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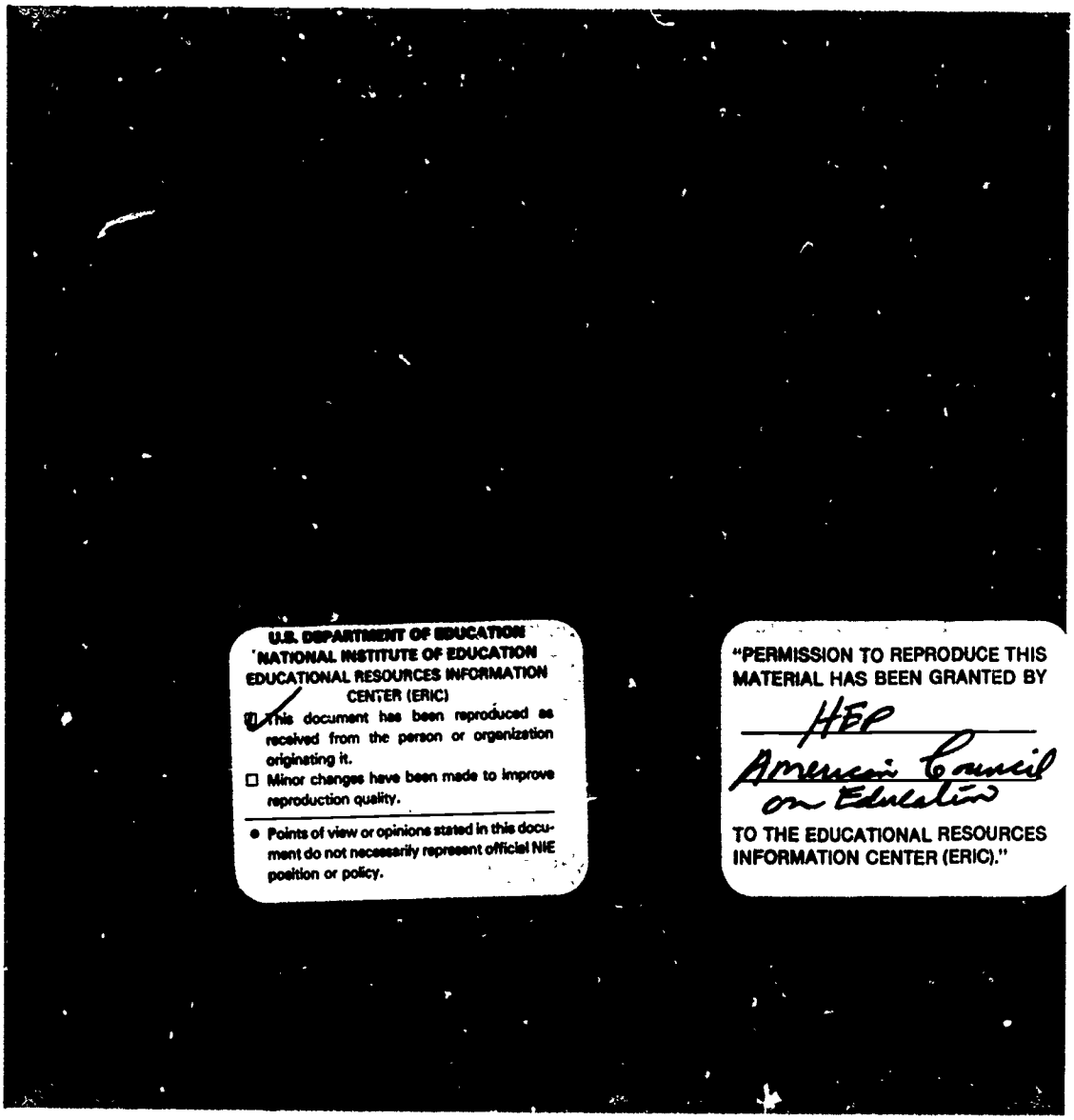
ABSTRACT

Baseline data on engineering programs, faculty, and students in selected and rapidly developing engineering specialties are presented, based on a survey of engineering schools. The specialties of interest are: computers, materials, microelectronics, robotics, manufacturing, and biotechnology programs. National estimates are derived from the responses of 96 engineering schools. Attention is directed to the availability of qualified faculty, including the supply of doctoral students, in emerging engineering areas. Information is presented on: the total number of faculty recruitments in progress and completed during the 1983-1984 academic year; sources of qualified applicants and their citizenship; the organization and location of the engineering programs; how programs at public and private colleges compare; programs at the top 50 institutions that granted the largest number of doctoral degrees in engineering in 1981-1982; and programs at the top 50 institutions ranked highest in terms of research expenditures. It was found that in 1983-1984, there were 470 operational programs in emerging engineering areas, averaging nearly four programs per institution. Appendices present the questionnaire, information on survey methodology, and technical notes. (SW)

ENGINEERING PROGRAMS IN EMERGING AREAS, 1983-84

Engin Inel Holmstrom
Janice Petrovich



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AMERICAN COUNCIL ON EDUCATION

Robert H. Atwell, President

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We offer special recognition and thanks to each campus Panel representative, whose cooperation and coordination were vital to the success of this study.

Finally, we wish to acknowledge that the early stages of this survey were conducted under the guidance of Frank J. Atelsek, the Higher Education Panel's Director until his untimely death in May 1985.

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HIGHLIGHTS

General

- In 1983–84, there were about 470 operational programs in emerging engineering areas (i.e., computers, materials, microelectronics, robotics, manufacturing, and biotechnology), averaging nearly four programs per institution.
- The most numerous were programs in computers, followed by microelectronics, and materials. The least numerous were programs in biotechnology, followed by manufacturing.
- These programs employed over 4,060 faculty, averaging nearly nine faculty per program. Compared to total faculty in engineering programs, the faculty in emerging programs were somewhat junior in rank although nearly one-half were full professors. One-fifth of the total faculty had non-U.S. bachelor's degrees. There were more foreign-trained faculty among the junior than senior ranks.
- Programs enrolled about 7,500 doctoral students, averaging just over 16 students per program. Nearly one-half were non-U.S. citizens.
- Seventy percent of the programs were in public institutions. Public and private programs employed relatively similar numbers of faculty, but private programs enrolled more doctoral students than did public programs.
- About one-half of the programs were located in the 50 institutions ranking highest in doctoral production as well as in the top 50 in terms of research expenditures. Programs in these institutions tended to have larger numbers of faculty and doctoral students than did programs in other institutions.
- Although three-quarters of the programs in emerging engineering areas engaged in faculty recruitment activities during 1983–84, over one-half reported faculty shortages.
- Nearly 30 percent of the programs reported that non-U.S. citizens comprised over one-half of their faculty applicant pool. The most important source of qualified applicants for faculty positions was the pool of new doctorates from U.S. institutions.

Program Highlights

- **Biotechnology:** 58 programs, averaging seven faculty and 12 doctoral students, with private programs having more doctoral students than public programs. Three-fifths of programs report faculty shortages. Lowest proportion of non-U.S. citizens among faculty, faculty applicant pool, and students.
- **Computers:** The most numerous with 96 programs, averaging 12 faculty and 20 doctoral students. Private programs larger than public programs. Heavy faculty recruiting in 1983–84; the least likely to report shortages with only 32 percent indicating unfilled faculty positions. Compared to other programs, more non-U.S. citizens among faculty, faculty applicant pool, and students.
- **Manufacturing:** 59 programs, averaging eight faculty and eight doctoral students. Fewer than half report faculty shortages. Relatively large concentration of non-U.S. citizens among faculty, faculty applicant pool, and students. Nearly three-fifths of doctoral students are non-U.S. citizens.
- **Materials:** 86 programs, averaging 11 faculty and 28 doctoral students. More likely than others to be housed in private institutions. Programs in private institutions and in the top 50 institutions by research expenditures much larger than programs in other institutions. Heaviest concentration of full professors among faculty (62 percent). Heavy faculty shortages with 80 percent of programs reporting unfilled faculty positions. Relatively few non-U.S. citizens among faculty, faculty applicant pool, and doctoral students.
- **Microelectronics:** 86 programs, averaging eight faculty and 15 doctoral students. Private programs larger than public programs. Over one-half of the doctoral students are non-U.S. citizens. Heavy faculty recruitment in 1983–84, but over two-fifths still report faculty shortages.
- **Robotics:** 64 programs, averaging five faculty and seven doctoral students. Somewhat more likely to be housed in public institutions than other programs. Over one-half report faculty shortages.

BACKGROUND

The importance of engineering in the development of technology is widely acknowledged. Recognizing that much of the nation's economic, technological, and industrial leadership hinges on the innovations and technologies provided by the engineering profession, the National Science Foundation has been devoting special attention to engineering education. The availability of qualified faculty, the scope and number of engineering programs, and the production of doctorates are among the subjects that have been studied.

Colleges of engineering have been establishing new programs in a number of emerging areas that have applications in production and manufacturing. Although previous surveys have documented some shortages of faculty in major engineering fields, information on emerging areas has not been available. A primary purpose of this survey is to provide reliable baseline data on faculty, programs, and students in selected and rapidly developing engineering specialties. These include, for purposes of this study: computers, materials, microelectronics, robotics, manufacturing, and biotechnology programs.

The term "program" was defined as "an organized instructional activity leading to the Ph.D., Sc.D., or equivalent degree." The programs could be administered either separately or as areas of concentration within established departments in engineering schools.

The study population was defined as all institutions of higher education that granted at least one doctorate in engineering in 1981–82 and offered doctoral programs in emerging areas. Of 142 institutions that granted doctorates, 19 reported no activity in any of the emerging areas, reducing the study population to 123. The national estimates presented in this report are derived from responses obtained from 96 institutions (78 percent response rate). Respondents included deans of engineering schools who completed the first section of the survey questionnaire, providing data on the number and type of emerging programs, and program heads who provided detailed information on faculty and students. A copy of the survey questionnaire is presented in Appendix A. A description of the survey procedures, including sampling and weighting, is found in Appendix B (Methods Summary) and Appendix C (Technical Notes).

The survey was designed to provide information on the availability of qualified faculty, including the supply of doctoral students, in emerging engineering areas. Institutions were asked to report the total number of faculty recruitments in progress and completed during the 1983–84 academic year and to indicate the sources of qualified applicants and their citizenship.

The report presents national estimates for the programs, faculty, and doctoral students. It presents information on organization and location of these programs. Whenever relevant, comparisons are made between programs located in public institutions and those in private institutions. Information is also presented for programs in the top 50 institutions that granted the largest number of doctoral degrees in engineering in 1981–82 as well as the top 50 ranked highest in terms of research expenditures in that year. (Twenty-five institutions of higher education appear on both lists. See detailed tables 1 and 2 presented after the text for lists of top 50 institutions.)

Readers are reminded that the national estimates presented in this report may underestimate the number of programs, faculty, and doctoral students involved in emerging engineering areas. The survey population consisted only of programs located in engineering departments. The report does not contain information on programs administered by other departments or schools, such as, computer programs in computer science departments and biotechnology programs in schools of medicine. Moreover, information was requested only for those *full-time, regular* faculty employed by the institution who were involved in the emerging programs in one capacity or another. Some programs may hire large numbers of adjunct faculty—such as personnel from industry in manufacturing or materials programs—who are not accounted for in this report.

FINDINGS

Program Organization and Location

In 1983–84, the doctorate-granting colleges of engineering had about 470 operational programs in emerging areas, averaging nearly four programs per institution. They also had about 30 authorized but non-operational programs (see detailed table 2).

Public institutions administered 70 percent of the operational programs (see table A). The 50 institutions that granted the largest number of doctoral degrees in engineering had about half of the programs, as did the 50 institutions with the largest research expenditures.

in the departmental distribution of specific programs. Biotechnology programs are most likely to be administered by departments of chemical engineering, followed by departments of bioengineering/biomedical engineering, and electrical engineering. Programs in computers are usually located in departments of electrical engineering or computer engineering/computer science. Materials programs tend to be housed in departments of mechanical engineering, chemical engineering, and materials science and engineering, including metallurgy. Programs in manufacturing are usually found in departments of mechanical systems

TABLE A—Percentage Distribution of Programs in Emerging Areas in Engineering, by Control and Top 50 Status of Institutions

Program Area	(N)	Control		Top 50 by Degrees Conferred		Top 50 by Research Expenditures	
		Public	Private	Top 50	Other	Top 50	Other
Total	(467)	70	30	48	52	51	49
Biotechnology	(58)	72	28	48	52	51	49
Computers	(96)	69	31	48	52	48	52
Manufacturing	(59)	78	22	53	47	56	44
Materials	(86)	64	36	46	54	50	50
Microelectronics	(86)	69	31	46	54	48	52
Robotics	(64)	75	25	50	50	56	44
Other	(19)	68	32	37	63	47	53

Reference: Detailed tables 2 and 3

Computer programs were the most numerous of all the programs in emerging areas, comprising 21 percent of all the programs, followed by microelectronics (18 percent) and materials (18 percent); biotechnology was one of the least numerous, comprising only 12 percent of the programs (see figure 1 and table B). Nineteen miscellaneous programs were categorized as "other" and include programs in laser holography, hydrology/hydraulics, transportation, construction management, hazardous wastes, ocean engineering, and industrial and management systems.

