ChE survey

THE CHEMICAL ENGINEERING CURRICULUM—1994

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The most recent survey of the chemical engineering undergraduate curricula, conducted every five years since 1957, was made by the Undergraduate Curriculum Subcommittee of the Education Projects Committee of the American Institute of Chemical Engineers (AIChE) in the summer of 1994.[1] A questionnaire that closely corresponds with ABET/AIChE categories was sent to the 158 chemical engineering departments listed with AIChE; sixty-three departments responded, and the survey results are based on those responses.

The spreadsheets that contained the data collected were prepared using Quattro Pro (Borland Int'l.) to assist in analyzing the survey results. Table 1 summarizes the responses received. As shown, seventeen Canadian schools were sent the questionnaire, but only one responded. This school's data was difficult to translate into reasonably related US numbers, so it was not included in the report. The data available from US schools was reported at the Department Heads' Meeting of the AIChE annual meeting in Miami Beach, Florida, in November of 1995.

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TABLE 1
Summary of Responses Received

	United States	*Canada*
Total Schools Surveyed	158	17
Total Responses Received	63	1
Percent Responses	39.9%	5.9%
Percent Responses Overall	*36.6%*	

SURVEY RESULTS AND DISCUSSION

The semester credit hours required for the Bachelor's Degree remains almost the same as it was in the previous 1989 survey (when ninety-two schools responded). Figure 1 shows that the trend seems to have stabilized in the low 130s. The detailed information on the spreadsheet, however, indicates that semester hours actually range from 115 to 145. The lower bound has increased only slightly since the last survey. More than 80% of the departments require 125 to 140 semester hours, with only six having fewer than 125 and five

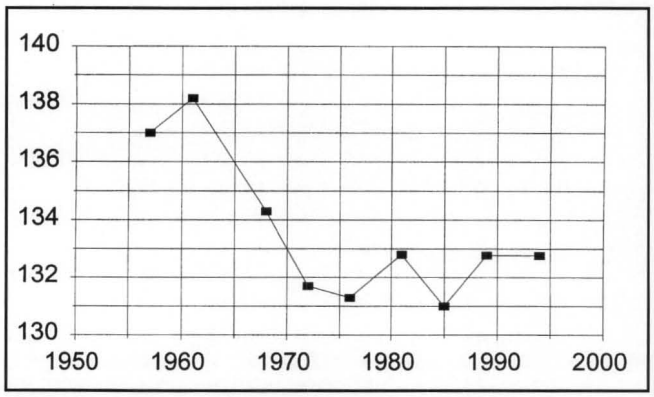

Figure 1. *Total semester hours required for undergraduate chemical engineering degree.*

[This survey] was conducted by the Undergraduate Curriculum Subcommittee of the Education Projects Committee of the American Institute of Chemical Engineers (AIChE) in the summer of 1994. A questionnaire that closely corresponds with ABET/AIChE categories was sent to the 158 chemical engineering departments listed with AIChE; sixty-three departments responded, and the survey results are based on those responses.

having more than 140. Most schools operate on the *Nominal Semester* basis; few use a quarter system.

As in the previous survey, the average curricular area distribution continue to be somewhat close to ABET/AIChE requirements. A closer look at the individual departmental requirements reveals a wide range (see Table 2). For example, mathematics, which has an average value of 16.5 contact hours (semester credits), ranges from 12 to 22 hours. Most of the departments' requirements fall within 15 to 18 hours. Expressed as a percentage, the mathematics requirement is 12.5%, equaling the AIChE requirement of 12.5%.

Similar traits are observed in other categories. For example, "engineering science/design" and "humanities/social sciences" continue to increase their share and move away from ABET/AIChE requirements at the expense of other categories that show a downward movement.

TABLE 2
Distribution of Course Work

Curricular Area	*AIChE %*	*1981 Avg*	*1985 Avg*	*1989 Avg*	*1994 Avg*
Mathematics beyond Trigonometry	12.5	13.6	12.7	12.4	12.5
Basic Sciences	25.0	24.3	25.4	24.8	24.1
(Incl. Advanced Chemistry)	(12.5)	(11.7)	(12.8)	(12.3)	(11.9)
Engineering Sciences/Design	37.5	37.3	37.2	39.7	39.7
Humanities/Social Sciences	12.5	16.1	15.1	13.5	14.6
Other	12.5	8.7	9.7	9.6	8.9
Total Percent	*100.0*	*100.0*	*100.0*	*100.0*	*100.0*
Total Credit Hours		*133.4*	*131.4*	*132.8*	*132.8*

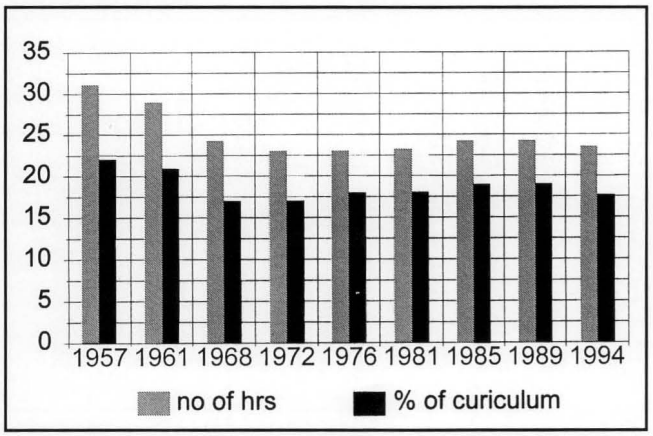

Figure 2. *Chemistry content exclusive of advanced chemistry.*

Some changes can be observed within the categories. Mathematics, which used to be predominantly calculus and differential equations, show that calculus has maintained its dominance, but differential equations has lost some of its share to analytical geometry and advanced calculus.

