Peter Freeman and William Aspray

The Supply of Information Technology Workers in the United States

Seperate Appendix
Charts, Figures, Tables

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Box 1-1. H-1A Visas and the Nursing Shortage

In response to labor shortages of nurses reported by hospitals and some other employer groups, the Congress passed the Immigration Nursing Relief Act of 1989 (INRA, Public Law 101-238). This law added a new provision allowing admission of nonimmigrant registered nurses (RNs) during a five-year pilot period to expire in September 1995.

The history of this program was carefully reviewed in 1995 by the Immigration Nursing Relief Advisory Committee established under the above law, and its report provides an instructive model for discussion of the issues surrounding the debate about foreign IT workers. The rationales for the H-1A nursing visas were:

a) reports of a nationwide shortage of nurses;
b) increasing dependence on foreign temporary nurses admitted under other visas;
c) pending expiration of work authorizations for many existing temporary foreign nurses admitted under other programs;
d) concern that foreign nurses were detrimentally affecting the pay and working conditions of the domestic nursing workforce; and
e) declining numbers and quality of applicants to basic nursing education programs.

The new act, first, allowed foreign nurses previously admitted on temporary visas to convert their status to legal permanent resident, and waived numerical limits in existing law in order to allow this to happen. Second, it created a new temporary nursing visa (the H-1A visa) that included provisions intended to: 1) encourage employers to reduce their dependency on foreign nurses, 2) provide protection for the wages and working conditions of nurses who are citizens and legal permanent residents of the United States, and 3) foster the development of a stable pool of domestic RNs so that future shortages could be minimized.

According to the Advisory Committee, the debate on this particular legislation embodied many of the issues that repeatedly arise in discussions regarding the admission of foreign workers to meet skill shortfalls and labor shortages in the United States. The Advisory Committee summarized these issues with a long quotation from a 1991 staff report:[10]

The debate about relying on immigration more significantly to meet "labor shortages," and thereby contribute to America's competitiveness in the global marketplace, inevitably included the need to provide realistic protection for U.S. workers. For immigration policy, this issue involved two interrelated points. First, how to evaluate independently an employer's claim that a foreign worker is needed. And second, how to strike an intellec-

[10] Gary B. Read and Demetrios G. Papademetriou, "U.S. Legal Immigration Reform: Recent Developments," Immigration Nursing Relief Advisory Committee report, 1995, pp. 12-13.

tually and politically satisfactory balance between being responsive to employer needs while also being sensitive to concerns that greater access to foreign workers by U.S. employers might affect adversely the wages and job opportunities of U.S. workers. Such adverse effects could occur through direct displacement of U.S. workers or through significant interference with the market's natural propensity to adjust to a tighter labor supply, thereby leading to an increasing dependence on foreign workers. This debate clearly raised the issue that over-reliance on immigration to meet labor shortages, as opposed to educating and training the domestic workforce, could turn temporary labor market shortages into structural deficiencies.

The conclusions of the Advisory Committee were mixed. They noted that because only a tiny percentage of the U.S. nursing workforce ever came to be accounted for by H-1A nurses (about 13,800 in 1994, less than 1% of employed RNs), at the national level essentially all the effects of this program were negligible. However, because the H-1A nurses were heavily concentrated in only a few metropolitan areas (over one-third in the New York City area alone, and two-thirds in New York, Chicago, Houston, Los Angeles, and Dallas together), H-1As in these cities mitigated a tight nursing labor market with "no adverse impacts on patient care," but also "may have lessened the pressure to find long-term solutions to nurse staffing problems." [11]

The Committee found the "attestation" procedures required of employers to be ineffectual, and reported that the "use of employer-specific vacancy rates as a justification for the need for H-1A nurses was problematic, as these rates could be calculated in several ways, making them difficult to verify." It noted further that the prevailing wage determinations were often of doubtful validity and reliability, and that the act's requirement that "employers take timely and significant steps to recruit and retain U.S. nurses was ineffective because it did not require any new steps" beyond those that most employers had long practiced. [12]

Lastly, the Advisory Committee reported that the rate of increases in RN employment had slowed since passage of the 1989 Act; that press reports had begun to appear about nurse layoffs; and that "the future labor market for registered nurses is uncertain."[13] The H-1A nursing visa program was allowed to expire in September 1995. In its final year, FY1994, approximately 6,300 nonimmigrant nurses had been admitted under this visa program.

