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International Collaborations of Scientists and Engineers in the United States

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International collaboration is a key aspect of the globalization of science and engineering (S&E). In 2006, according to the Scientists and Engineers Statistical Data System (SESTAT), one in six scientists and engineers in the United States reported working with individuals in other countries (table 1).[2] International collaboration was more likely to occur among persons working in the for-profit sector, men, and those with higher levels of educational attainment. Individuals who earned postsecondary degrees both in the United States and abroad reported the highest levels of international collaboration.

This InfoBrief examines the profile of U.S. scientists and engineers engaged in international collaboration, the means of communication they used, and the relationship between work activities in their principal job and the extent to which they collaborated internationally. Much of the previous literature on scientific international collaboration has focused on its impact on scientific research. Measurement of international collaboration has primarily used coauthorship and publication citation data (Frame and Carpenter 1979, Schubert and Braun 1990, Okubo et al. 1992). Others have focused on international collaboration relationships among specific countries (He 2009, Mattson et al. 2008) or on understanding the growth of international collaboration (Wagner and Leydesdorff 2005). This InfoBrief takes a different approach, focusing on individuals who report engaging in international collaboration in their work, regardless of whether that work has a research component, and covering international collaboration activities in all sectors of the economy.

Profile of International Collaborators

Employment sector. Reported international collaborations were higher among scientists and engineers working in the for-profit sector (27%) than in the federal government (18%) or in 4-year educational institutions (15%) (table 1). The higher level of for-profit sector collaboration holds regardless of gender, place of birth, highest degree attained, location of postsecondary education, as well as in most broad occupations.

Gender. Across all employment sectors, men were more likely than women to report international collaboration.

Place of birth. Across most employment sectors, scientists and engineers born outside of the United States were more likely than the U.S.-born to work with colleagues in other countries. However, among those working for the federal government, the U.S.-born had higher collaboration levels than those born outside of the United States.

Highest degree of educational attainment. Doctorate holders in all sectors were more likely than individuals with other types of degrees to engage in international collaborations.

Location of postsecondary education. Individuals with degrees from both U.S. and foreign institutions were the most likely to collaborate internationally across almost all employment sectors. The one exception was for the employment sector of 4-year colleges and universities, where those who had earned all their degrees abroad were the most likely to collaborate internationally. Generally, those with U.S.-only degrees were the least likely to report international collaboration, the exception being federal government employees.

Occupation. Individuals employed as computer and mathematical scientists were the most likely of those in all broad occupations to collaborate

TABLE 1. Scientists and engineers reporting international collaboration, by employment sector and demographic characteristics: 2006
(Percent)

Characteristic	Total (*n*)	Reporting international collaboration	Business/industry			Government		Education	
			For profit	Self-employed[a]	Nonprofit	Federal	State/local	4-year educational institutions[b]	Other educational institutions[c]
All employed scientists and engineers (*n*)	18,927,000	-	7,682,000	3,624,000	1,830,000	824,000	1,405,000	1,549,000	2,014,000
Reporting international collaboration	3,157,000	16.7	26.7	13.2	6.9	17.8	4.9	14.8	3.0
Sex									
Male	2,293,000	21.5	30.8	15.6	11.5	19.5	5.7	18.1	4.4
Female	865,000	10.5	18.9	8.6	4.9	14.3	4.1	11.6	2.3
Place of birth									
United States	2,397,000	15.3	25.0	11.5	6.7	18.5	4.7	13.9	2.9
Outside of United States	761,000	23.7	33.4	21.2	8.5	12.4	6.6	17.9	3.8
Highest degree of educational attainment[d]									
Bachelor's	1,761,000	16.2	24.2	14.0	5.4	15.2	4.9	10.5	3.1
Master's	970,000	18.0	33.7	16.9	8.6	20.6	4.6	10.1	2.7
Doctorate	254,000	28.8	43.7	20.1	24.1	32.8	12.8	26.5	8.1
Location of postsecondary education									
All degrees earned in United States	2,675,000	15.7	25.4	12.3	6.7	17.9	4.7	13.9	2.9
Degrees earned abroad and in United States	229,000	31.4	44.9	25.8	13.3	21.4	11.1	19.0	7.4
All degrees earned abroad	254,000	22.8	31.1	18.2	8.6	10.6	7.2	21.7	4.1
Occupation									
S&E occupations	1,416,000	28.2	37.1	25.6	16.8	18.4	6.1	18.8	2.7
Computer and mathematical scientists	667,000	31.6	40.1	29.7	12.5	18.2	5.3	12.1	1.9
Biological, agricultural, and other life scientists	116,000	23.9	34.0	24.4	28.3	18.5	11.2	22.3	7.4
Physical scientists	80,000	23.9	30.7	17.5	35.7	25.5	4.6	23.7	4.4
Social scientists	70,000	14.8	34.3	9.2	10.4	20.0	2.9	19.0	1.8
Engineers	483,000	29.8	34.6	28.8	24.5	16.5	6.4	19.4	6.7
S&E-related occupations	394,000	7.5	13.6	4.9	3.4	13.0	4.0	9.6	2.7
Non-S&E occupations	1,348,000	15.6	24.1	13.9	8.8	19.7	4.8	14.1	3.2