Sixty-three percent of the institutions responding to the survey reported that they had doctoral programs in at least three of the emerging engineering areas; 22 percent had programs in all six areas. A list of institutions offering doctoral programs in emerging engineering areas appears in detailed table 4.

Programs in emerging engineering areas are often administered by different departments at different institutions. There are some general trends, however,

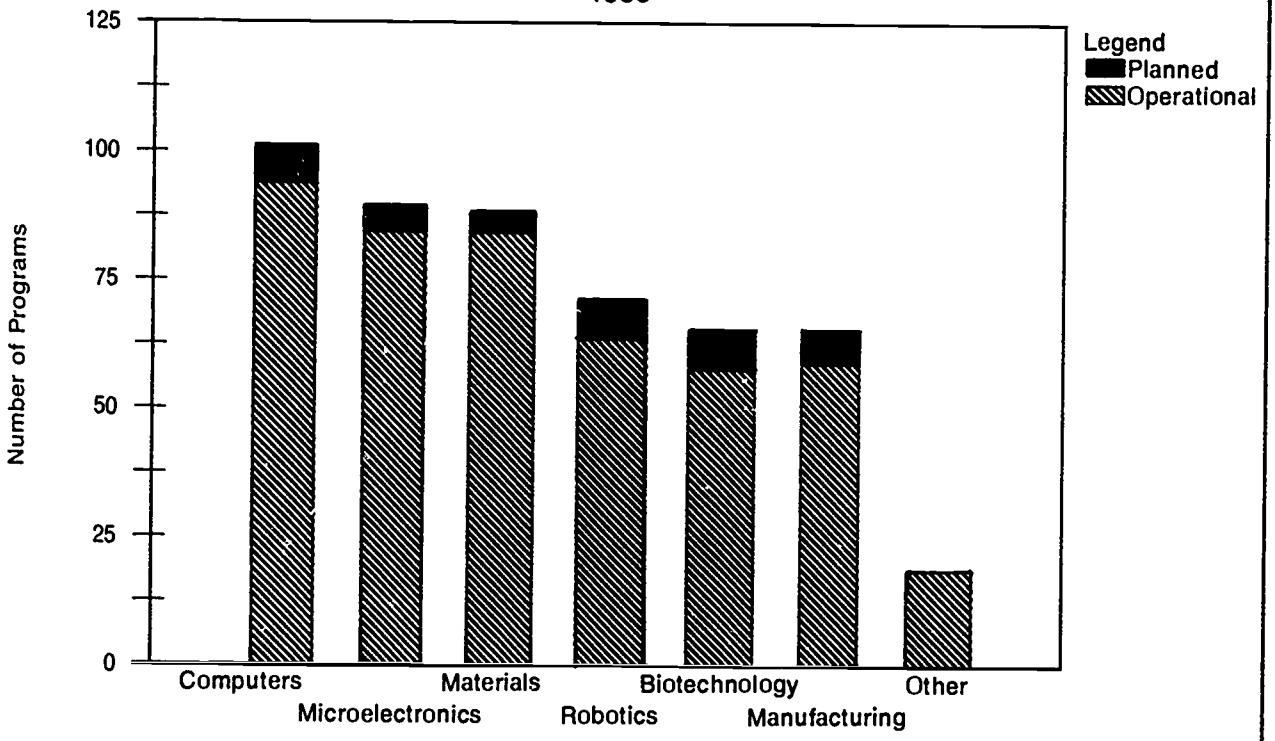
TABLE B—Percentage Distribution of Programs in Emerging Areas in Engineering, by Control of Institution

Program Area	Total (N = 467)	Public (N = 329)	Private (N = 137)
Total programs	100	100	100
Biotechnology	12	13	11
Computers	21	20	22
Manufacturing	12	14	9
Materials	18	17	23
Microelectronics	18	18	20
Robotics	14	15	12
Other	4	4	4

Note: Percentages may not sum to 100 because of rounding.
Reference: Detailed table 2.

or industrial engineering. Finally, programs in microelectronics tend to be administered by departments of electrical engineering, and robotics programs by departments of electrical, mechanical, industrial, or aeronautical engineering.

Figure 1
Doctoral Programs
in Emerging Engineering Areas,
1983



Respondents were asked to indicate other departments or units outside the engineering college that cooperate with the emerging programs. Biotechnology programs were the most likely to have cooperative arrangements with departments and units outside the engineering college. They reported 17 such cooperative efforts, eight of which were in schools of medicine. Engineering departments with computers programs were also likely to have cooperative arrangements with other computer science departments. Robotics programs were the least likely to have cooperative arrangements. Only two were reported: one with a computer science department, another with a psychology department. Most often, departments cooperating with engineering programs in emerging areas were in the natural sciences (chemistry, physics, mathematics, medicine) or business.

Within the six areas, institutions were asked to identify specific program specialties. Computer programs generally reported specializing in software design, artificial intelligence, and computer architecture. The specialties cited by materials programs included polymers, metals, and electronic materials. Microelectronics programs focused on artificial intelligence and integrated circuit fabrication. Manufacturing and robotics concentrated on computer-assisted design/computer-assisted manufacturing (CAD/CAM). Robotics also included artificial intelligence and kinematics. Biotechnology programs cited biomedical engineering and biomaterials as program specialties.

The information on program specialties within the emerging engineering areas suggests that the six areas are not mutually exclusive and that there is considerable overlap. For example, artificial intelligence was cited as an area of specialization in computers as well as in microelectronics and robotics programs.

Faculty Composition

About 4,060 faculty were employed in some 470 programs in emerging engineering areas, averaging nearly nine faculty per program (see tables C and D). Not surprisingly, the larger program areas had most of the faculty. For instance, computers which accounted for 21 percent of the programs, claimed 27 percent of the faculty, averaging 12 faculty per program. In contrast, robotics, which accounted for 14 percent of the programs, had eight percent of the faculty, averaging only five faculty per program. Computers and materials programs had more faculty than others, while robotics and biotechnology had fewer.

In general there was no difference in the average number of faculty employed in public and private programs, except in robotics which averaged nearly two more faculty in public programs than in private programs. Programs in the top 50 institutions had more faculty than programs in other institutions. For instance, programs in the 50 institutions that granted the largest number of doctorates in engineering averaged nearly three more faculty than other programs. Similarly, programs in the 50 institutions with largest research expenditures averaged nearly five more faculty than did others. Differences between programs in the top 50 and other institutions were most apparent in materials programs where the top 50 institutions had, on average, eight more faculty than programs located in other institutions.

TABLE C—Percentage Distribution of Faculty in Emerging Programs in Engineering, by Control of Institution

Program Area	Total (N=4,062)	Public (N=2,846)	Private (N=1,216)
Total programs	100	100	100
Biotechnology	10	11	9
Computers	27	26	30
Manufacturing	12	14	8
Materials	22	21	26
Microelectronics	17	16	19
Robotics	8	9	5
Other	4	3	4

Note: Percentages may not sum to 100 because of rounding.
Reference: Detailed table 2

Faculty Rank. Almost half of the faculty in emerging areas held the rank of professor, about one-fourth were associate professors, and another one-fourth were assistant professors (see figure 2 and detailed table 6). The greatest concentrations of assistant professors were in computers, robotics, and manufacturing where about 30 percent of the faculty were assistant professors. In contrast, about 60 percent of the faculty in materials and in "other" programs and over half of those in microelectronics were full professors.

Degree Background. Over 20 percent of the faculty in emerging areas had bachelor's degrees from institutions outside the U.S. (see table E). There was basically little difference in the proportion of foreign-trained faculty in programs located in public and private institutions and in the top 50 institutions (see detailed table 7). One exception was in robotics programs that were located in the top 50 institutions granting engineering degrees which had a slightly higher proportion of faculty with foreign baccalaureates than did other programs. Another exception was in manufacturing programs located in the top 50 institutions with research expenditures which had a slightly lower proportion of foreign faculty than did others. The highest concentration of foreign trained faculty was in manufacturing (28 percent), followed by robotics (26 percent), microelectronics (25 percent), and computers (24 percent).

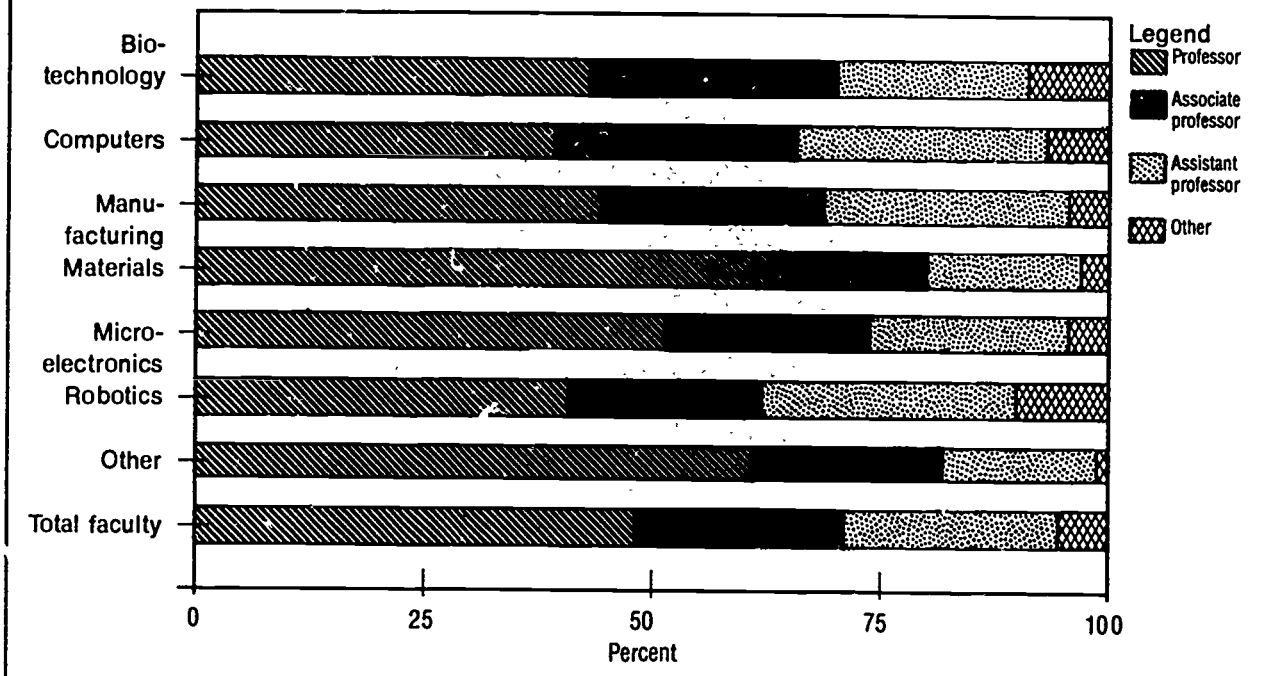
Junior faculty were more likely to have foreign backgrounds than senior faculty. Among assistant professors, the proportion with foreign training was 33 percent overall, compared to 24 percent among associate professors, and 16 percent among full professors. Academic rank distribution of foreign faculty differed somewhat by program area. For instance, nearly half the foreign-trained faculty in computers and 42 percent of those in manufacturing held the rank of assistant professor. In contrast, nearly half the foreign-trained faculty in materials and 42 percent of those in microelectronics were full professors (see figure 3).