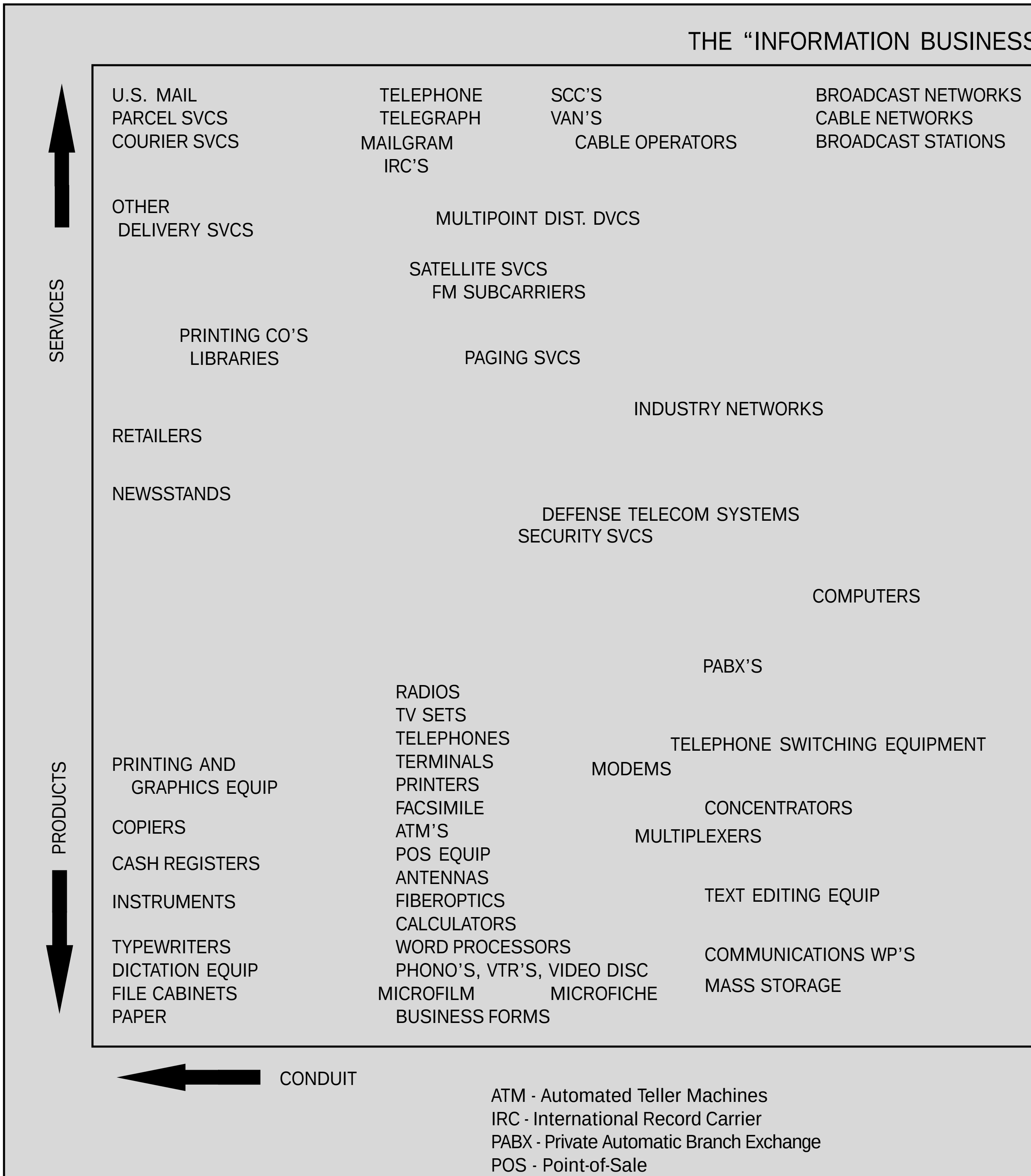
Source: Computing Research Association, Intersociety Study Group on Information Technology workers, based on the "U.S. Legal Immigration Reform: Recent Developments," Immigration Nursing Relief Advisory Committee report, 1995.

