A AND CATEGORY B															
54.	Physical Metallurgy	1.2	0.6	0.4	0.2	0.2	40.7	20.6	13.3	9.0	7.0	2.9	3.1	3.1	2.6	2.5
55.	Other Category A Courses	0.1	0.3	1.7	1.4	1.2	5.0	11.9	57.8	49.0	38.0	2.0	2.6	3.0	2.8	3.0
56.	Metallurgy	0.4	0.6	0.o	0.o	0.1	12.7	21.7	2.4	3.0	2.0	2.9	3.0	3.0	0.8	2.2
57.	Other Category B Courses	0.6	0.3	0.3	0.2	0.2	28.4	11.9	10.8	12.0	11.0	2.1	2.6	2.3	1.8	1.8
58.	Total Items 54-57	2.3	1.9	2.4	2.0	1.6	67.9	55.4	71.1	58.0	49.0	3.4	3.4	3.4	3.4	3.2
59.	SUPPLEMENTARY SCIENCES AND PRACTICES															
60.	Biology and Geology	0.2	0.2	0.3	0.3	0.3	4.9	4.3	6.0	8.0	7.0	3.8	4.0	4.4	3.4	3.7
61.	Heat Power	0.8	0.2	0.0	0.1	0.0	23.5	8.7	1.2	5.0	1.0	3.4	2.3	4.0	2.1	1.0
62.	Shop Practice	0.4	0.1	0.0	0.1	0.0	23.5	8.7	1.2	3.0	1.0	1.7	1.3	1.0	1.8	1.0
63.	Other	0.4	0.3	0.5	0.9	0.5	13.6	15.2	18.1	20.0	12.0	2.8	2.2	3.0	4.5	4.2
64.	Total Items 60-63	1.8	0.8	0.8	1.3	0.9	45.7	29.3	24.1	27.0	23.0	3.9	2.8	3.3	4.9	3.9
65.	CHEMICAL ENGINEERING															
66.	Material & Energy Bal.	3.8	3.1	3.1	2.8	3.1	98.8	9.3	91.6	86.0	90.0	3.9	3.3	3.3	3.2	3.4
67.	Thermodynamics	4.8	5.0	4.5	4.4	4.5	100.0	100.0	98.8	99.0	97.0	4.8	5.0	4.6	4.4	4.6
68.	Chemical Kinetics	0.5	1.2	2.6	2.9	3.0	18.5	53.2	89.2	95.0	100.0	2.5	2.3	3.0	3.1	3.0
69.	Subtotal Items 66-68	9.1	9.2	5.0	10.1	9.6	100.0	100.0	75.9	100.0	100.0	9.1	9.2	6.6	10.1	11.0
70.	Unit Operations Theory	7.6	8.2	4.3	9.7	9.7	100.0	97.8	73.5	98.0	100.0	7.6	8.4	5.9	9.9	9.7
71.	Unit Operations Lab.	4.1	3.9	2.7	2.8	2.9	100.0	98.9	81.9	88.0	89.0	4.1	4.0	3.3	3.1	3.3
72.	Subtotal Items 70-71	11.7	12.1	7.0	12.5	12.6	100.0	98.9	91.6	98.0	100.0	11.7	12.2	7.7	12.7	13.0
73.	Ch.E. Design	3.7	3.5	3.6	3.6	4.1	90.1	86.9	90.4	91.0	100.0	4.1	4.0	4.0	3.9	4.1
74.	Chemical Technology	2.7	1.8	0.6	0.3	0.2	75.3	53.2	19.3	15.0	11.0	3.6	3.3	3.0	2.3	1.9
75.	Investigational Skills	2.5	1.5	0.8	0.7	0.8	70.4	50.0	24.1	25.0	26.0	3.5	3.1	3.5	3.0	3.1
76.	Intro. to Ch.E.	0.8	0.9	0.6	0.8	0.6	38.3	39.1	30.1	33.0	34.0	2.0	2.3	1.8	2.3	1.9
77.	Instrumentation	0.7	1.1	2.3	2.3	2.0	32.1	41.3	71.1	74.0	80.0	2.3	2.5	3.3	3.1	2.3
78.	Unit Processes	0.6	0.7	0.2	0.4	0.2	27.2	23.9	7.2	14.0	5.0	2.2	3.0	3.2	2.6	3.4
79.	Trips	0.3	0.3	0.1	0.1	0.1	21.0	17.4	7.2	6.0	5.0	1.5	1.7	1.2	1.4	0.9
80.	Fuels and Lubricants	0.3	0.1	0.0	0.0	0.0	13.6	4.3	2.4	0.0	0.0	1.9	1.5	1.0	0.0	0.0
81.	Other	0.6	1.7	4.1	4.5	5.5	19.8	42.3	61.5	69.0	100.0	2.9	3.9	6.6	6.5	5.5
82.	Subtotal Items 73-80	12.1	11.5	12.3	8.1	13.5	100.0	98.9	98.8	97.0	100.0	12.1	11.6	12.5	8.4	23.1
83.	Total Items 69, 72, 82	32.9	32.9	33.4	35.5	35.7	100.0	100.0	98.8	100.0	100.0	32.9	32.8	33.8	35.5	36.9
84.	TECHNICAL ELECTIVES															
85.	Total Tech. Electives	3.6	5.2	6.2	7.7	7.6	65.4	75.0	72.3	83.0	82.0	5.5	7.0	8.6	9.3	9.4