TABLE D—Average Number of Faculty in Emerging Programs in Engineering, by Program Area, and by Control and Top 50 Status of Institution

Program Area	Institutional Control			Top 50 by Engineering Degrees	Other	Top 50 by Research Expenditures	Other
	Total	Public	Private				
Total	9	9	9	10	7	11	6
Biotechnology	7	7	7	8	6	9	5
Computers	12	11	12	13	10	14	9
Manufacturing	8	8	8	8	8	9	7
Materials	11	11	10	15	7	15	7
Microelectronics	8	8	8	9	7	11	6
Robotics	5	6	4	5	5	6	4
Other	8	7	9	9	7	10	6

Reference: Detailed tables 2, 3, and 6

Figure 2
Faculty Rank
Distribution in Emerging Areas,
by Program Area



Reference: Detailed table 5

TABLE E—Proportion of Engineering Faculty in Emerging Areas Who Hold Non-U.S. Bachelor's Degrees, by Program Area and Academic Rank

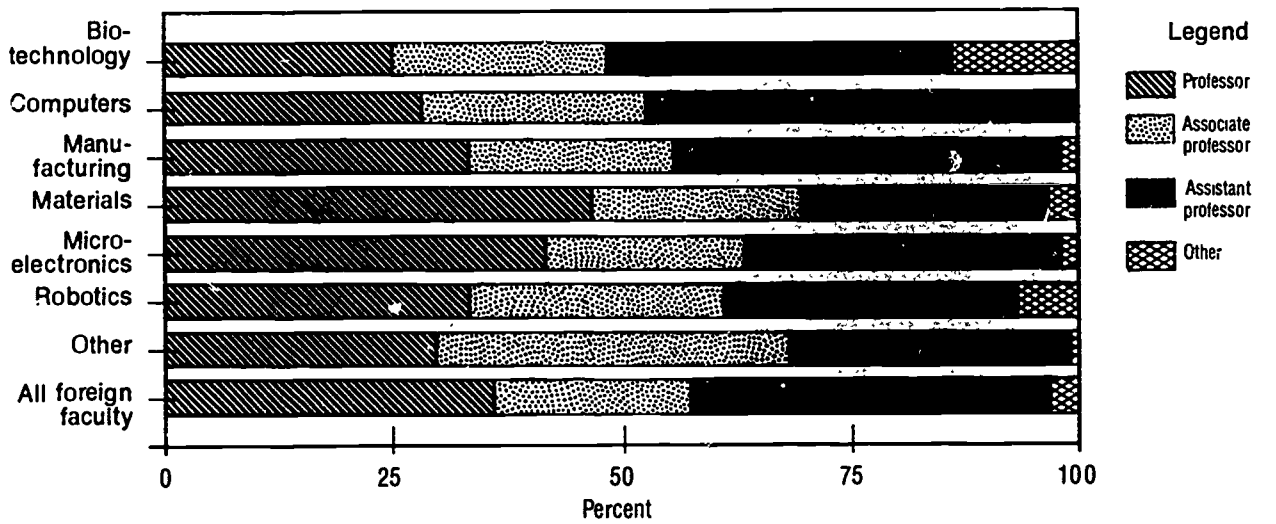
Program Area	All Faculty	Professors	Associate Professors	Assistant Professors	Other
All programs	22%	16%	24%	33%	13%
Biotechnology	13	8	11	23	24
Computers	24	17	23	36	1
Manufacturing	28	21	25	42	16
Materials	19	14	27	29	29
Microelectronics	25	20	25	39	14
Robotics	26	21	36	27	21
Other	12	6	23	19	0

Faculty Recruitment

The majority of the engineering deans indicated that availability of human resources is the major determining factor in the development of engineering programs in emerging areas (see table F). The deans of engineering schools in public institutions were more likely to endorse this statement than were deans in private institutions (90 percent versus 74 percent).

The rapid growth of programs in emerging engineering areas is evident by the fact that the staff recruited during 1983–84 accounted for 21 percent of the total engineering faculty (see table G). New faculty accounted for 28 percent of the total faculty in robotics but only 11 percent of those in biotechnology programs. Computer programs were the most likely to report faculty recruitment during 1983–84 (92 percent), followed by programs in microelectronics (85 percent), and manufacturing (80 percent). Only 31 percent of biotechnology programs tried to recruit faculty in 1983–84. The average number of faculty recruited was two, with computers programs recruiting as many as three, while biotechnology programs recruiting only one, on average.

FIGURE 3
Distribution of Engineering Faculty
Who Hold Non-U.S. Bachelor's Degrees,
by Emerging Program Area and Academic Rank



Reference: Detailed Table 7

TABLE F—Engineering Deans Who Believe that the Availability of Human Resources is the Major Determining Factor in the Development of Engineering Programs in Emerging Areas

Type of Institution	Number	Percent
Total	104	85
Public	75	90
Private	29	74
"Top 50" Degrees	46	92
Other than "Top 50" Degrees	58	80
"Top 50" in Research Dollars	43	86
Other than "Top 50" in Research Dollars	61	84
With Programs in:		
Biotechnology	52	90
Computers	82	88
Manufacturing	46	84
Materials	73	84
Microelectronics	71	86
Robotics	54	88
Other	20	89

Qualified faculty were in short supply in 1983–84. Fully half of the programs were unable to fill all the faculty positions for which they were recruiting (see figure 4). A majority of the materials, biotechnology, robotics, and "other" programs reported shortages. Computers, microelectronics, and manufacturing were less likely to report shortages than were other programs. Nonetheless, over 40 percent of the programs in manufacturing and microelectronics and over 32 percent of computers programs still reported unfilled faculty positions. Programs in private institutions were somewhat more likely to report that they were unable to fill all faculty positions than were programs in public institutions (see detailed table 8).

The survey included a question requesting information on the specialties for which the programs were not able to find faculty. Biotechnology, computers, and robotics programs reported problems in recruiting faculty specializing in artificial intelligence (see table H). Microelectronics, manufacturing, robotics, and computers programs sought applicants with knowledge of computer-assisted design (CAD) without success. These responses suggest that emerging area programs may be competing against each other for persons with similar expertise.

Respondents were asked to indicate from a list of eight statements the two most important sources of qualified applicants for faculty positions in their programs. The most important source for faculty positions in emerging areas was the pool of new doctorates from U.S. institutions (see detailed table 9). The second-ranked source cited by all program areas, except microelectronics, was faculty from other U.S. institutions. In microelectronics, doctorate holders coming from U.S. industry were cited as the second-ranked source of qualified applicants for faculty positions.

Non-U.S. citizens constituted a substantial proportion of the qualified faculty applicant pool in some

FIGURE 4
Number of Programs Recruiting Faculty in Emerging Engineering Areas in 1983–84 and Number of Programs Unable to Fill All Faculty Positions, by Program Area

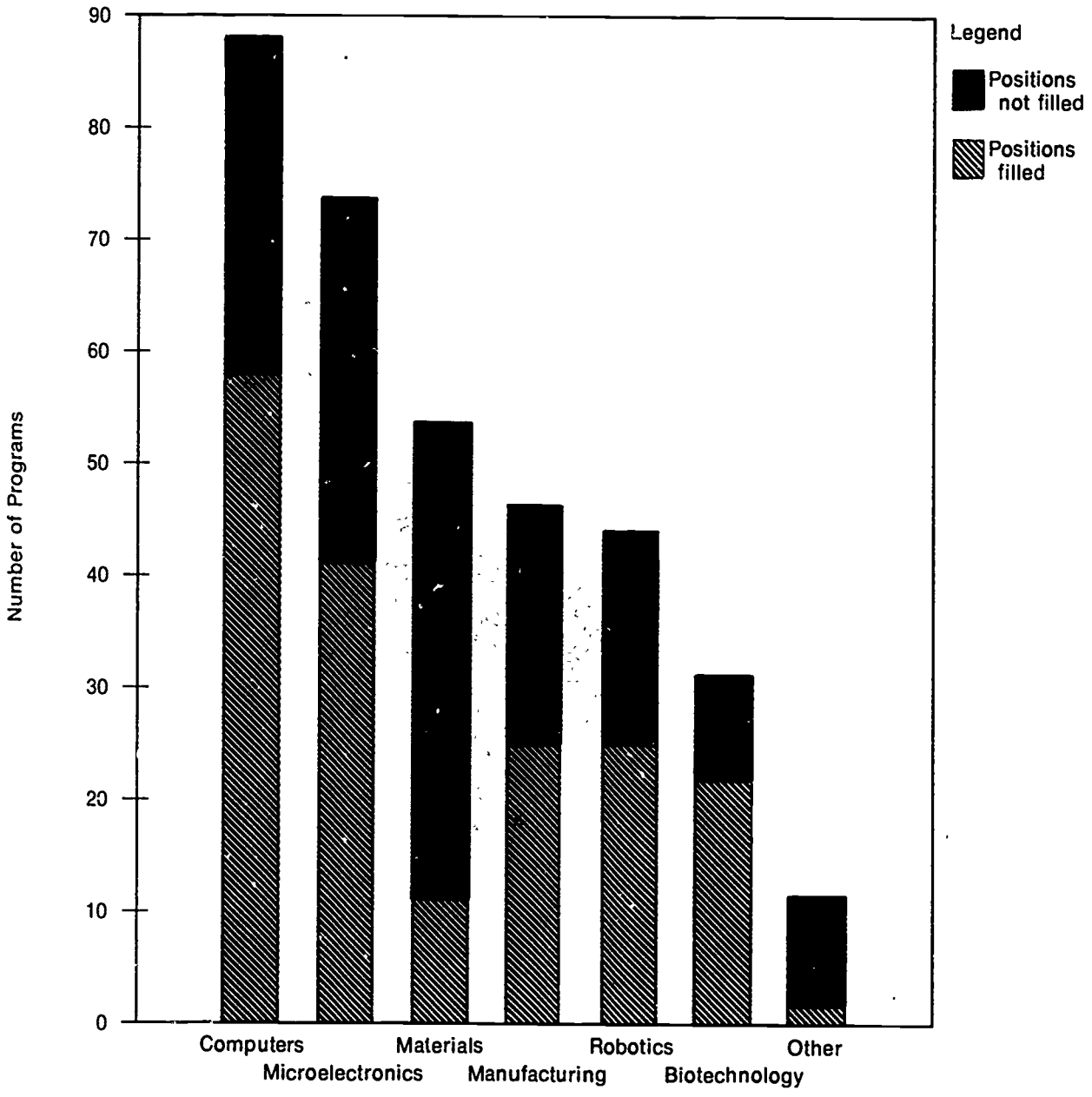


TABLE G—Faculty Recruitment During Academic Year 1983–84 in Engineering Programs in Emerging Areas

Program Area	Programs Recruiting Faculty		Faculty Recruited		Programs Unable to Fill All Positions	
	Number	Percent[1]	Number	Percent[2]	Number	Percent[3]
All programs	349	75	860	21	179	51
Biotechnology	31	53	43	11	21	66
Computers	88	92	289	26	29	32
Manufacturing	47	80	118	24	22	46
Materials	54	63	127	14	43	80
Microelectronics	73	85	178	26	32	43
Robotics	44	69	89	28	24	55
Other	11	58	17	12	9	81

[1]Based on total number of programs.
[2]As a percent of total faculty.
[3]Based on number of programs which recruited faculty during 1983–84.

TABLE H—Engineering Programs in Emerging Areas in 1983–84, with Unfilled Faculty Positions in Specialty Areas

Speciality Areas	Program Area					
	Computers	Materials	Microelectronics	Manufacturing	Robotics	Biotechnology
Artificial intelligence	×			×	×	×
Biomedical/bioelectrical engineering						×
Computer architecture	×					
Computer-assisted design	×		×	×	×	
Computer-assisted manufacturing				×	×	
Database systems	×					
Electronic materials		×	×			
Integrated circuit design		×				
Metallurgy		×				
Microprocessor instrumentation					×	
Software enginering	×					
VLSI	×		×		×	

program areas. For example, 43 percent of the computers programs and 37 percent of the manufacturing programs reported that over half of their qualified applicants did not have U.S. citizenship (see table I). Biotechnology, materials, and "other" programs reported the lowest proportion of foreign applicants.

Doctoral Students

Nearly 7,500 doctoral students were enrolled in engineering programs in emerging areas, averaging just over 16 students per program. The greatest concentration of students was in materials (32 percent), followed by computers (25 percent) and microelectronics programs (17 percent) (see table J). Programs in materials averaged 28 doctoral students, computers 20 students, and microelectronics 15 students (see table K). The smallest programs were robotics and manufacturing, averaging seven and eight doctoral students, respectively; they were also the two programs that had the most favorable faculty/student ratio, averaging nearly one faculty per doctoral student.