[11] Ibid., p. 5.

[12] Ibid., p. 6.

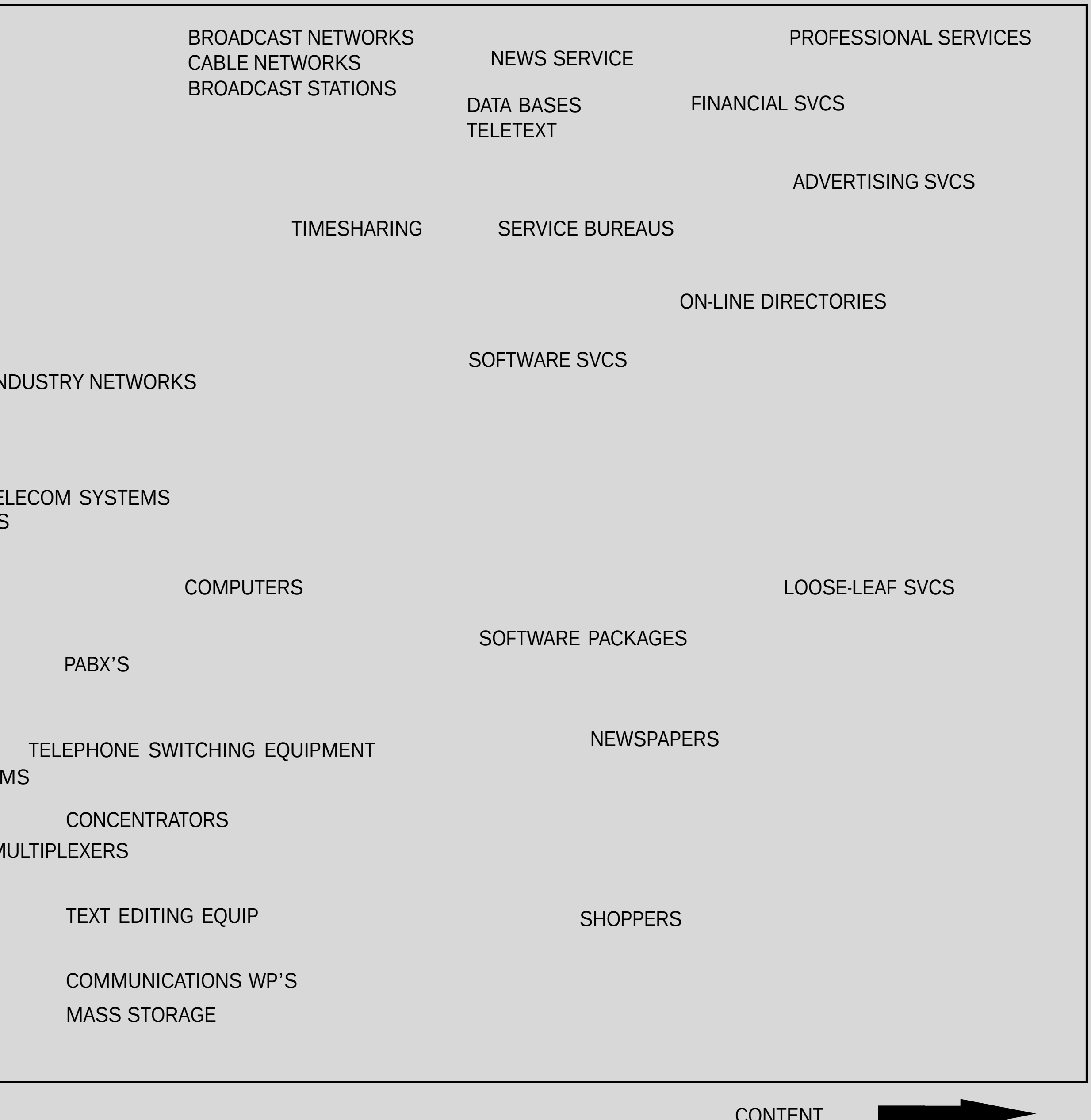
[13] Ibid., pp. 7, 31.