as an increase from 11 to 14 percent over the period of the various surveys. However, there has been a slight decrease since the 1972 survey.

Figure 3 shows the changes in the chemistry part of the curricula. The figures in parenthesis again represent the percentage of the total offering. In 1957 22% of the curricula was chemistry, while in 1976 only 18% represented chemistry. This includes beginning chemistry as well as advanced chemistry. There has been very little change over the last eight years, but a further decrease could be of concern to the chemical engineer. Current AIChE minimums require one semester or 12.5 percent chemistry beyond the introductory chemistry.

COMMUNICATIONS IN CURRICULA

PERHAPS ONE OF THE greatest areas of concern is shown in Figure 4. This figure presents the data relative to the percentage of

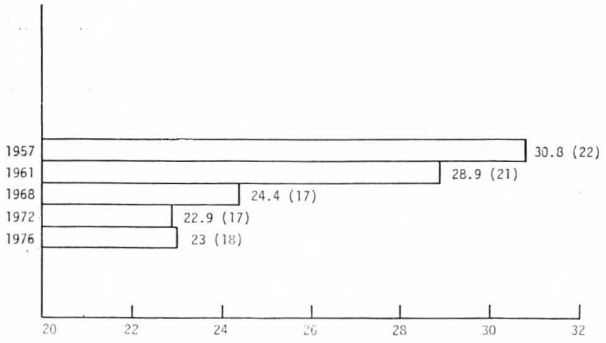
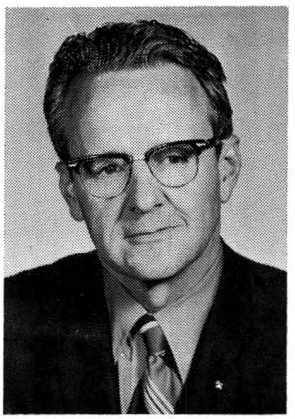


FIGURE 3. Chemistry SH (% of curriculum).

schools offering communications as part of their curricula. It should be noted that in 1957 98.8% of the schools offered courses in communications, that is in written and oral communication. By 1976 only 77% of the schools offered courses in communications. In addition, the number of semester hours has decreased from 7.7 to 5.2. There is an obvious need for the ChE student to be proficient in written and oral communications. This part of the undergraduate ChE education should be given attention by the ChE educators. This does not mean to say that there needs to be a formal course in oral or written communication, but that these skills should be developed. It might be possible that these skills are currently being developed in seminars and laboratories.