On average, programs in private institutions had 10 more doctoral students than programs in public institutions. The public-private difference was particularly large in biotechnology and computers. Biotechnology programs in private institutions had 20 more doctoral students than programs in public in-

stitutions. Similarly, computers programs in private institutions had 13 more students than programs in public institutions.

Emerging engineering programs located in the top 50 institutions also had larger enrollments than those located in other institutions. The average number of doctoral students in programs in the top 50 institutions by research expenditures was 22 whereas the average number of doctoral students in other programs was 10. Materials programs in such top 50 institutions had 24 more doctoral students than materials programs in other institutions.

Citizenship Status. Nearly one-half of all doctoral students were foreign citizens (see figure 5). The programs with the largest proportion of foreign students were manufacturing (59 percent) and microelectronics (52 percent); biotechnology and "other" programs had the smallest proportion.

In general, there was very little difference in the distribution of foreign students in public and private institutions: 47 percent of doctoral students in public institutions and 43 percent of those in private institutions were non-U.S. citizens (see detailed table 10). However, private biotechnology programs had fewer foreign students than public programs (29 percent versus 41 percent).

Similarly, there was very little difference in the proportion of foreign students enrolled in programs in the top 50 institutions that granted engineering degrees, but programs in the top 50 institutions by research expenditures were generally less likely to enroll foreign students than were programs in other institutions (see detailed tables 10.5 and 10.6).

About 22 percent of the respondents reported that their programs had to address significant differences in the background and experience of their U.S. and foreign students (see figure 5 and detailed table 11). The main differences cited were language, undergraduate training, and laboratory experiences. There was no apparent relationship between a program's report of these differences and the number of foreign doctoral students enrolled. Only 21 percent of the programs in manufacturing reported that they had to deal with differences in students' backgrounds even though this area had the largest proportion of foreign students. Since manufacturing programs had a high proportion of foreign faculty as well as a relatively high faculty/student ratio, one could argue that these factors led to greater interaction between faculty and students and helped compensate for differences in students' backgrounds. It is also possible that the quality of training of foreign students varies somewhat by specialty areas, presenting different problems for faculty in different program areas.

TABLE I—Percentage Distribution of Programs in Emerging Areas in Engineering, by Proportion of Non-U.S. Citizens Among Their Faculty Applicant Pool

Program Area	Total	Proportion of Non-U.S. Citizens in Faculty Applicant Pool			
		0–10%	11–50%	51–70%	71–100%
Total	100	43	28	12	16
Biotechnology	100	64	17	9	9
Computers	100	24	34	14	29
Manufacturing	100	36	27	17	20
Materials	100	53	27	10	9
Microelectronics	100	37	36	15	13
Robotics	100	50	22	8	20
Other	100	62	33	6	0

Note: Percentages may not sum to 100 because of rounding.

TABLE J—Percentage Distribution of Doctoral Students in Emerging Engineering Areas, by Program Area and by Control of Institution

Program Area	Total (N=7,496)	Public (N=4,316)	Private (N=3,180)
Total students	100	100	100
Biotechnology	9	7	13
Computers	25	24	27
Manufacturing	7	9	3
Materials	32	32	32
Microelectronics	17	17	18
Robotics	6	8	4
Other	3	4	3

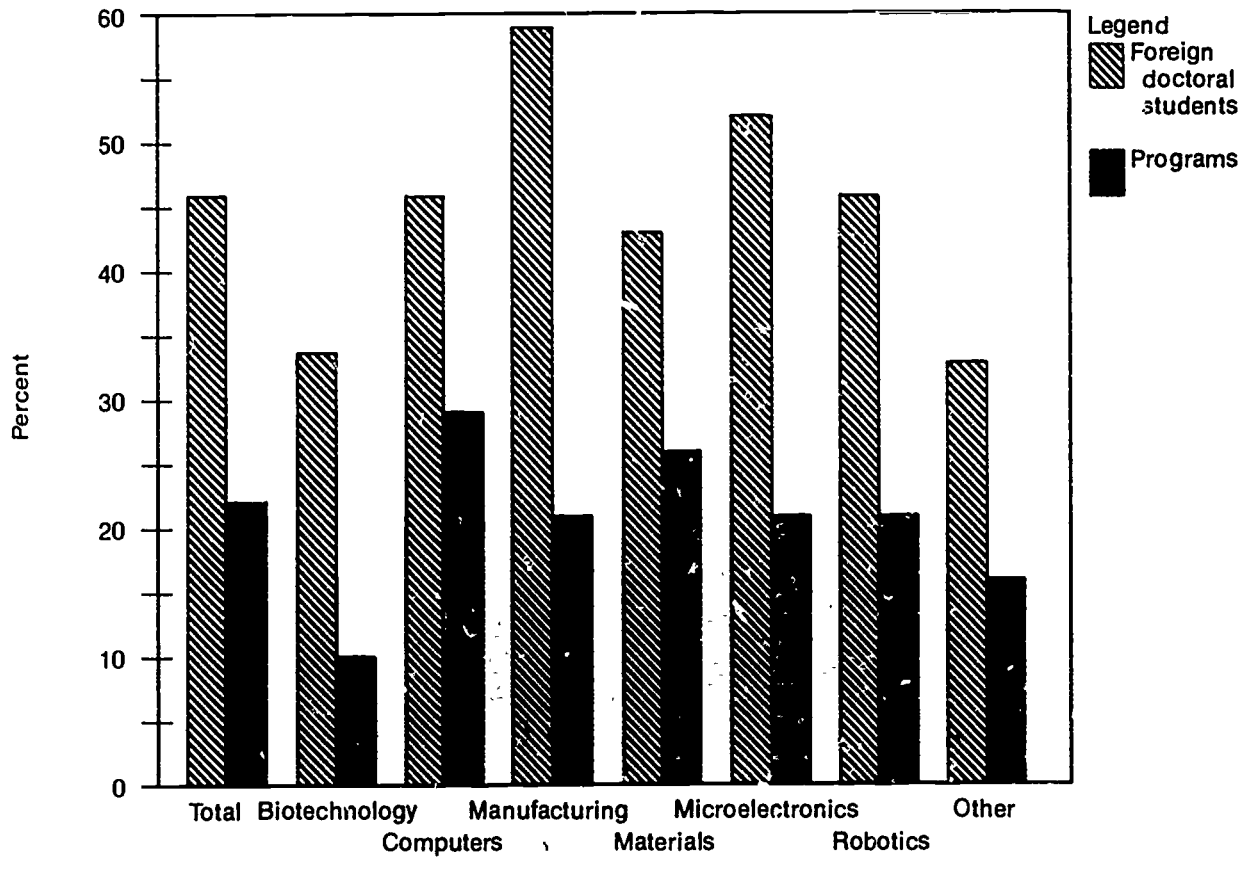
Note: Percentages may not sum to 100 because of rounding.
Reference: Detailed table 10.

TABLE K—Average Number of Doctoral Students in Emerging Engineering Areas, by Program Area and by Control and Top 50 Status of Institution

Program Area	Total Institutions	Public	Private	Top 50 by Engineering Degrees	Other	Top 50 by Research Expenditures	Other
Total programs	16	13	23	20	12	22	10
Biotechnology	12	7	27	15	9	18	6
Computers	20	16	29	22	18	27	13
Manufacturing	8	9	8	10	7	10	6
Materials	28	25	33	39	18	40	16
Microelectronics	15	12	21	20	11	22	8
Robotics	7	7	7	10	3	10	4
Other	14	13	18	21	9	18	10

Reference: Detailed tables 2, 3, and 10

FIGURE 5
Foreign Doctoral Students and Programs Needing to Address Differences in Student Background



22

Institutional and Program Differences

Institutional location of the programs was related to major differences in the number of faculty and students. While public institutions had 70 percent of the engineering programs in emerging areas and 70 percent of the faculty, they accounted for only 58 percent of the doctoral students (see figure 6). In contrast, private institutions had only 30 percent of the programs and 30 percent of the faculty but 42 percent of the students. An average program in private institutions had 10 more students than a program in public institutions. Since programs in both public and private institutions had, on average, nine faculty, the faculty/student ratios were somewhat more favorable in public than in private programs.

The top 50 institutions had larger numbers of faculty as well as students. The top 50 institutions ranked highest in terms of research expenditures had 51 percent of the engineering programs in emerging areas, 64 percent of the faculty, and 70 percent of the doctoral students. On average, there were five more faculty and 12 more students in programs in such institutions than in others. Clearly, the availability of research funds allowed these programs to enroll more students and hire more faculty than was possible in programs in other institutions. Programs located in the top 50 institutions that granted engineering degrees had eight more doctoral students but only three more faculty than programs in other institutions.

There were also some interesting differences by program areas. For instance, while materials comprised 18 percent of the emerging programs in engineering, they represented 22 percent of the faculty and 32 percent of the doctoral students (see figure 7). Compared to all programs, an average program in materials had nearly two more faculty and 12 more students. Manufacturing and robotics, on the other hand, enrolled relatively fewer students and had more favorable faculty/student ratios (with nearly one faculty per student).

Figure 6
Distribution of Programs, Faculty, and Doctoral Students, by Institutional Characteristics