Figure 2-1



Source: John McLaughlin and Anne Birinyi, "Information Business," Harvard College, 1980.

THE “INFORMATION BUSINESS”



Teller Machines
Record Carrier
matic Branch Exchange
e

SCC - Specializied Common Carrier
VAN - Value Added Network
VTR - Video Tape Recorder
WP - Word Processor

lege, 1980.

Table 2-1

IT-related Academic Disciplines Offered in the United States

1. Computer Science
2. Information Science
3. Information Systems
4. Management Information Systems
5. Software Architecture
6. Software Engineering
7. Network Engineering
8. Knowledge Engineering
9. Database Engineering
10. System Security and Privacy
11. Performance Analysis (Capacity Planning)
12. Scientific Computing
13. Computational Science
14. Artificial Intelligence
15. Graphics
16. HCI (Human Computer Interface)
17. Web Service Design
18. Multimedia Design
19. System Administration
20. Digital Library Science

Source: Peter Denning, "Information Technology: Developing the Profession," Discussion Document, December 4, 1998.

Box 2-1

Undergraduate Degree Programs in Information Technology

Computer engineering - Graduates work primarily in computer hardware.

Computer science and engineering - Graduates work primarily in hardware, firmware, and software, depending on program and choices made by the student.

Computer science - Graduates work primarily in software design and implementation.

Software engineering - Graduates work with the engineering of software, with special attention devoted to large and critical systems.

Computer information science - Graduates work on the development of information systems, probably with more emphasis on information as an enterprise resource than is given in programs in computer science or software engineering.

Information systems - Graduates design, develop, implement, and maintain business information systems.

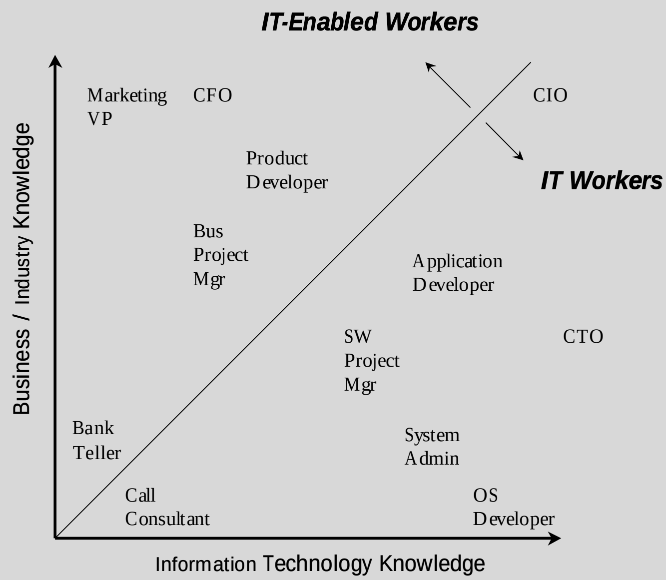
Management information systems - Graduates design, develop, implement, maintain, and manage information systems with a greater emphasis on the management of the systems than on the other aspects.

Information science - Graduates usually work in libraries or develop other facilities to provide information to users.

Source: Adapted from "U.S. Degree Programs in Computing" in *Computing Professionals - Changing Needs for the 1990s*, National Academy Press, 1993.

Figure 2-2

Distinquishing IT Workers from IT-Enabled Workers



Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Table 2-2

Categorization of IT Jobs

Conceptualizers - those who conceive of and sketch out the basic nature of a computer system artifact:

- Entrepreneur
- Product designer
- Research engineer
- Systems analyst
- Computer science researcher
- Requirements analyst
- System architect

Developers - those who work on specifying, designing, constructing, and testing an information technology artifact:

- System designer
- Programmer
- Software engineer
- Tester
- Computer engineer
- Microprocessor designer
- Chip designer

Modifiers/Extenders - those who modify or add on to an information technology artifact:

- Maintenance programmer
- Programmer
- Software engineer
- Computer engineer
- Database administrator

Supporters/Tenders - those who deliver, install, operate, maintain, or repair an information technology artifact:

- System consultant
- Customer support specialist
- Help desk specialist
- Hardware maintenance Specialist
- Network installer
- Network administrator

Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Table 2-3

Typical Educational Preparation for IT Jobs					
	High School	Associate	Bachelor's	Master's	Doctorate
Conceptualizers	Occasionally	Occasionally	Common	Frequent	Frequent
Developers			Common	Common	Occasionally
Modifiers		Occasionally	Common	Common	Occasionally
Supporters	Occasionally	Frequent	Common		

Unlikely= (blank) Occasionally= ✓ Common= ✔ **Frequent= ✔**

Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Table 2-4

Numbers and Annual Change in IT Workers in the United States, 1988 - 1997

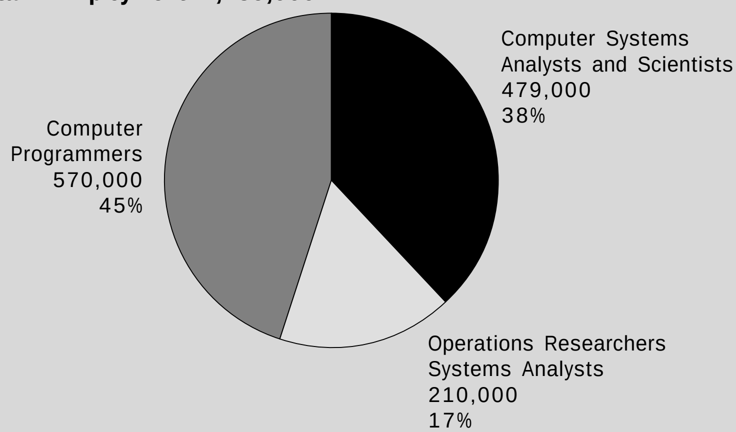
Year	**Number of Workers (thousands)**	**Annual % Change**
1988	1,259	--
1989	1,366	8.5
1990	1,411	3.3
1991	1,422	0.7
1992	1,435	0.9
1993	1,583	10.3
1994	1,687	6.6
1995	1,703	0.9
1996	1,863	9.4
1997	2,063	10.7

Source: Adapted from Burt S. Barnow, John Trutko, and Robert Lerman, "Skill Mismatches and Worker Shortages: The Problem and Appropriate Responses," Draft Final Report, The Urban Institute, February 25, 1998, Exhibits 7 and 8. Based on the Bureau of Labor Statistics data.

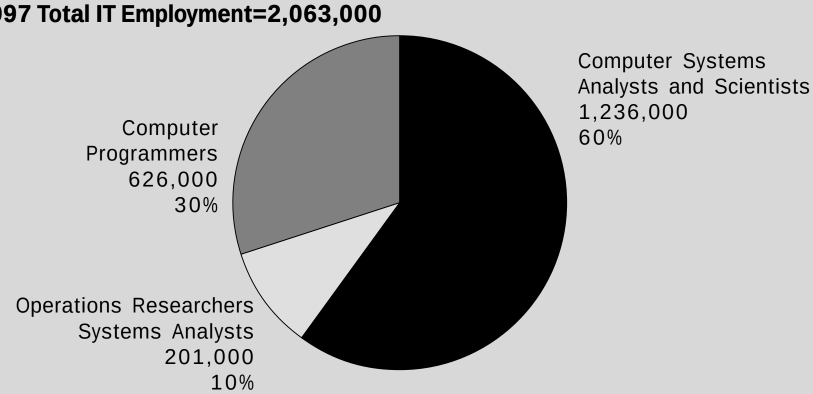
Figure 2-3

Comparison of IT Employment 1988 and 1997

1988 Total IT Employment=1,259,000



1997 Total IT Employment=2,063,000



Source: Adapted from Burt S. Barnow, John Trutko, and Robert Lerman, "Skill Mismatches and Worker Shortages: The Problem and Appropriate Responses," Draft Final Report, The Urban Institute, February 25, 1998, Exhibits 7 and 8. Based on the Bureau of Labor Statistics data.