S&E = science and engineering.

[a] Includes those who are self-employed or business owners in incorporated or unincorporated businesses, professional practices, or farms.
[b] Includes 4-year colleges or universities, medical schools (including university-affiliated hospitals or medical centers), and university-affiliated research institutes.
[c] Includes 2-year colleges, community colleges, technical institutes, and other precollege institutions.
[d] Professional degrees are included in total reporting international collaboration but are not shown separately.

NOTES: Scientists and engineers refers to all persons who have received a bachelor's degree or higher in S&E or S&E-related field, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation in 2003. Numbers rounded to nearest thousand. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2006.

internationally (32%); in the for-profit sector, this proportion rose to 40%. In 4-year educational and in non-profit institutions, physical scientists and biological, agricultural, and other life scientists were the most likely to collaborate internationally. Among the self-employed, the most likely to do so were computer and mathematical scientists and engineers.

Large differences in the incidence of international collaboration exist within the same broad occupational categories (table 2). Postsecondary teachers within each occupational category were among the least likely to report international collaborations, whereas S&E managers within S&E-related occupations generally reported high involvement. Chemical engineers reported the highest level of international collaboration out of all occupations (43%), and psychologists; civil, architectural, or

TABLE 2. Rate of international collaboration of employed U.S. scientists and engineers, by detailed occupation: 2006

Occupation	Total	Percent
All employed scientists and engineers	18,927,000	16.7
S&E occupations	5,024,000	28.2
Computer and mathematical scientists	2,112,000	31.6
Computer and information scientists	1,938,000	32.8
Mathematical scientists	85,000	26.3
Postsecondary teachers—computer and math sciences	90,000	10.7
Biological, agricultural, and other life scientists	487,000	23.9
Agricultural and food scientists	57,000	23.8
Biological and medical scientists	336,000	27.0
Environmental life scientists	35,000	8.2
Postsecondary teachers—life and related sciences	60,000	15.5
Physical scientists	334,000	23.9
Chemists, except biochemists	134,000	31.3
Earth scientists, geologists, and oceanographers	80,000	17.4
Physicists and astronomers	29,000	29.7
Other physical and related scientists	39,000	13.4
Postsecondary teachers—physical and related sciences	52,000	19.5
Social scientists	470,000	14.8
Economists	33,000	31.8
Political scientists	20,000	24.0
Psychologists	177,000	6.5
Sociologists and anthropologists	21,000	22.2
Other social and related scientists	103,000	20.0
Postsecondary teachers—social and related sciences	115,000	15.2
Engineers	1,621,000	29.8
Aerospace, aeronautical, or astronautical engineers	96,000	29.1
Chemical engineers	80,000	43.0
Civil, architectural, or sanitary engineers	266,000	7.4
Electrical or computer hardware engineers	395,000	35.6
Industrial engineers	93,000	37.0
Mechanical engineers	305,000	38.2
Other engineers	348,000	29.3
Postsecondary teachers—engineering	38,000	19.8
S&E-related occupations	5,246,000	7.5
Health-related occupations	3,625,000	4.2
S&E managers	382,000	33.9
S&E pre-college teachers	644,000	2.9
S&E technicians and technologists	371,000	17.4
Other S&E-related occupations	224,000	12.5
Non-S&E occupations	8,657,000	15.6
Non-S&E managers	1,118,000	29.0
Management-related occupations	1,361,000	22.6
Non-S&E precollege teachers	724,000	2.3
Non-S&E postsecondary teachers	141,000	12.6
Social services and related occupations	714,000	5.6
Sales and marketing occupations	1,435,000	18.7
Art, humanities, and related occupations	262,000	19.3
Other non-S&E occupations	2,902,000	11.2