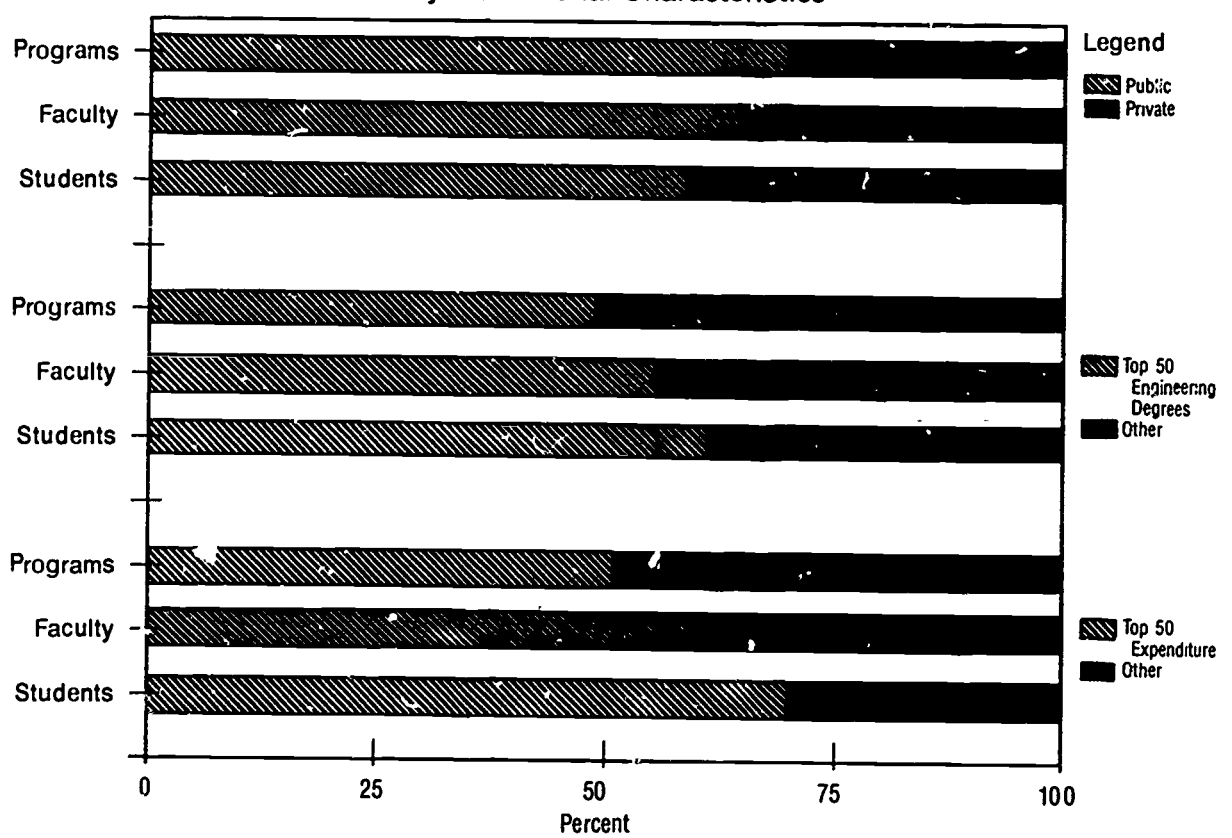
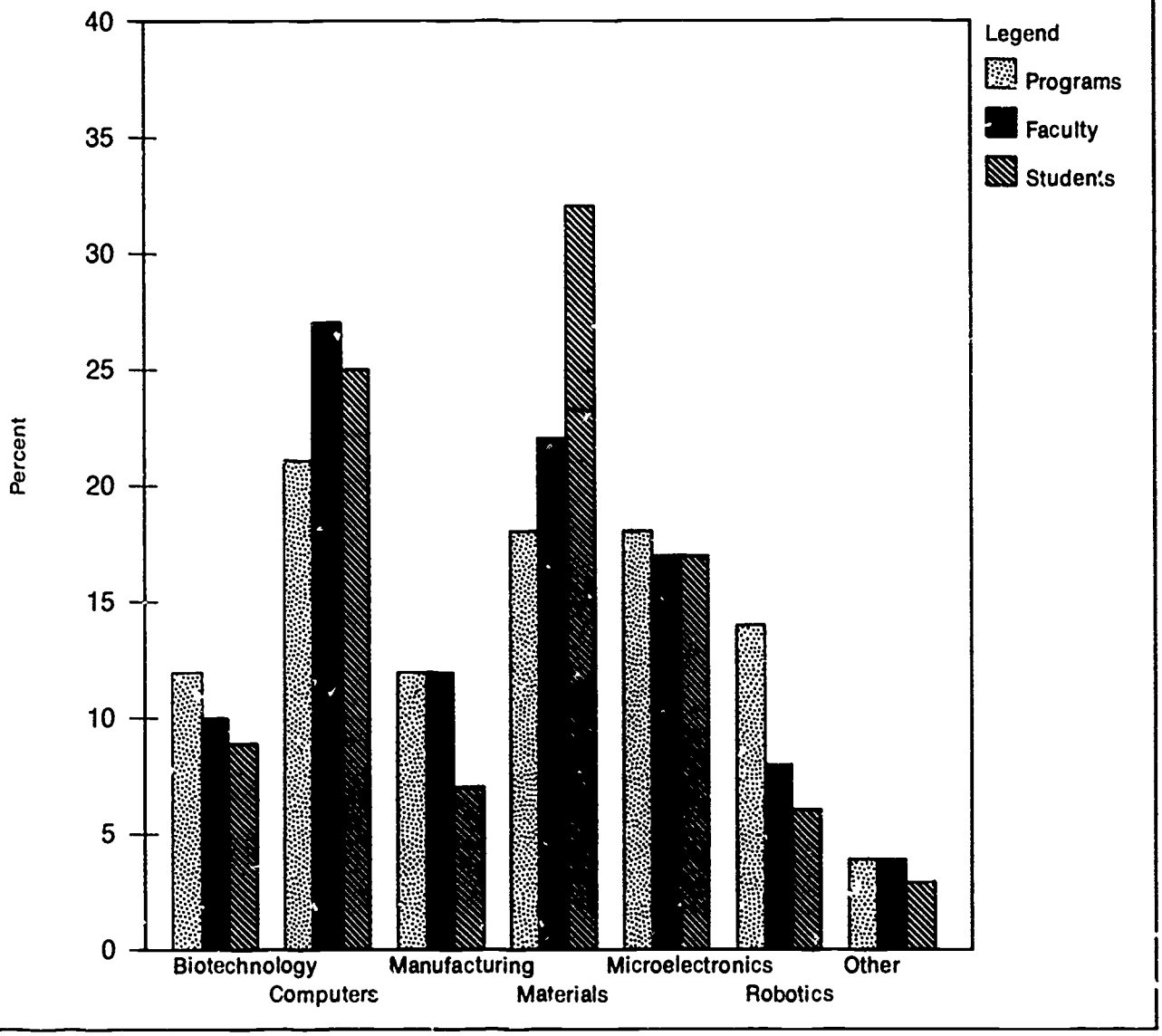


FIGURE 7
Programs, Faculty, and Doctoral Students in Emerging Areas



SUMMARY

In 1984–85, there were about 470 programs in emerging areas in engineering in 123 institutions of higher education that granted doctoral degrees in engineering. The most numerous were programs in computers; the least, programs in biotechnology.

The programs employed about 4,060 faculty, averaging nearly nine per program. Two-fifths of the faculty were full professors. The proportion of faculty with non-U.S. bachelor's degrees ranged from 13 percent (biotechnology) to 28 percent (manufacturing). There were relatively more foreigners among junior than among senior faculty.

Compared to total engineering faculty in doctoral departments, the faculty in emerging area programs were somewhat more junior in rank. On average, about 25 percent of faculty in emerging area programs were assistant professors compared to 19 percent of total engineering faculty.[1] They were also more likely to have foreign baccalaureate degrees than faculty in engineering programs in general.

The programs enrolled about 7,500 doctoral students, averaging over 16 students per program. Nearly

1. Data provided by the National Science Foundation.

one-half the doctoral students were non-U.S. citizens, which is somewhat larger than the proportion of foreign students in engineering programs in general. About one-fourth of the programs reported that they had to address significant differences in the background and experience of their students. The main differences cited were language, undergraduate training, and laboratory experience.

Although most programs had actively recruited faculty during 1983–84, fully one-half of the respondents reported unfilled faculty positions. Shortages were particularly acute in programs in materials and biotechnology, both of which had smaller proportions of non-U.S. citizens among their faculty, faculty applicant pool, and students. In contrast, computers—which had larger proportions of foreigners among faculty, faculty applicants, and students—reported fewer shortages. According to the majority of respondents, the most important source of qualified applicants for faculty positions was the pool of new doctorates from U.S. institutions.

DETAILED STATISTICAL TABLES

TABLE 1—Top 50 Institutions on the Basis of Ph.D. Degrees Conferred in Engineering, AY 1981–82

NOTE: Only responding institutions are listed.

1. Massachusetts Institute of Technology
3. Illinois, University of (Urbana)
7. Michigan, University of (Ann Arbor)
10. Ohio State University (Main Campus)
11. Rensselaer Polytechnic Institute
12. Wisconsin, University of (Madison)
14. Texas, University of (Austin)
16. Georgia, Institute of Technology
17. Virginia Polytechnic Institute
19. Minnesota, University of (Minneapolis, St. Paul)
20. California, University of (Davis)
22. Texas A&M University (Main Campus)
24. Case Western Reserve University
25. Princeton University
26. Florida, University of
27. Iowa State University of Science & Technology
28. Columbia University
29. SUNY at Stony Brook (Main Campus)
31. Michigan State University
33. Pennsylvania, University of
34. Oklahoma, University of (Norman Campus)
35. Virginia, University of (Main Campus)
37. Washington, University of (Seattle)
38. Pittsburgh, University of (Main Campus)
39. Tennessee, University of (Knoxville)
41. Polytechnic Institute of New York
42. Washington University (St. Louis)
43. Houston, University of (Central Campus)
44. Colorado, University of (Boulder)
45. Missouri, University of (Columbia)
46. Utah, University of
47. Arizona, University of
48. Wayne State University
49. Iowa, University of

TABLE 1.1—Top 50 Institutions on the Basis of Research Expenditures,* AY 1982–83

NOTE: Only responding institutions are listed.

1. Massachusetts Institute of Technology
2. Georgia Institute of Technology
3. Stanford University
4. Illinois, University of (Urbana)
5. Texas A&M University (Main Campus)
10. Rensselaer Polytechnic Institute
11. Ohio State University (Main Campus)
12. Wisconsin, University of (Madison)
13. Michigan, University of (Ann Arbor)
15. Florida, University of
19. Texas, University of (Austin)
21. Oklahoma, University of (Norman Campus)
22. Case Western Reserve University
23. Pennsylvania, University of
24. Virginia Polytechnic Institute
25. Dayton, University of
26. Columbia University
29. Texas Tech University
31. Washington, University of (Seattle)
33. Princeton University
34. Minnesota, University of (Minneapolis, St. Paul)
35. Oklahoma State University
37. Utah, University of
38. Virginia, University of (Main Campus)
39. Maryland, University of (College Park)
40. Iowa State University of Science & Technology
41 Rutgers University (New Brunswick)
43. Washington University (St. Louis)
44. Arizona, University of
45. California, University of (Davis)
46. New Hampshire, University of
47. Polytechnic Institute of New York
48. Houston, University of (Central Campus)
50. Delaware, University of

*These expenditures include federal and all other sources of support. Rankings are based on data provided by the ASEE Engineering College Research and Graduate Study (3/84).

TABLE 2—Operational and Planned Doctoral Engineering Programs in Emerging Areas, by Control of Institution

All Institutions

Program Area	Operational			Planned		
	Total	Public	Private	Total	Public	Private
Total programs	467	329	137	28	20	8
Biotechnology	58	42	15	6	3	3
Computers	96	66	30	5	4	1
Manufacturing	59	46	13	5	5	0
Materials	86	55	31	3	3	0
Microelectronics	86	59	27	4	2	1
Robotics	64	48	16	6	3	3
Other	19	13	5	0	0	0

TABLE 3—Operational Doctoral Engineering Programs in Emerging Areas in Top 50 Institutions, by Control of Institution

Program Area	Top 50 by Engineering Degrees			Top 50 by Research Expenditures		
	Total	Public	Private	Total	Public	Private
Total programs	224	181	43	237	180	57
Biotechnology	28	24	4	30	24	6
Computers	46	36	10	46	33	13
Manufacturing	31	24	7	33	27	6
Materials	40	33	7	43	29	14
Microelectronics	40	33	7	41	30	11
Robotics	32	25	7	36	30	6
Other	7	6	1	9	7	1

Includes only responding institutions that granted permission to list their names and programs.

TABLE 4—Institutions Offering Doctoral Programs in Emerging Engineering Areas, by Program Area

Institution	Biotech-nology	Com-puters	Manu-factur-ing	Mate-rials	Micro-elec-tronics	Robot-ics	Other
Akron, University of (Main Campus)	x			x			
Alabama, University of (Main Campus)			x		x	x	x
Arizona State University	x	x	x		x	x	x
Arizona, University of		x	x		x	x	
Auburn University		x					
California, University of (Davis)		x		x	x	x	
California, University of (San Diego)	x	x			x		
California, University of (Santa Barbara)		x		x	x	x	
Case Western Reserve University		x		x	x		
Catholic University of America						x	
Cincinnati, University of	x	x	x	x	x	x	
Clemson University	x	x	x		x	x	
Colorado, University of (Boulder)		x					
Columbia University		x		x	x		
Dartmouth College	x			x	x		
Dayton, University of				x			
Delaware, University of	x	x		x	x	x	x
Drexel University	x	x	x	x	x	x	
Duke University	x			x	x	x	x
Florida, University of	x	x	x	x	x	x	
Georgia Institute of Technology	x	x	x	x	x	x	
Hawaii, University of (Manoa)		x			x	x	
Houston, University of (Central Campus)	x	x		x	x	x	
Howard University			x		x		
Illinois Institute of Technology	x	x		x	x	x	
Illinois, University of (Urbana)	x	x	x	x	x	x	
Iowa State University		x		x	x		x
Iowa, University of	x	x	x	x	x	x	
Johns Hopkins University		x		x	x		
Kansas State University	x	x	x	x	x	x	
Kansas, University of (Main Campus)	x		x	x		x	
Lamar University							
Louisiana State University		x	x	x			
Louisiana Tech University	x	x	x				
Maine, University of (Orono Campus)					x		
Marquette University	x			x			
Maryland, University of (College Park)	x	x	x	x	x	x	
Massachusetts Institute of Technology	x	x	x	x	x	x	
Massachusetts, University of (Amherst)		x	x	x			x
Miami, University of (Miami, FL)		x					
Michigan State University		x		x			
Michigan Technological University				x			
Michigan, University of (Ann Arbor)	x	x	x	x	x	x	
Minnesota, University of (Minneapolis, St. Paul)	x	x	x	x	x	x	
Mississippi, University of (Main Campus)		x					

Continued on next page.