Table 2-5

Use of Computer Systems in the Operation of American Industry
◆ Inventory management by large retailers ◆ Shipping scheduling and quality assurance by express courier services ◆ Financial controls in virtually every large business ◆ Frequent flyer programs by the airlines ◆ Credit card validation by merchants ◆ Production of movies and videos ◆ Distance education ◆ Control of manufacturing lines in the chemical and automobile industries ◆ Processing data for oil exploration companies ◆ Global positioning systems used in the trucking industry and in scientific agriculture ◆ Literature searching in biomedical research ◆ Computer-aided design by engineers ◆ Automated switching in the communications industry
Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Table 2-6

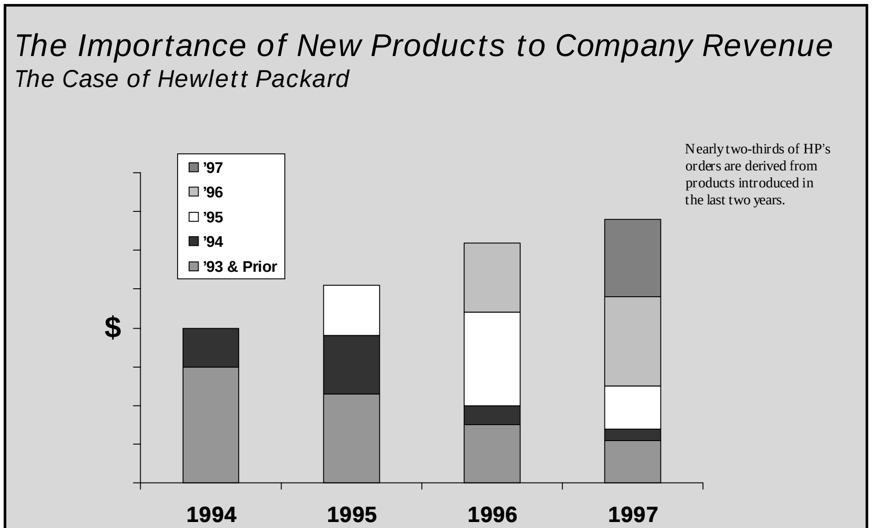
Typical Knowledge, Skill Mix for IT Jobs (scale: 1-4)

	Information Technology	Business and Industry	Communication and Organization
Conceptualiziers	4	2	3
Developers	3	2	3
Modifiers	2	3	3
Supporters	1	2	3

Scale: 1- least important; 2- moderately important; 3- important; 4- critically important.

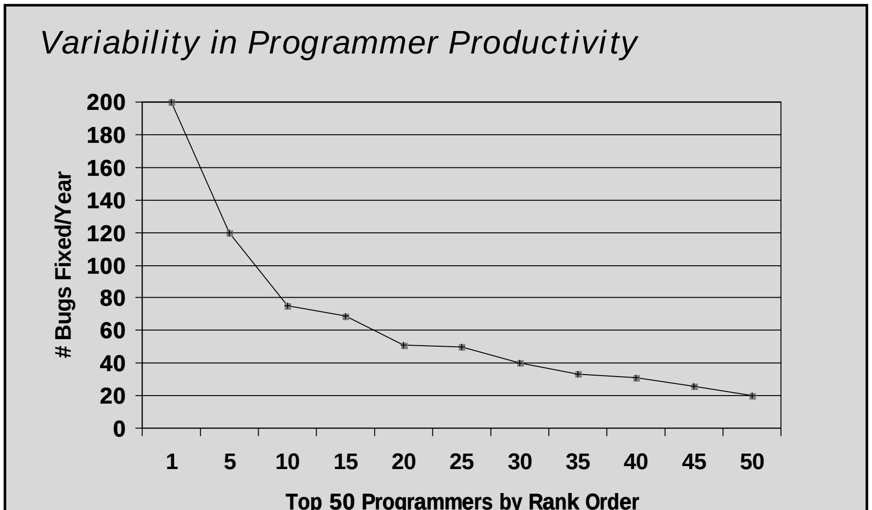
Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Figure 2-4



Source: Hewlett Packard

Figure 2-5



Source: "Not all Programmers Are Created Equal," G. Edward Bryan, IEEE, 1994.

Figure 2-6

Who's Getting the Top Talent?