S&E = science and engineering.

NOTES: Scientists and engineers refers to all persons who have received a bachelor's degree or higher in S&E or S&E-related field, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation in 2003. Numbers rounded to nearest thousand. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2006.

sanitary engineers; and environmental life scientists reported the lowest levels (7%–8%).

Means and Patterns of International Collaboration

Travel. Nearly half of all employed scientists and engineers indicated that their foreign collaborators traveled to the United States to conduct their work. Fewer U.S. scientists and engineers reported that they themselves had traveled abroad (table 3), with more men than women reporting that they traveled abroad or that their collaborators traveled to the United States. Travel abroad for international collaboration activities increased with respondent's age and level of degree. Non-U.S.-born scientists and engineers traveled more than their U.S.-born counterparts.

Communication patterns. Scientists and engineers used multiple means of communicating during international collaboration. Virtually all scientists and engineers involved in international collaboration used telephone or e-mail, and over half used Web-based or virtual communication (table 3). Most of them combined two or more means of communication (figure 1). One out of five communicated by telephone, e-mail, or through Web-based or virtual communication without any travel involved. A similar proportion reported communicating by telephone or e-mail without any Web-based or virtual communication or travel. Sixteen percent of scientists and engineers combined all means of communication, including telephone or e-mail with Web-based or virtual communication and travel in both directions, whereas a similar proportion indicated the same pattern without traveling abroad.

Work Activities and International Collaboration

U.S. scientists and engineers collaborate across national boundaries in a

range of work activities. Scientists and engineers who are engaged in computer programming, systems, or applications most often reported international collaboration (26%), and those engaged in teaching or professional services least often reported international collaboration (11% and 10%, respectively) (table 4). For most work activities, rates of international collaboration among those in S&E occupations (in particular among computer and mathematical scientists; biological, agricultural, and other life scientists; and engineers) were higher than rates among those in S&E-related or non-S&E occupations, including for work activities such as teaching and professional services.

TABLE 3. Employed U.S. scientists and engineers reporting international collaboration, by means of communication, demographic characteristics, and employment sector: 2006