TABLE 4 (continued)—Institutions Offering Doctoral Programs in Emerging Engineering Areas, by Program Area

Institution	Biotech-nology	Com-puters	Manu-factur-ing	Mate-rials	Micro-elec-tronics	Robot-ics	Other
Missouri, University of (Columbia)	x	x		x	x		x
Montana State University	x	x		x	x	x	
Nebraska, University of (Lincoln)				x			x
Nevada, University of (Reno)		x				x	
New Hampshire, University of		x					x
New Mexico State University (Main Campus)		x			x		x
New Mexico, University of (Main Campus)		x			x		
Northeastern University		x			x	x	
Notre Dame, University of	x	x	x	x	x	x	x
Ohio State University		x	x	x	x	x	
Oklahoma State University		x	x				
Oklahoma, University of (Norman Campus)		x	x	x			
Old Dominion University							
Oregon State University		x		x	x	x	
Pennsylvania, University of	x	x	x	x	x	x	
Pittsburgh, University of (Main Campus)		x		x	x		
Polytechnic Institute of New York		x		x			x
Princeton University		x		x	x		
Rensselaer Polytechnic Institute	x	x	x	x	x	x	
Rice University		x		x			
Rochester, University of				x			
Rutgers University (New Brunswick Campus)	x	x		x	x	x	
South Carolina, University of	x	x		x		x	
Southern Methodist University	x	x	x	x	x	x	
Stanford University	x	x	x	x	x	x	
Stevens Institute of Technology		x	x	x			
SUNY at Buffalo	x	x			x		
SUNY at Stony Brook (Main Campus)		x		x	x	x	
Syracuse University					x		x
Tennessee, University of (Knoxville)				x			
Texas A & M University (Main Campus)	x	x	x	x	x	x	
Texas Tech University	x	x	x		x	x	
Texas, University of (Arlington)	x	x	x	x	x	x	
Texas, University of (Austin Campus)	x	x	x	x	x	x	x
Toledo, University of			x	x	x	x	
Tulane University		x					
Utah, University of		x		x	x	x	x
Vermont, University of				x	x		
Virginia Polytechnic Institute	x	x	x	x	x	x	x
Virginia, University of (Main Campus)	x	x	x	x	x	x	x
Washington, State University	x	x	x	x	x		
Washington University (St. Louis)	x	x		x	x		
Washington, University of (Seattle)	x	x	x	x	x	x	x
Wayne State University	x	x		x	x		
West Virginia University	x	x	x		x	x	
Wichita State University							
Wisconsin, University of (Madison)			x	x	x		
Wisconsin, University of (Milwaukee)		x	x	x	x	x	
Wyoming, University of	x	x	x	x			

TABLE 5—Engineering Faculty in Emerging Areas, by Program Area and Academic Rank, AY 1983–84

All Institutions

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Total faculty	4062	3624	1928	1687	938	851	990	909	206	177
Biotechnology	408	368	168	151	112	103	95	91	33	23
Computers	1102	1001	412	362	284	256	334	320	71	62
Manufacturing	484	381	205	155	124	100	136	113	19	12
Materials	914	830	567	504	161	147	162	154	25	25
Microelectronics	686	647	359	331	154	149	145	139	28	28
Robotics	322	271	130	110	72	66	92	70	29	25
Other	145	127	87	73	31	30	26	23	1	1

TABLE 5.1—Engineering Faculty in Emerging Areas, by Program Area and Academic Rank, AY 1983–84

Public Institutions

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Total faculty	2846	2510	1298	1118	713	639	712	642	123	111
Biotechnology	303	279	121	108	90	81	79	76	14	14
Computers	732	659	271	234	199	177	218	207	44	42
Manufacturing	388	298	162	120	101	81	108	88	16	10
Materials	604	535	366	315	114	102	116	110	8	8
Microelectronics	456	440	221	213	127	123	94	89	15	15
Robotics	265	214	103	84	59	53	77	55	26	23
Other	98	85	54	45	23	22	21	18	0	0

TABLE 5.2—Engineering Faculty in Emerging Areas, by Program Area and Academic Rank, AY 1983–84

Private Institutions

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Total faculty	1216	1114	630	569	226	212	278	267	83	66
Biotechnology	105	89	47	43	22	22	16	15	19	9
Computers	370	342	141	129	86	79	117	114	27	20
Manufacturing	97	83	43	36	23	19	28	26	3	3
Materials	310	295	201	189	47	46	46	44	17	17
Microelectronics	230	207	139	119	27	26	51	49	13	13
Robotics	57	57	27	27	12	12	15	15	3	3
Other	47	42	32	27	8	8	5	5	1	1

TABLE 5.3—Engineering Faculty in Emerging Areas, by Program Area and Academic Rank, AY 1983–84

[Top 50 Institutions, by Engineering Degrees]

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Total faculty	2281	2045	1102	982	561	511	550	488	68	64
Biotechnology	218	208	88	82	64	63	58	56	8	8
Computers	614	557	250	224	178	161	154	143	32	29
Manufacturing	254	186	90	63	72	53	83	64	8	7
Materials	601	550	376	340	117	107	101	96	7	7
Microelectronics	371	356	195	185	85	83	83	79	8	8
Robotics	163	128	65	51	33	32	60	40	4	4
Other	60	60	38	38	13	13	10	10	0	0

TABLE 5.4—Engineering Faculty in Emerging Areas, by Program Area and Academic Rank, AY 1983–84

[Top 50 Institutions, by Research Expenditures]

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Total faculty	2601	2268	1278	1086	589	532	626	559	109	92
Biotechnology	266	250	119	106	76	74	59	57	13	13
Computers	669	586	257	217	173	153	199	186	40	30
Manufacturing	296	213	127	87	70	51	84	67	14	7
Materials	630	560	396	344	106	94	112	104	17	17
Microelectronics	439	406	239	214	110	107	84	79	6	6
Robotics	212	179	84	71	39	37	70	51	19	19
Other	90	74	56	46	16	14	19	14	0	0

TABLE 6—Faculty Rank Distribution in Emerging Areas, by Program Area, AY 1983–1984

All Institutions

Program Area	Total Headcount	Total Percent	Professor	Associate Professor	Assistant Professor	Other
Total faculty	4062	100.0	47.5	23.1	24.4	5.1
Biotechnology	408	100.0	41.1	27.5	23.3	8.1
Computers	1102	100.0	37.4	25.8	30.3	6.5
Manufacturing	484	100.0	42.3	25.7	28.1	3.9
Materials	914	100.0	62.0	17.6	17.7	2.7
Microelectronics	686	100.0	52.4	22.4	21.1	4.1
Robotics	322	100.0	40.4	22.3	28.5	8.9
Other	145	100.0	59.6	21.3	18.1	1.0

TABLE 6.1—Faculty Rank Distribution in Emerging Areas, by Program Area, AY 1983–1984

Public Institutions

Program Area	Total Headcount	Total Percent	Professor	Associate Professor	Assistant Professor	Other
Total faculty	2846	100.0	45.6	25.1	25.0	4.3
Biotechnology	303	100.0	39.8	29.7	26.0	4.5
Computers	732	100.0	37.1	27.2	29.7	6.0
Manufacturing	338	100.0	41.9	26.1	27.8	4.2
Materials	604	100.0	60.6	18.8	19.3	1.3
Microelectronics	456	100.0	48.4	27.8	20.6	3.2
Robotics	265	100.0	38.9	22.4	29.0	9.7
Other	98	100.0	55.2	23.5	21.3	0.0

TABLE 6.2—Faculty Rank Distribution in Emerging Areas, by Program Area, AY 1983–1984

Private Institutions

Program Area	Total Headcount	Total Percent	Professor	Associate Professor	Assistant Professor	Other
Total faculty	1216	100.0	51.8	18.5	22.9	6.8
Biotechnology	105	100.0	45.0	21.3	15.4	18.2
Computers	370	100.0	38.1	23.1	31.5	7.3
Manufacturing	97	100.0	44.0	23.9	29.3	2.7
Materials	310	100.0	64.8	15.2	14.7	5.4
Microelectronics	230	100.0	60.3	11.8	22.0	5.8
Robotics	57	100.0	47.1	21.5	26.6	4.7
Other	47	100.0	68.7	16.8	11.3	3.0

TABLE 6.3—Faculty Rank Distribution in Emerging Areas, by Program Area, AY 1983–1984

(Top 50 Institutions, by Engineering Degrees)

Program Area	Total Headcount	Total Percent	Professor	Associate Professor	Assistant Professor	Other
Total faculty	2281	100.0	48.3	24.6	24.1	3.0
Biotechnology	218	100.0	40.1	29.3	26.7	3.8
Computers	614	100.0	40.7	29.0	25.1	5.2
Manufacturing	254	100.0	35.5	28.4	32.8	3.3
Materials	601	100.0	62.6	19.4	16.9	1.1
Microelectronics	371	100.0	52.4	22.8	22.5	2.2
Robotics	163	100.0	40.2	20.5	36.7	2.6
Other	60	100.0	62.8	20.9	16.2	0.0

TABLE 6.4—Faculty Rank Distribution in Emerging Areas, by Program Area, AY 1983–1984

(Top 50 Institutions, by Research Expenditures)

Program Area	Total Headcount	Total Percent	Professor	Associate Professor	Assistant Professor	Other
Total faculty	2601	100.0	49.1	22.6	24.1	4.2
Biotechnology	266	100.0	44.6	28.5	22.0	4.9
Computers	669	100.0	38.5	25.9	29.7	6.0
Manufacturing	296	100.0	43.0	23.7	28.5	4.8
Materials	630	100.0	62.8	16.8	17.7	2.7
Microelectronics	439	100.0	54.4	25.1	19.2	1.3
Robotics	212	100.0	39.9	18.3	33.1	8.8
Other	90	100.0	61.9	17.4	20.7	0.0

TABLE 7—Engineering Faculty in Emerging Areas Who Hold Non-U.S. Bachelor's Degrees, by Program Area and Academic Rank

All Institutions

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Faculty with non-U.S. BA's	896	831	314	289	221	198	334	318	27	26
Biotechnology	55	54	14	14	12	11	22	22	8	8
Computers	259	252	72	71	64	60	121	120	1	1
Manufacturing	134	103	43	29	31	24	57	47	3	3
Materials	176	169	82	77	43	41	47	47	5	5
Microelectronics	171	166	72	67	38	38	57	56	4	4
Robotics	[illegible]	75	27	27	26	18	25	25	6	5
Other	1	12	5	4	7	6	5	2	0	0

TABLE 7.1—Engineering Faculty in Emerging Areas Who Hold Non-U.S. Bachelor's Degrees, by Program Area and Academic Rank

Public Institutions

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Faculty with non-U.S. BA's	651	609	222	209	161	145	248	236	20	19
Biotechnology	42	42	9	9	8	8	20	20	5	5
Computers	188	186	60	59	41	40	85	85	1	1
Manufacturing	97	77	25	19	26	21	44	35	2	2
Materials	111	38	48	45	29	29	30	30	3	3
Microelectronics	127	125	53	52	27	27	43	42	4	4
Robotics	71	62	23	23	23	15	21	21	4	3
Other	14	10	3	2	6	5	5	2	0	0

TABLE 7.2—Engineering Faculty in Emerging Areas Who Hold Non-U.S. Bachelor's Degrees, by Program Area and Academic Rank

Private Institutions

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Faculty with non-U.S. BA's	245	222	92	80	61	53	86	83	7	7
Biotechnology	13	11	4	4	4	3	1	1	3	3
Computers	71	67	12	12	23	20	36	35	0	0
Manufacturing	37	26	18	10	4	3	13	12	1	1
Materials	65	62	33	32	14	12	16	16	1	1
Microelectronics	44	41	19	16	11	11	14	14	0	0
Robotics	13	13	4	4	3	3	4	4	1	1
Other	3	3	1	1	1	1	0	0	0	0

TABLE Engineering Faculty in Emerging Areas Who Hold Non-U.S. Bachelor's Degrees, by Program Area and Academic Rank

(Top 50 Institutions, by Engineering Degrees)

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Faculty with non-U.S. BA's	503	464	181	171	138	120	179	168	6	6
Biotechnology	25	24	3	3	8	7	14	14	0	0
Computers	143	136	42	40	44	40	57	56	0	0
Manufacturing	69	53	17	14	18	13	33	25	1	1
Materials	107	104	54	51	26	26	25	25	1	1
Microelectronics	99	95	46	43	18	18	32	31	3	3
Robotics	54	47	18	18	18	11	18	18	0	0
Other	6	6	1	1	4	4	0	0	0	0

TABLE 7.4—Engineering Faculty in Emerging Areas Who Hold Non-U.S. Bachelor's Degrees, by Program Area and Academic Rank

(Top 50 Institutions, by Research Expenditures)

Program Area	Total		Professor		Associate Professor		Assistant Professor		Other	
	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE	Headcount	FTE
Faculty with non-U.S. BA's	523	477	196	182	137	119	179	166	11	11
Biotechnology	31	31	10	10	6	6	11	11	4	4
Computers	147	140	46	44	39	34	63	61	0	0
Manufacturing	66	50	20	16	17	13	27	20	1	1
Materials	106	100	56	51	24	23	24	24	1	1
Microelectronics	104	100	43	40	27	27	33	31	1	1
Robotics	54	47	17	17	19	11	16	16	3	3
Other	14	9	4	3	6	4	4	1	0	0