Tier 1 - Hot Software Companies

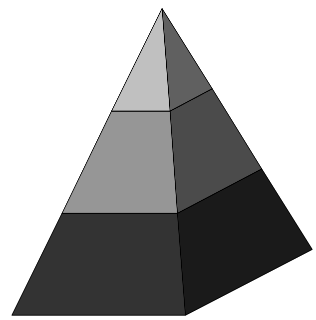
- Software start-ups and boutique service firms
- Software publishers
- Wall Street
- R&D (corporate and university)

Tier 2 - Software-aware Companies

- VARs, consulting firms, systems, integrators
- Software intensive industries (computer hardware, communications, financial services)
- Aerospace systems firms

Tier 3 - Everyone Else

- Other industries with incidental software
- Most IS applications development and maintenance
- DoD, federal, state, and local governments



Source: Stanford Computer Industry Project, 1999.

Table 4-1

Year	Computer Systems Analysts & Scientists	Operations & Systems Researchers & Analysts	Computer Programmers	All Professional Specialty Occupations	All Workers 16 years & older
1988	1.4%	2.2%	2.9%	1.7%	4.9%
1989	1.4	2.8	1.6	1.7	4.7
1990	1.5	1.3	3.0	2.0	5.0
1991	2.6	3.2	3.5	2.4	6.2
1992	2.7	2.0	3.1	2.6	6.8
1993	3.1	1.9	2.7	2.6	6.2
1994	1.8	2.7	2.1	2.5	5.7
1995	1.9	1.5	1.8	2.5	5.2
1996	1.3	1.2	1.6	2.3	5.0
1997	1.1	1.4	1.6	2.1	4.5

Unemployment Rate for IT Workers, 1988 - 1996, Based on Current Population Survey (CPS) Data

Source: U.S. Department of Labor, Bureau of Labor Statistics, Employment and Earnings, Household Data, Annual Averages (published in January after each year).

Table 4-2

Earnings and Change in Earnings for IT and Other Workers

Type of Job	Median Weekly Earnings ($) (1997)	% Change in Salary 1988 - 1997	% Change in Salary 1996 - 1997
Computer Systems Analysts and Scientists	918	36.2	3.0
Operations Researchers/ Systems Analysts	867	28.4	6.4
Computer Programmers	840	42.9	8.8
All Professional Occupations	750	35.1	2.7
All Workers with 4 or more years of college	779	33.2	2.8
All Workers 16 years old or older	503	30.6	2.7

Source: Adapted from Burt S. Barnow, John Trutko, and Robert Lerman, "Skill Mismatches and Worker Shortages: The Problem and Appropriate Responses," Draft Final Report, The Urban Institute, February 25, 1998, Exhibits 13 and 14. Based on the Bureau of Labor Statistics data.

Table 4-3

IT Occupations with Anticipated High Job Growth 1996-2006			
	Employment (thousands)		
Type of Job	**1996**	**2006**	**% Change**
Database Administrators, Computer Support Specialists, and all other Computer Scientists	212	461	118
Computer Engineers	216	451	109
Systems Analysts	506	1,025	103
Desktop Publishing Specialists	30	53	74
Data Processing Equipment Repairers	80	121	52
Engineering, Science, and Computer Systems Managers	343	498	45

Source: Bureau of Labor Statistics, *Monthly Labor Review*, November 1997.