The remaining credits still demonstrate wide diversity. The popularity of linear algebra has increased to 26 departments (41%) requiring the course, compared to 20 departments (22%) in 1989. Partial differential equations show reduced popularity. Many departments require a mathematics elective.

In the fundamentally important "basic science" category, introductory physics and chemistry continue to maintain diversity and dominate the credit hours. But ten departments reported modern physics, five listed biology, and four indicated that other basic sciences are required. A comparison of these numbers to previous survey results indicates that the popularity of these courses is decreasing. The advanced chemistry requirements showed a drop to 11.95% from the AIChE requirement of 12.5%, but, as usual, showed a wide range of 10.67 to 21.0 hours. The total chemistry contents, as indicated by Figure 2, has maintained a stable trend.

The engineering science and design requirements increased to 39.9% from their 39.7% value in the 1989 survey. The statics course has suffered a significant drop in popularity, with nearly 68% of the departments offering the course in 1989 and only about 59% in 1994. But dynamics and/or mechanics of materials maintain their positions, with approximately one-quarter of the departments requiring the courses.

Another startling change is seen in the introduction to electrical engineering courses, which suffered a major drop in popularity from 65% of departments requiring the courses in 1989 to only 48% in 1994; material science maintained its position at about 46%.

The chemical engineering component constitutes 65% of the engineering category, a drop of 5% from the previous survey. Although transport phenomena and unit operations do overlap in course content to a considerable extent, they suggest a difference in focus. The number of departments

requiring unit operation theory decreased significantly from about 74% to 63%, but departments requiring unit operations laboratory is almost 94%.

In the case of transport phenomena, theory courses were reported by nearly 80% of the departments; the laboratory component was reported by only half of that number. Mass transfer is offered by 58%, and process control and process dynamics were reported by approximately 86% and 57% of the departments, respectively. Reactor design is required by three-quarters of the departments.

Regarding electives, twenty-one specific electives and a broad "other" choice were included in this category of the questionnaire. The results are given in Table 3. Biochemical, polymers, and the environmental electives continue to be the top three, with approximately 49% of the departments offering them. There has been a shuffling of positions between other electives. Equipment and energy related areas, such as natural gas and fuel, are still in the lower end.

The cultural content (which includes the humanities and the social sciences) has managed to break its declining trend of the past three surveys and is approximately equal to that of the 1985 survey (see Figure 3); it never actually reached the ABET minimum value of 12.5%. Interestingly, the range of credit hours required has narrowed, with the low end moving up from 6 to 13 hours and the high end moving significantly down from 55.3 to 37.36 hours. The high actually moved from 42% of the program to 28%, while the low end shifted from 5% to 10%.

The fifth and final major section of the questionnaire was classified as "other" and included diverse course offerings. The communication category formed a major portion of this section, but it has shown fluctuation over the years. In accordance with this fluctuating trend, it decreased from 90% to slightly less than 80%. As one would normally expect, computer programming (which is in this fifth, "other" category) was another course required by a significant number of the departments. Figure 4 shows results of responses for this category.

Table 4 depicts an average program that could be used for comparison. The information provided in this table might be useful to a school starting up a chemical engineering program.

Table 5 indicates that the average department reported 8% foreign undergraduate students, but 48% foreign graduate students. There are on the average 7.04 full professors, 2.59 associate professors, 1.83 assistant professors, and 0.62 full-time equivalent other faculty in the 63 schools that responded to the survey.

About 14% of salaries are obtained from other than general educational funds, and there are about 0.59 faculty positions available on the average. The number of faculty positions for the 63 reporting schools is about 37, but closer

TABLE 3
Elective Offerings

Elective	*# Depts*	*%*	*Elective*	*# Depts*	*%*
1. Biochemical	34	54.0	12. Petroleum	5	7.9
2. Polymers	29	46.0	13. Catalysts	6	9.5
3. Environmental	29	46.0	14. Paper	3	4.8
4. Transport Phenomena	11	17.5	15. Nuclear	4	6.3
5. Applied Mathematics	16	25.4	16. Coal	6	9.5
6. Control	13	20.6	17. Energy	4	6.3
7. Biomedical	13	20.6	18. Equipment	1	1.6
8. Design	8	12.7	19. Food	2	3.2
9. Mass Transfer	8	12.7	20. Fuel	2	3.2
10. Reactors	6	9.5	21. Natural Gas	2	3.2
11. Electrochemistry	10	15.9	22. Others	27	42.9