TABLE 8—Faculty Recruitment in Progress or Completed During Academic Year 1983–84 for Engineering Programs in Emerging Areas, and Reported Difficulty in Filling Positions

All Institutions

Program Area	Programs that Recruited Faculty		Faculty Recruited		Programs Unable to Fill All Positions	
	Number	Percent	Number	Percent	Number	Percent
Total	349	100.0	860	100.0	179	51.4
Biotechnology	31	8.9	43	5.0	21	65.8
Computers	88	25.3	289	33.5	29	32.4
Manufacturing	47	13.4	118	13.7	22	46.3
Materials	54	15.5	127	14.7	43	79.8
Microelectronics	73	21.1	178	20.7	32	43.2
Robotics	44	12.6	89	10.3	24	55.4
Other	11	3.3	17	2.0	9	80.8

TABLE 8.1—Faculty Recruitment in Progress or Completed During Academic Year 1983–84 for Engineering Programs in Emerging Areas, and Reported Difficulty in Filling Positions

Public Institutions

Program Area	Programs that Recruited Faculty		Faculty Recruited		Programs Unable to Fill All Positions	
	Number	Percent	Number	Percent	Number	Percent
Total	251	100.0	664	100.0	114	45.4
Biotechnology	23	9.1	31	4.7	15	64.7
Computers	61	24.3	221	33.2	13	20.6
Manufacturing	37	14.6	95	14.3	16	42.7
Materials	37	14.7	93	14.0	29	77.6
Microelectronics	52	20.8	145	21.9	20	38.4
Robotics	34	13.6	68	10.2	17	50.2
Other	8	3.0	12	1.8	5	71.0

TABLE 8.2—Faculty Recruitment in Progress or Completed During Academic Year 1983–84 for Engineering Programs in Emerging Areas, and Reported Difficulty in Filling Positions

Private Institutions

Program Area	Programs that Recruited Faculty		Faculty Recruited		Programs Unable to Fill All Positions	
	Number	Percent	Number	Percent	Number	Percent
Total	98	100.0	197	100.0	65	66.5
Biotechnology	9	8.6	12	6.3	6	68.7
Computers	27	27.8	68	34.6	16	58.7
Manufacturing	10	10.2	23	11.7	6	59.8
Materials	17	17.6	34	17.3	15	84.6
Microelectronics	21	21.8	33	16.8	12	55.0
Robotics	10	10.0	21	10.8	7	73.4
Other	4	3.9	5	2.6	4	100.0

TABLE 8.3—Faculty Recruitment in Progress or Completed During Academic Year 1983–84 for Engineering Programs in Emerging Areas, and Reported Difficulty in Filling Positions

[Top 50 Institutions, by Engineering Degrees]

Program Area	Programs that Recruited Faculty		Faculty Recruited		Programs Unable to Fill All Positions	
	Number	Percent	Number	Percent	Number	Percent
Total	174	100.0	478	100.0	86	49.6
Biotechnology	13	7.2	15	3.2	7	55.6
Computers	42	24.0	167	34.9	14	33.3
Manufacturing	26	15.2	67	14.0	13	47.4
Materials	33	19.2	76	16.0	29	87.5
Microelectronics	33	19.2	103	21.5	10	29.2
Robotics	22	12.8	46	9.6	11	50.0
Other	4	2.4	4	0.9	3	66.7

TABLE 8.4—Faculty Recruitment in Progress or Completed During Academic Year 1983–84 for Engineering Programs in Emerging Areas, and Reported Difficulty in Filling Positions

[Top 50 Institutions, by Research Expenditures]

Program Area	Programs that Recruited Faculty		Faculty Recruited		Programs Unable to Fill All Positions	
	Number	Percent	Number	Percent	Number	Percent
Total	186	100.0	489	100.0	92	49.2
Biotechnology	20	10.8	23	4.7	13	64.3
Computers	44	23.8	169	34.5	10	22.6
Manufacturing	29	15.4	66	13.5	14	50.0
Materials	30	16.2	67	13.7	27	90.5
Microelectronics	41	22.3	124	25.4	14	34.5
Robotics	19	10.0	37	7.6	11	61.5
Other	3	1.5	3	0.6	1	50.0

TABLE 9—Most Important Sources of Qualified Applicants for Faculty Positions in Engineering Programs in Emerging Areas

All Institutions

Program Area	First-ranked Source	Second-ranked Source
Biotechnology	a	e
Computers	a	e
Manufacturing	a	e
Materials	a	e
Microelectronics	a	c
Robotics	a	e
Other	e	a

Sources of applicants listed in the questionnaire:

a. New doctorate recipients coming from U.S. institutions
b. New doctorate recipients coming from non-U.S. institutions
c. Doctorate holders coming from U.S. industry (with research and development experience)
d. Doctorate holders coming from foreign industry (with research and development experience)
e. Faculty coming from other U.S. institutions
f. Faculty coming from other departments at the same institution
g. Doctorate holders coming from U.S. postdoctoral appointments
h. Doctorate holders coming from foreign postdoctoral appointments
i. Other

TABLE 10—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

All Institutions

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	7496	4085	3411
Biotechnology	708	468	240
Computers	1907	1026	881
Manufacturing	492	199	292
Materials	2393	1356	1037
Microelectronics	1291	623	667
Robotics	447	240	207
Other	259	173	86

TABLE 10.1—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

Public Institutions

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	4316	2285	2031
Biotechnology	297	176	121
Computers	1038	530	508
Manufacturing	394	158	236
Materials	1366	770	596
Microelectronics	723	366	357
Robotics	329	175	154
Other	170	111	59

TABLE 10.2—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

Private Institutions

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	3180	1800	1380
Biotechnology	411	292	119
Computers	869	496	373
Manufacturing	98	41	57
Materials	1026	585	441
Microelectronics	568	257	311
Robotics	118	65	53
Other	90	63	27

TABLE 10.3—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

[Top 50 Institutions, by Engineering Degrees]

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	4585	2424	2161
Biotechnology	425	275	150
Computers	1032	535	497
Manufacturing	296	115	181
Materials	1549	858	690
Microelectronics	800	374	426
Robotics	336	186	150
Other	147	81	67

TABLE 10.4—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

[Other than Top 50 Institutions, by Engineering Degrees]

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	2911	1661	1250
Biotechnology	283	193	90
Computers	875	491	384
Manufacturing	196	84	112
Materials	844	497	347
Microelectronics	491	250	241
Robotics	110	54	57
Other	112	93	19

TABLE 10.5—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

[Top 50 Institutions, by Research Expenditures]

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	5263	3011	2252
Biotechnology	546	379	167
Computers	1252	749	503
Manufacturing	330	150	180
Materials	1716	966	750
Microelectronics	916	464	452
Robotics	343	209	134
Other	160	94	66

TABLE 10.6—Doctoral Students in Engineering Programs in Emerging Areas, by Citizenship Status

[Other than Top 50 Institutions, by Research Expenditures]

Program Area	Total	U.S. Citizens	Non-U.S. Citizens
Total students	2233	1074	1159
Biotechnology	162	89	73
Computers	655	277	373
Manufacturing	161	49	112
Materials	676	390	287
Microelectronics	375	159	216
Robotics	104	31	73
Other	99	79	20

Table 11—Programs in Emerging Areas that Must Address Significant Differences in Background and Experience of U.S. and Non-U.S. Doctoral Students

All Institutions

Program Area	Proportion that Must Address Differences	
	Number of Programs	Percent of All Programs
Total	103	22.0
Biotechnology	6	9.7
Computers	28	28.8
Manufacturing	13	21.2
Materials	23	26.3
Microelectronic	18	20.8
Robotics	14	21.2
Other	3	15.5

Table 11.1—Programs in Emerging Areas that Must Address Significant Differences in Background and Experience of U.S. and Non-U.S. Doctoral Students

Public Institutions

Program Area	Proportion that Must Address Differences	
	Number of Programs	Percent of All Programs
Total	84	25.6
Biotechnology	6	13.2
Computers	21	31.4
Manufacturing	11	23.7
Materials	16	28.4
Microelectronic	17	28.1
Robotics	12	25.1
Other	3	21.6

Table 11.2—Programs in Emerging Areas that Must Address Significant Differences in Background and Experience of U.S. and Non-U.S. Doctoral Students

Private Institutions

Program Area	Proportion that Must Address Differences	
	Number of Programs	Percent of All Programs
Total	18	13.4
Biotechnology	0	0.0
Computers	7	23.0
Manufacturing	2	12.4
Materials	7	22.6
Microelectronic	1	5.2
Robotics	1	9.0
Other	0	0.0

Table 11.3—Programs in Emerging Areas that Must Address Significant Differences in Background and Experience of U.S. and Non-U.S. Doctoral Students

[Top 50 Institutions, by Engineering Degrees]

Program Area	Proportion that Must Address Differences	
	Number of Programs	Percent of All Programs
Total	49	21.7
Biotechnology	4	15.0
Computers	11	24.2
Manufacturing	7	22.7
Materials	8	20.7
Microelectronic	10	24.1
Robotics	7	21.7
Other	1	20.0

Table 11.4—Programs in Emerging Areas that Must Address Significant Differences in Background and Experience of U.S. and Non-U.S. Doctoral Students

[Top 50 Institutions, by Research Expenditures]

Program Area	Proportion that Must Address Differences	
	Number of Programs	Percent of All Programs
Total	53	22.3
Biotechnology	4	14.3
Computers	13	28.1
Manufacturing	10	30.4
Materials	9	20.0
Microelectronic	10	24.1
Robotics	6	16.0
Other	1	16.7

APPENDIX A: SURVEY INSTRUMENT

AMERICAN COUNCIL ON EDUCATION

Higher Education Panel

June 13, 1984

Dear Higher Education Panel Representative,

Enclosed is Higher Education Panel survey number 64, "Engineering Programs in Emerging Areas." Sponsored by the National Science Foundation, its purpose is to obtain information about doctoral programs in emerging areas in colleges of engineering.

Colleges of engineering are establishing programs in a number of areas with applications in production and manufacturing, such as robotics and microelectronics. Previous studies have documented some shortages of full-time faculty in major engineering fields, but there is no information about the availability of faculty to staff the programs in the smaller emerging areas. This survey was designed to help determine the availability of engineering faculty to provide such specialized training and whether there is a sufficient number of engineering students in doctoral programs to provide an adequate future supply of new faculty for the emerging areas.

Since the requested information will likely be obtained from several people within the college of engineering, we suggest that the survey be directed to the Dean of the college of engineering. As usual, however, we leave that decision to you.

Please be assured that your institution's response will be protected to the maximum extent permissible by law. As with all our surveys, the data you provide will be reported in summary fashion only and will not be identifiable with your institution, except where explicitly authorized by you. This survey is authorized by the National Science Foundation Act of 1950, as amended. Although you are not required to respond, your cooperation is needed to make the results comprehensive, reliable, and timely.

Please return all completed forms to us by **July 6, 1984.** If not all forms have been completed by that date, do not delay forwarding those that have been completed. Two prepaid envelopes have been enclosed for your convenience. If you have any problems or questions, please do not hesitate to telephone us collect at (202) 833-4757.

Sincerely,

Frank J. Atelsek

Frank J. Atelsek
Panel Director

One Dupont Circle, Washington, D.C. 20036-1193 (202) 833-4757

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

OFFICE OF THE
ASSISTANT DIRECTOR
FOR ENGINEERING

MEMORANDUM

June 13, 1984

FOR: Deans of Engineering

FROM: Acting Assistant Director for Engineering

SUBJECT: Higher Education Panel Survey No. 64, "Engineering Programs in Emerging Areas"

I am writing to ask your cooperation and assistance in completing the attached survey on "Engineering Programs in Emerging Areas." This survey is sponsored by the National Science Foundation to obtain information about doctoral programs in emerging areas in colleges of engineering. The Foundation has asked the Higher Education Panel, a survey research program operated by the American Council on Education, to conduct this survey for us and we are sending it to 140 colleges of engineering.