Characteristic and employment sector	Total	Means of collaboration (%)			
		Telephone or e-mail	Web-based or virtual communication	Foreign collaborator traveled to United States	U.S. collaborator traveled abroad
Total reporting international collaboration	3,157,000	94.6	56.0	49.4	32.2
Sex					
Male	2,293,000	95.2	57.0	53.1	36.2
Female	865,000	93.2	53.4	39.7	21.6
Place of birth					
United States	2,397,000	94.2	54.4	49.0	30.3
Outside of United States	761,000	95.8	61.3	50.8	38.2
Age group					
29 or younger	354,000	93.9	56.0	45.2	20.3
30–39	911,000	95.1	57.8	49.7	29.1
40–49	1,008,000	96.1	58.4	51.5	33.9
50–59	671,000	92.1	53.7	48.7	37.3
60–69	192,000	95.1	45.5	47.5	40.6
70 or older	22,000	89.0	38.9	52.1	40.5
Highest degree of educational attainment[a]					
Bachelor's	1,761,000	93.7	56.1	47.0	28.4
Master's	970,000	96.0	60.2	52.4	35.7
Doctorate	254,000	97.4	47.0	58.6	47.3
Employment sector					
Business/industry	2,653,000	95.8	58.3	50.5	32.2
For profit	2,048,000	96.1	59.7	52.4	31.6
Self-employed[b]	478,000	95.1	56.8	42.9	34.2
Nonprofit	127,000	92.7	40.5	48.4	33.4
Government	216,000	87.8	48.4	41.4	29.4
Federal	146,000	89.2	50.3	43.3	35.9
State/local	69,000	84.7	44.4	37.3	15.7
Education	289,000	89.2	41.3	45.3	34.2
4-year educational institutions[c]	229,000	92.7	41.5	48.5	37.7
Other educational institutions[d]	60,000	75.9	40.3	33.2	20.6

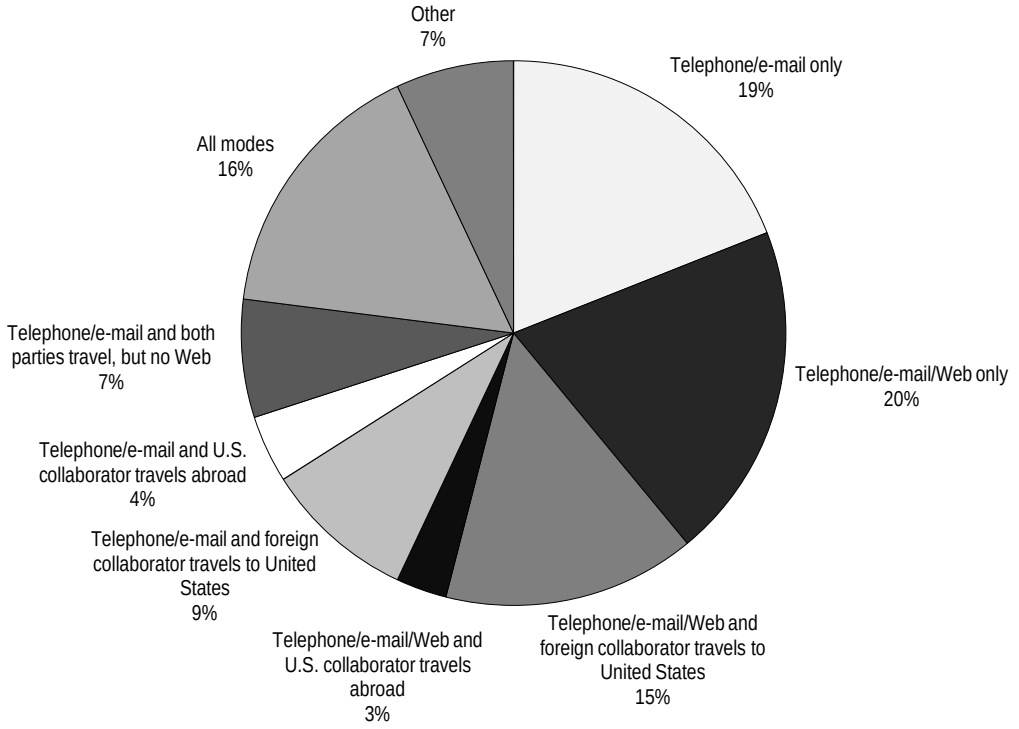
S&E = science and engineering.

[a] Professional degrees are included in total reporting international collaboration but are not shown separately.
[b] Includes those who are self-employed or business owners in incorporated or unincorporated businesses, professional practices, or farms.
[c] Includes 4-year colleges or universities, medical schools (including university-affiliated hospitals or medical centers), and university-affiliated research institutes.
[d] Includes 2-year colleges, community colleges, or technical institutes, and other precollege institutions.