The earlier surveys did not include an analysis



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of the actual course offerings under math, mechanics, kinetics, etc. The form used in the present survey asks for information relative to the different kinds of math, etc. These data are shown in Table 2. Under the math offerings introduction and review is not included since only 5% of all schools reporting required any introductory or review math. Under unit operations theory an attempt was made to differentiate between transport and the conventional unit operations of heat transfer fluid flow and mass transfer. As can be seen the curricula is almost balanced in relationship to transport theory and unit operation theory. Under instrumentation it should be noted that most of the work deals with process control. The analysis will be continued

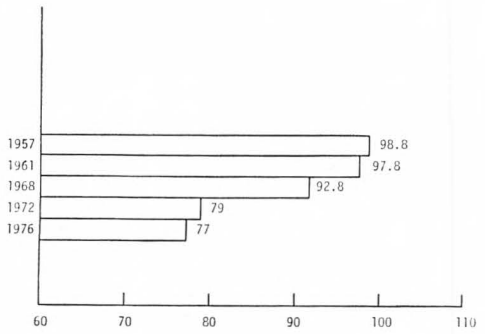

FIGURE 4. Communications % school offering.

in a future survey so that trends can be noted.

It is of interest to compare the distribution of course work as determined by the average of this survey with the distributions of course work under the AIChE minimum requirements; this comparison is shown in Table 3. As can be seen with the exception of chemistry, the present average curriculum would meet ECPD and AIChE minimum requirements. However, chemistry is somewhat low and this could be of some concern. It is not possible to make an entirely accurate assessment since there may be chemistry included in other courses such as thermodynamics. For the purpose of determining engineering sciences, items 48, 52, 58, 66, 67, 68, 70 and 77 were included as fulfilling requirements in engineering sciences. Since this division is somewhat arbitrary, the actual curricula offerings of the various schools may be somewhat different.

The survey requested the listing of the textbook used in ChE courses. The reason for this was to help decide which category to place the actual course under. It was intended to list the textbooks used in various courses. However, the results were that not all schools listed their books. In the areas of material and energy balance, thermodynamics, kinetics and process control, there is remarkable uniformity in the answers received. The book by Himmelblau is used by 63 schools. The book by Levenspiel is used by 62 schools, and the book by Smith and Van Ness is used by 54 schools. The book on process control by Coughanowr and Koppel was used by 34 schools. Fifty-eight schools reported the text used in design was that by Peters and Timmerhouse. In addition to Smith and Van Ness in thermodynamics, the book by Balzhiser was used by 16 of the schools reporting. And 18 schools used a book in kinetics by Smith.

The major books used in the transport theory and operations were those by McCabe and Smith

Continued on page 96.

TABLE II
B. Ch.E. Curriculum — 1976
Sub-Categories

	% OFFERING	AVG. SCH WHEN OFFERED
MATH		
Analytical Geometry	53	3.9
Calculus	89	8.6
Differential Equation	94	2.8
Linear Algebra	36	2.5
Advanced Calculus	20	3.4
Computer Variables	6	0.9
Partial Differential Equations	16	1.4
Numerical Analysis	20	1.9
Digital Computing & Progr.	79	2.1
Analog Computations	7	1.8
Applied Engineering Math	22	3.0
MECHANICS		
Statics	72	2.7
Dynamics	36	2.4
KINETICS		
Chemical Kinetics	60	2.0
Chemical Reactor Design	73	2.5
UNIT OPERATIONS THEORY		
Transport Theory	68	4.4
Transport Lab	36	1.7
Equilibrium Stage	47	2.6
U.O. Theory	83	5.9
DESIGN		
ChE Design	93	3.6
Process Synthesis	33	2.4
INSTRUMENTATION		
Instrumentation	14	1.5
Process Control	64	2.3
Process Dynamics	34	1.8
OTHER		
Mathematical Modeling	14	2.6
Computer Applications in ChE	15	2.4
Biomedical Engineering	1	4.0
Polymer Processing	5	1.8
Nuclear Engineering	2	4.5
Environmental Engineering	5	4.1
Other ChE required	34	2.3
Chemical Engineering Electives	49	7.1