As you are well aware, colleges of engineering are establishing programs in newly-identified areas such as biotechnology, robotics, microelectronics, materials and manufacturing. There have been several recent studies which have documented shortages on full-time faculty in major engineering fields such as electrical, chemical, etc. However, as of yet, no information exists as to the availability of faculty to staff programs in these new areas. This survey will help to provide this much needed data, not only as to the availability of faculty with qualifications to provide the needed specialized training, but also data on whether the number of engineering students in doctoral programs is adequate to provide a future supply of qualified faculty for these programs.

We realize that completing this questionnaire will require a substantial effort on the part of you and your staff. However, we hope you will agree that obtaining this information will be useful.

Please feel free to call the Higher Education Panel staff collect at (202) 833-4757 if there are any questions or problems in completing this survey.

Thank you for your assistance.

Carl W. Hall
Acting Assistant Director
for Engineering

AMERICAN COUNCIL ON EDUCATION

OMB #3145-0009
Exp. 03/31/87

American Council on Education
Higher Education Panel Survey #64

ENGINEERING PROGRAMS IN EMERGING AREAS, 1983–84

I. Check below the emerging areas in which your college of engineering now has a doctoral program. Also indicate *other cooperating units* if there are departments outside the engineering college that work with the engineering college in these programs. In which areas have doctoral programs been authorized but are not yet in operation?

Program Area in College of Engineering (include similar titles)	Doctoral Program in Operation	Other Cooperating Units	Doctoral Program Authorized But Not Yet in Operation
A. Biotechnology	☐	_____	☐
B. Computers	☐	_____	☐
C. Manufacturing	☐	_____	☐
D. Materials	☐	_____	☐
E. Microelectronics	☐	_____	☐
F. Robotics	☐	_____	☐
G. Other (specify):			
_____	☐	_____	☐
_____	☐	_____	☐

For this survey, the term "program" is defined to be an organized instructional activity leading to the Ph.D., Sc. D., or equivalent degree. The programs of interest may be administered either separately or as areas of concentration within established departments, but they must be within the College of Engineering.

II. May we have your permission to include your institution by name in a list of universities and colleges with engineering programs in emerging areas? (None of the information requested below would be released in a manner that would identify your institution.)

_____Yes _____ No

III. Do you believe that the availability of human resources is the major determining factor in the development of engineering programs in these emerging areas?

_____Yes _____ No If "no," please explain.

_____

_____

_____

IV. On the following sheets please provide the requested information for each currently operating program listed in question I above. If you have more than one program in a particular area, please provide separate information for each, using separate sheets as needed.

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by **July 6, 1984** to:

Higher Education Panel
American Council on Education
One Dupont Circle Suite 829
Washington, D.C. 20036

_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. A. BIOTECHNOLOGY (including similar titles).

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor	_____	_____	_____	_____
Associate professor	_____	_____	_____	_____
Assistant professor	_____	_____	_____	_____
Other ranks	_____	_____	_____	_____

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (If none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a. What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7. Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary.)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by **July 6, 1984,** either to your HEP representative or to:

Higher Education Panel
American Council on Education
One Dupont Circle, Suite 829
Washington, D.C. 20036

_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. B. COMPUTERS (including similar titles).

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor	_____	_____	_____	_____
Associate professor	_____	_____	_____	_____
Assistant professor	_____	_____	_____	_____
Other ranks	_____	_____	_____	_____

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (If none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a. What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7. Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary.)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by **July 6, 1984**, either to your HEP representative or to:

Higher Education Panel
American Council on Education
One Dupont Circle, Suite 829
Washington, D.C. 20036

_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. C. MANUFACTURING (including similar titles).

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor	_____	_____	_____	_____
Associate professor	_____	_____	_____	_____
Assistant professor	_____	_____	_____	_____
Other ranks	_____	_____	_____	_____

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (If none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a. What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7. Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary.)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by July 6, 1984, either to your HEP representative or to:

Higher Education Panel
American Council on Education
One Dupont Circle, Suite 829
Washington, D.C. 20036

_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. D. MATERIALS (including similar titles).

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor				
Associate professor				
Assistant professor				
Other ranks				

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (If none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a. What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7 Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary.)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by **July 6, 1984**, either to your HEP representative or to:

Higher Education Panel
American Council on Education
One Dupont Circle, Suite 829
Washington, D.C. 20036

_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. E. MICROELECTRONICS (including similar titles).

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor	_____	_____	_____	_____
Associate professor	_____	_____	_____	_____
Assistant professor	_____	_____	_____	_____
Other ranks	_____	_____	_____	_____

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (If none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7. Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary.)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by **July 6, 1984**, either to your HEP representative or to:

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Washington, D.C. 20036

_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. F. ROBOTICS (including similar titles).

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor	_____	_____	_____	_____
Associate professor	_____	_____	_____	_____
Assistant professor	_____	_____	_____	_____
Other ranks	_____	_____	_____	_____

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (if none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a. What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7. Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by July 6, 1984, either to your HEP representative or to:

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_____
Person completing form

_____
Department/telephone

(DESCRIBE PROGRAMS WITHIN THE COLLEGE OF ENGINEERING ONLY.)

IV. G. OTHER

1. Area of specialization _____

2. Name of engineering department or unit responsible for this program _____

3. Number of faculty—headcount and full-time-equivalent in AY 1983–84—in this program, by academic rank. Of these, how many did not receive their bachelor's degree in the U.S.?

	Total		Non-U.S. Bachelor's Degree	
	Headcount	FTE	Headcount	FTE
Professor	_____	_____	_____	_____
Associate professor	_____	_____	_____	_____
Assistant professor	_____	_____	_____	_____
Other ranks	_____	_____	_____	_____

Include only regular faculty with full-time appointments at your institution. Please provide both the total headcount of faculty, irrespective of their level of involvement in the program, as well as the full-time-equivalent in the program.

Faculty not part of the College of Engineering may be included if they have a major involvement in the program and function in a manner similar to the faculty of the College of Engineering.

4a. How many faculty recruitments were in progress or completed during AY 1983–84 for this program, irrespective of the proposed year of employment? (Include all regular faculty recruited as full-time for the institution even if only part-time for this program.)

_____ (If none, enter "0" and skip to item 6 below.)

b. Were you able, or do you expect to be able, to fill all these positions?

_____ Yes _____ No

If "no", please indicate which specialties you are unable to fill:

_____

_____

5a. What were the two most important sources of qualified applicants for faculty positions? Rank in order using "1" for the most important source, "2" for the second most important source.

_____ New doctorate recipients coming from U.S. institutions
_____ New doctorate recipients coming from non-U.S. institutions
_____ Doctorate-holders coming from U.S. industry (with research and development experience)
_____ Doctorate-holders coming from foreign industry (with research and development experience)
_____ Faculty coming from other U.S. institutions
_____ Faculty coming from other departments at the same institution
_____ Doctorate-holders coming from U.S. postdoctoral appointments
_____ Doctorate-holders coming from foreign postdoctoral appointments
_____ Other (explain)_____

b. Approximately what proportion of the qualified applicant pool did not have U.S. citizenship? _____ %

6. Headcount of doctoral students in the program in AY 1983–84, by citizenship:

_____ U.S. citizens _____ non-U.S. citizens

7. Are there significant differences in the background and experience of the U.S. and non-U.S. doctoral students that must be addressed as part of the program?

_____ Yes _____ No (If yes, please explain; use back of page if necessary.)

Thank you for your cooperation. Please keep a copy of this form for your records. Please return all completed forms by **July 6, 1984**, either to your HEP representative or to:

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APPENDIX B: METHODS SUMMARY

The Higher Education Panel forms the basis of an ongoing survey research program created in 1971 by the American Council on Education. Its purpose is to conduct specialized surveys on topics of current policy interest to the higher education community and to government agencies.

The Panel is a disproportionate stratified sample of 1,040 colleges and universities, divided into two half-samples of 520 institutions each. Institutions were drawn from the more than 3,200 colleges and universities listed in the National Center for Education Statistics' *Education Directory, Colleges and Universities*. All institutions in the population are grouped according to the Panel's stratification design, which is based primarily upon institution type (doctorate-granting, comprehensive, baccalaureate, specialized, two-year academic or occupational), control (public, private), and size (full-time-equivalent enrollment). For any given survey, either the entire Panel or an appropriate subgroup is used.

The survey operation is dependent upon a network of campus representatives who, through their presidents, have agreed to participate. The representatives receive the Panel questionnaires and direct them to the most appropriate campus officials for response.

The survey instrument (see Appendix A) was mailed on June 13, 1984, to 135 Panel institutions which, during 1981–82, awarded at least one doctorate degree in engineering. Only seven institutions in the eligible population of 142 were not in the Panel and, consequently, were not sent the survey instrument.

In the first section of the instrument, engineering deans were asked to provide summary information about the number and kind of emerging program areas in which their engineering college offers, or plans to offer, a doctoral program. In the second section, individual program heads were asked detailed questions about number and rank of faculty, recruitments and sources of applicants for faculty positions, and the number and citizenship status of doctoral students in the program for each emerging area.

After mail and telephone follow-ups were completed, substantive data were received from 96 institutions, for a response rate of 78 percent. (Of the originally defined survey population of 142, 19 institutions reported no activity in any of the emerging areas under study, reducing the population to 123). Data from the 96 responding Panel institutions were statistically adjusted to represent the national population of 123 colleges and universities that award engineering doctorate degrees and offer doctoral programs in emerging areas.

The technical notes (Appendix C) contain a description of the weighting methodology and a comparison of respondents and nonrespondents.

APPENDIX C: TECHNICAL NOTES

The survey population for this study was defined as the doctorate-granting colleges of engineering that offered doctoral programs in the emerging areas. There were, in total, 142 schools awarding Ph.D.'s in engineering. Of these, 135 were Panel members and seven were not. Of the 135 Panel members, eighteen schools did not have programs in the emerging areas. Of the 117 remaining Panel institutions, 96 responded to the survey. The seven institutions which were not Panel members were contacted by phone: one did not have any programs in emerging areas; six did. These six institutions as well as 21 Panel institutions which did not respond to the survey were treated as non-respondents. Thus, substantive data were received from 78 percent of the institutions in the total population of 123.

Non-Response Adjustment Procedure

The Higher Education Panel's (HEP) stratification design divides institutions by size (full-time equivalent enrollment), control (public, private), and type (doctoral-granting, comprehensive, baccalaureate, specialized, two-year academic or occupational). For purposes of non-response adjustment, within the HEP stratification design by type and control of institutions, post-stratification by number of engineering doctorates was used within two of the original HEP strata; all other engineering doctorate-granting institutions were simply grouped by control as shown in table C-1 below. The post-stratification grouping was judged to produce a more accurate non-response

adjustment procedure because institutions within groups, by number of engineering degrees awarded, are likely to be more homogeneous than when treated as an overall class.

The survey responses were weighted using the non-response adjustment weights (as shown in table C-1) to calculate estimates for all doctorate-granting colleges of engineering that offered doctoral programs in emerging areas. No estimates of sampling error were computed because the entire population of institutions was involved, given the manner of adjustment for non-response; the procedure implied that no sampling process was involved.

Comparison of Respondents and Nonrespondents

Table C-2 compares survey respondents and non-respondents and presents the non-response rates on the basis of several variables. Higher than average response rates were recorded for public institutions and those in the South. Institutions in the East and West had lower than average response rates.

TABLE C-1: Post-stratification Groupings

Cell	Type of Institution	Population	Respondent	Non-response Adjustment Factor
	HEP—public doctorate-granting:			
01	Granting 40 or more engineering doctorates	9	5	1.800
02	Granting 10–39 engineering doctorates	36	33	1.091
03	Granting 1–9 engineering doctorates	22	18	1.222
	HEP—private doctorate-granting:			
04	Granting 25 or more engineering doctorates	12	7	1.583
05	Granting 10–24 engineering doctorates	10	7	1.429
06	Granting 1–9 engineering doctorates	11	9	1.222
07	HEP—All other public	16	12	1.333
08	HEP—All other private	7	5	1.400
	Totals	123	96	

TABLE C-2: Response Rates and Selected Characteristics of Respondents and Nonrespondents

(In percentages)

Institutional Characteristic	Respondents	Nonrespondents	Response Rate
Total	100.0	100.0	78.0
Control			
Public	70.8	55.6	81.9
Private	29.2	44.4	70.0
Region			
East	21.9	37.0	67.7
South	33.3	18.5	86.5
Midwest	26.0	22.2	80.6
West	18.8	22.2	75.0
Top 50 based on Ph.D degrees conferred	37.5	37.0	78.3
Top 50 based on research expenditures	36.5	51.9	71.4

Other Reports of the Higher Education Panel
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