NOTES: Scientists and engineers refers to all persons who have received a bachelor's degree or higher in S&E or S&E-related field, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation in 2003. Respondents can report more than one means of collaboration. Numbers rounded to nearest thousand. Detail may not add to total because of rounding.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2006.

FIGURE 1. Combined patterns of communication that are used by U.S. scientists and engineers for international collaboration: 2006



NOTES: Web includes Web-based and virtual communication. Scientists and engineers refers to all persons who have received a bachelor's degree or higher in science and engineering (S&E) or S&E-related field, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation in 2003.

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2006.

Data Sources and Availability

Data presented here are from the 2006 SESTAT, which comprises three large demographic and workforce surveys of individuals conducted by the National Science Foundation: the National Survey of College Graduates, the National Survey of Recent College Graduates, and the Survey of Doctorate Recipients. The 2006 surveys included 105,064 individuals, representing a population of about 22 million scientists and engineers, including people trained in S&E or S&E-related fields or working in S&E or S&E-related occupations. All demographic, employment, and education data on scientists and engineers represent the status of these individuals at the respective survey reference dates.

Further information on the SESTAT system can be found at http://www.nsf.gov/statistics/sestat/. The full set of detailed tables from the SESTAT integrated database is available in the report *Characteristics of Scientists and Engineers in the United States: 2006* at http://www.nsf.gov/statistics/us-workforce/.

Definitions

Scientists and engineers include any person who has ever received a bachelor's degree or higher in an S&E or S&E-related field through 30 June 2005, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation on 1 October 2003.

S&E fields include biological, agricultural, environmental life sciences; computer and information sciences; mathematics and statistics; physical sciences; psychology; social sciences; and engineering. S&E-related fields include health, science and mathematics teacher education, technology and technical fields, and other S&E-related fields, such as architecture and environmental design and actuarial science. See http://sestat.nsf.gov/docs/ed03maj.html for a detailed description of the educational classification.

S&E occupations include computer and mathematical scientists; biological, agricultural, and other life scientists; physical and related scientists; social and related scientists; and engineers. S&E-related occupations include health related occupations, S&E managers, S&E pre-college teachers, S&E techni-

TABLE 4. International collaboration rates of employed scientists and engineers, by level of work activity engagement and broad occupation: 2006