TABLE III
Distribution of Course Work

CURRICULAR AREA	AIChE MINIMUM (%)	AVG.
Mathematics beyond Trigonometry	12.5	13.6
Basic Sciences [Show Advanced Chemistry in ( )]	25.0 (12.5)	24.3 (11.7)
Engineering Sciences	25.0	24.0
Engineering Design, Synthesis, and Systems	12.5	12.4
Humanities/ Social Sciences	12.5	14.4
Other Required Technical Courses		
Other Required Courses (Non-Technical)		
Other Technical Electives		
Other Free Electives		
Total of "Other"	12.5	23.7
TOTAL: Percent	100.0	100.0

NPW, risk and forecasting, inventory planning, decision trees, etc. GPSS and/or Simscript are not mentioned.

Appendix 1 contains illustrative numerical methods for root finding, solving simultaneous equations, integration, linear programming, optimization, regression and dynamic programming. Appendix 2 discusses briefly design of experiments.

Appendix 3 is entitled Suggested Contents of a Chemical Engineering Computer Library. Fortran subroutines or references to subroutines available in the IBM Scientific Subroutine package are given for many of the numerical methods in Appendix 1. The descriptions of the various subroutine calling arguments do not have the preciseness of expression that is necessary. This appendix includes more than 25 pages of listings of FORTRAN subroutines, which are very poorly done. For example, the FORTRAN is not completely standard, very few comment cards are used, arithmetic IF's are used where logical IF's should be, etc. The computer listings are typed rather than being direct reproductions of computer-produced subroutine listings, almost guaranteeing the presence of difficult-to-find typographical errors!

The back of the book contains a Problem section with a large number of problems for Chapters 2-6.

The Bibliography section contains 119 references. There seems to be no sense at all to the ordering sequence of the references. Many of the references would be difficult to retrieve for a United States engineer without access to an unusually comprehensive chemical engineering library.

The author's approach to modelling is very practical—the purpose of modelling is to obtain timely, usable results. He carries this theme throughout the book. At times he seems overly concerned about computer resources used in simulation; this is rarely a problem with today's high-speed/low cost computers.

ChE letters

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Honor Scroll of the IEC Division of the ACS in 1961. Brenner graduated with honors from Pratt Institute and received a doctor of engineering science degree from New York University. He has been associate editor of the International Journal of Multiphase Flow since 1973.

Prof. Brenner succeeds Prof. John Ferron, who will return to full-time teaching and research at the university.

INTERNATIONAL DIVISION ACTIVITIES

Sir:

One of the newest and fastest growing divisions in the American Society of Engineering Education is the International Division. This division was formed from the international relations committee, a group of individuals interested in the international aspects of engineering education. The division publishes a newsletter which is sent to all members of the division. In addition, it publishes a magazine entitled Technos which is dedicated to the publication of international engineering education articles. It sponsored the World Congress on educating engineers for world development in 1975 and has since published the proceedings of this meeting. In addition, a mid-winter meeting is held in which interesting international education projects are developed and discussed. The division is desirous of obtaining members who are interested in any aspect of international education such as teaching in a foreign country, teaching students from foreign countries in our own country, interchange with scholars by writing, presentation of programs at the national meeting, etc.

I invite those persons interested in joining the division or those persons having an interest in international education to contact me.

Dee H. Barker
ChE Dept., Brigham Young University, CB 350, Provo Utah, 84602

UNDERGRADUATE CURRICULA: Barker

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with 48 schools reporting, Bird Stewart and Lightfoot with 31 schools reporting and mass transfer by Treybal with 21 schools reporting use of this book. There are numerous other books being used, however, the total number of reported adoptions in each is very small. Thus it would appear that in the basic ChE subjects that a small number of books dominate the field, and thus would indicate a uniformity in the material being given to the ChE students throughout the country. □

REFERENCES

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3. Balch, C. W., Undergraduate Curricula in Chemical Engineering 1969-70, *Chemical Engineering Education*, Vol. VI, No. 1, Winter 1972.
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