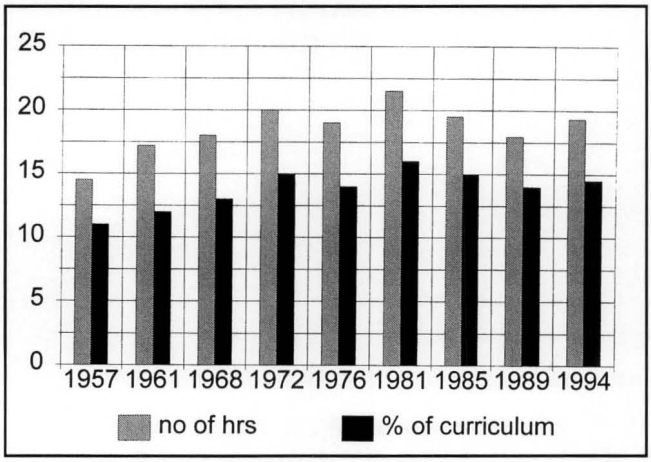

Figure 3. *Cultural content.*

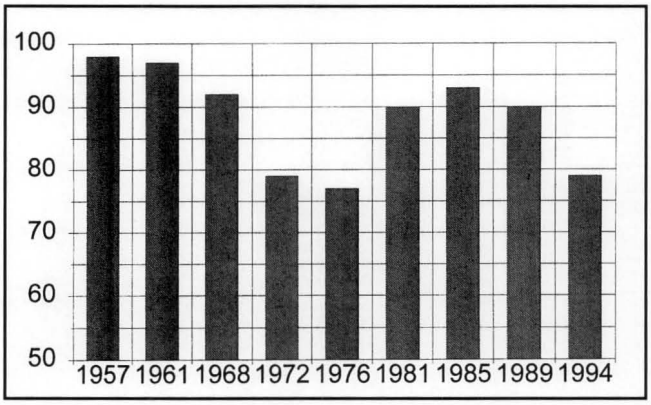

Figure 4. *Communications (% of schools offering).*

TABLE 4
Average Program Abstract

Course	*Hours*
Analytical Geometry	2.94
Calculus	8.31
Differential Equations	3.21
General Physics	7.67
General Chemistry	7.69
Physical Chemistry	6.36
Organic Chemistry	7.10
Other Chemistry	3.98
Statics	3.06
Electrical Engineering	3.77
Material Science	3.94
Fluid Mechanics	2.73
Heat Transfer	2.56
Material and Energy Balances	3.61
Thermodynamics	4.22
Reaction Engineering	1.88
Transport Phenomena	3.88
Mass Transfer	2.97
Unit Operations	3.20
Laboratory	3.74
Process Control	2.36
Design	4.93
ChE Electives	5.93
Humanities	9.72
Social Science	6.99
Communications	6.82
Computer Programming	2.58
Other	6.62
Total	***132.77***

TABLE 5
Summary of Student and Faculty Information

	Total	*Avg.*
Students (ChE)		
Fraction, Non-U.S. Undergraduate	N/A	0.08
Fraction, Non U.S. Graduate	N/A	0.48
Faculty (Number of)		
Full-time professors	443.63	7.04
Full-time associate professors	163.33	2.59
Full-time assistant professors	115.00	1.83
Full time equivalent, other teaching staff	39.3	0.62
% of salaries funded from other than general education funds	N/A	13.99
Number of full-time faculty positions open (tenure track)	37.00	0.59

understanding of the variation among departments necessitates a review of the entire information contained in the data received in all of the 63 responses.

The spreadsheets have been made available for all participating departments. For others who are interested, the spreadsheet will be made available upon request made in writing to the authors.

CONCLUSIONS

- Sixty-three departments of chemical engineering (out of 158 schools that were solicited) completed the most recent survey conducted by the Undergraduate Curriculum Subcommittee of the AIChE Education Projects Committee. The number of credits requirement for a BS degree in chemical engineering ranges from 115-145 on the ABET semester basis.
- The average number of credits required for a BS degree in the U.S. has remained almost the same at about 133 credits for the past twenty-two years.
- The chemistry content remained approximately the same for the past ten years, while the cultural content appears to have fluctuated the most for the past twenty years. The number of schools offering communications has seemed to decrease since 1985, although it had initially increased since 1976.
- The results in Table 2 indicate that the distribution of course work has remained fairly constant for the past thirteen years. There has been a slight increase in math courses beyond trigonometry, although it had decreased slightly and fairly steadily until 1989. Basic sciences has decreased slightly and fairly steadily for the past nine years; engineering science has increased in a similar fashion.
- The results in Table 3 indicate that biochemical electives are offered at the highest percentage of the schools.
- Table 4 provides an average program abstract of the course offerings and indicates little change since the last survey, performed in 1989.[1]

ACKNOWLEDGMENTS

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REFERENCES

1. Coulman, G.A., "The Chemical Engineering Curriculum," *Chem. Eng. Ed.*, **23**(4), 184 (1990). *Note; this reference contains a bibliography (seven related references) for this paper's topic.* ❐