Level of work activity engagement	All occupations	S&E occupations						S&E-related occupations	Non-S&E occupations
		All S&E occupations	Computer, mathematical scientists	Biological, agricultural, other life scientists	Physical scientists	Social scientists	Engineers		
All employed scientists and engineers (*n*)	18,927,000	5,024,000	2,112,000	487,000	334,000	470,000	1,621,000	5,246,000	8,657,000
Rate of international collaboration	16.7	28.2	31.6	23.9	23.9	14.8	29.8	7.5	15.6
Engaged in work activity 10% of time or more									
Computer programming, systems, or applications development	26.4	32.4	28.5	28.7	20.8	29.6	29.6	17.2	21.9
R&D	22.5	30.7	33.7	26.8	27.6	19.8	31.8	12.0	20.8
Production, operations, maintenance	21.4	31.9	33.4	22.3	25.5	38.0	34.4	10.4	18.8
Quality or productivity management	20.7	33.6	38.8	25.7	26.9	21.7	32.0	10.9	19.2
Managing or supervising people or projects	20.3	32.3	36.9	28.5	29.6	19.9	31.8	9.8	19.6
Accounting, finance, contracts	20.2	27.3	31.6	25.9	25.1	23.2	25.2	12.4	19.8
Human resources, including recruiting, personnel development, training	19.2	32.7	40.3	28.7	24.1	19.2	31.1	11.2	18.7
Sales, purchasing, marketing, customer service, public relations	18.8	32.7	35.9	23.2	22.4	23.4	35.2	8.4	18.6
Teaching	11.0	25.9	28.0	25.4	23.7	14.6	33.7	5.1	11.1
Professional services	9.8	19.5	34.3	21.2	10.1	10.6	15.5	4.5	13.7
Engaged in as primary or secondary work activity									
Computer programming, systems, or applications development	27.8	30.6	31.2	22.6	25.9	28.4	27.3	20.2	20.8
R&D	25.3	30.4	31.8	28.4	29.4	20.8	32.0	15.9	21.3
Production, operations, maintenance	17.1	25.4	29.0	15.3	14.9	13.1	27.7	7.4	15.7
Quality or productivity management	20.2	31.1	36.7	19.0	24.8	16.7	30.7	11.3	18.2
Managing or supervising people or projects	20.7	32.4	39.6	27.0	26.3	20.2	30.1	11.1	19.9
Accounting, finance, contracts	17.1	20.9	25.4	17.2	12.1	9.9	21.6	9.2	17.4
Human resources, including recruiting, personnel development, training	16.3	27.3	37.1	15.3	20.9	13.3	25.6	11.1	16.1
Sales, purchasing, marketing, customer service, public relations	18.7	34.0	36.0	11.6	28.5	19.5	40.7	7.9	18.0
Teaching	6.3	15.8	12.9	15.1	18.2	14.0	25.2	3.8	5.8
Professional services	7.5	13.4	29.3	13.9	4.6	6.7	14.0	3.6	12.3
Not engaged in work activity									
Computer programming, systems, or applications development	14.0	25.4	28.4	23.3	22.8	14.1	29.9	5.9	14.7
R&D	10.4	19.8	26.7	5.0	6.4	5.8	18.7	3.6	12.0
Production, operations, maintenance	15.8	27.3	31.2	24.4	23.1	14.0	28.1	7.1	15.0
Quality or productivity management	15.0	26.1	28.9	23.4	22.7	13.9	28.6	6.2	14.0
Managing or supervising people or projects	11.2	22.4	25.7	16.3	16.7	9.8	25.5	4.5	8.7
Accounting, finance, contracts	15.3	28.4	31.6	23.4	23.7	12.8	31.6	6.5	12.3
Human resources, including recruiting, personnel development, training	15.7	27.2	29.9	22.7	23.8	13.8	29.5	6.3	13.9
Sales, purchasing, marketing, customer service, public relations	15.6	27.1	30.6	24.0	24.1	12.7	28.2	7.2	12.7
Teaching	19.4	28.8	32.3	23.1	23.9	15.0	29.2	9.8	17.4
Professional services	21.2	29.7	31.3	24.4	25.6	18.6	31.8	14.2	16.6

S&E = science and engineering.

NOTES: Scientists and engineers refers to all persons who have received a bachelor's degree or higher in S&E or S&E-related field, plus persons holding a non-S&E bachelor's or higher degree who were employed in an S&E or S&E-related occupation in 2003. R&D includes basic research, applied research, development, or design activities. Respondents may report more than one work activity. Numbers rounded to nearest thousand. Detail may not add to total because of rounding. See SESTAT questionnaires for examples of work activity (http://nsf.gov/statistics/question.cfm#ScienceandEngineeringWorkforce).

SOURCE: National Science Foundation, National Center for Science and Engineering Statistics, Scientists and Engineers Statistical Data System (SESTAT), 2006.

cians and technologists, and other S&E-related occupations, such as architects and actuaries. See http://sestat.nsf.gov/docs/occ03maj.html for a detailed description of the occupational classification.

Notes

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2. Data on international collaboration were collected only in 2006. The wording of the question was as follows: "In performing the principal job you held during the week of April 1, 2006, did you work with individuals located in other countries?" The wording of the means of communication was "In your work with individuals located in other countries, did you…? (Mark yes or no for each item). The response categories were as follows: communicate by telephone or e-mail to conduct the work, use web-based or virtual technology to conduct the work, travel to a foreign country for collaborative activities, work with foreign collaborator(s) who traveled to the U.S. to meet with you.

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