Table 4-4

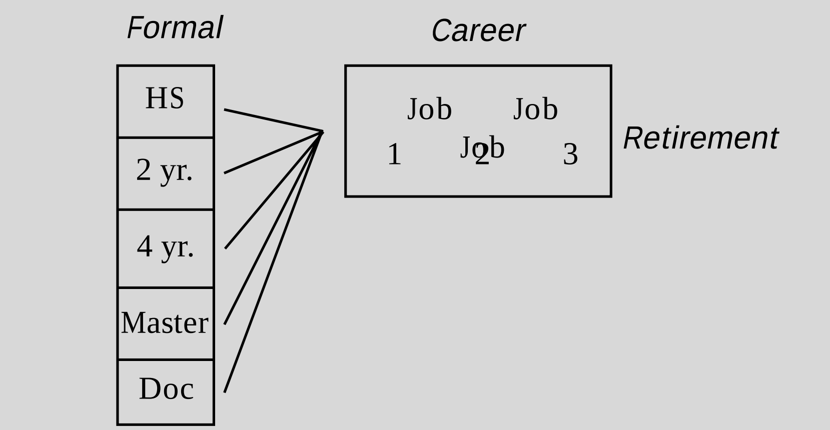
Company Reactions to a Worker Shortage

- Increase recruiting efforts
- Increase use of overtime
- Reduce minimum qualifications for the job
- Restructure work to use current or new employees in other occupations
- Substitute machinery and equipment for labor
- Train workers for the jobs
- Improve working conditions
- Offer bonuses to new employees
- Improve wages and fringe benefits
- Contract out the work
- Turn down work

Source: Burt S. Barnow, John Trutko, and Robert Lerman, “Skill Mismatches and Worker Shortages: The Problem and Appropriate Responses,” submitted by the The Urban Institute to the Office of the Assistant Secretary for Policy, U.S. Department of Labor, draft final report, February 25, 1998, pp. 22-31.

Figure 5-1

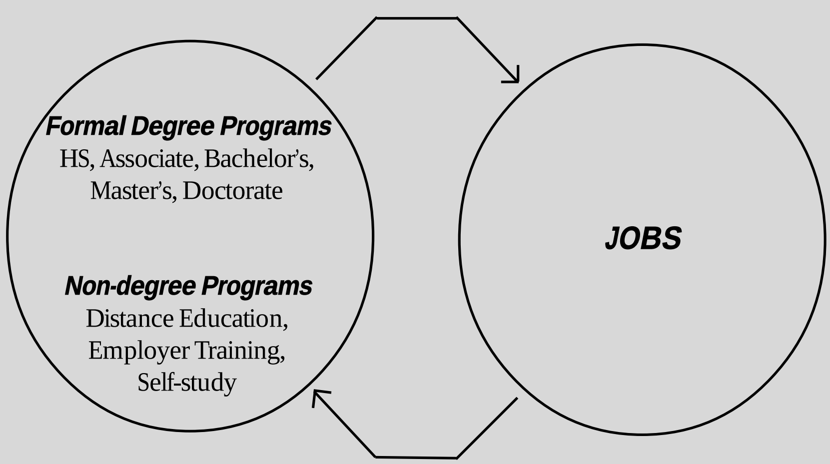
IT Worker Traditional Career Path



Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Figure 5-2

Current IT Worker Career Path



Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Box 5-1

Non-traditional Paths to and from IT Careers

AAA is a 56-year-old Ph.D. in Astronomy. He worked for nearly twenty years in a number of large and small companies, the last ten years in the Aerospace industry. When that industry downsized in the early '90s, he was laid off. Living off savings, his wife's salary, and his severance package, he returned to school full time and earned a master's degree in Computer Science. He quickly found work with a semiconductor company.

BBB is a 25-year-old college graduate who majored in Psychology, and worked in a daycare center after graduation. As a result of both home and college environments, she had basic computer literacy, and, discouraged by the low salaries in childcare, took a temporary job in IT doing quality assurance. She enjoyed this work, and now works full time doing quality assurance for a company involved in Internet commerce.

CCC is a 38-year-old with a master's degree in Russian economic history. While working on his masters, his roommate got a PC, and CCC became intrigued with it. He started reading books on computing. He landed a job with a company that made systems software, and ended up moving to a job where he is one of the major software resources of a small company.

DDD was a poetry major in college, working on her master's. She took a summer job at a bank as a technical writer when the bank was just introducing ATM machines. She became interested in the technology, dropped out of school, and ended up working for five years with the bank, by the end of which she was doing software project management. She joined a start-up company that eventually became a major producer of computers, and ran their software delivery system for many years.

EEE was a COBOL programmer for a major automaker. His department had more than 200 workers in his division. After a successful pilot project the company decided to move to Java and object-oriented programming. They used a rapid re-skilling program designed by one of the largest IT consulting companies. About forty co-workers passed the certification tests and are working on other projects. EEE is working at the local McDonald's. The company is busy recruiting new college hires and experienced object programmers to fill the void.

FFF was married at 18 to a Navy man, who left her with two small children and only a high-school education. She got work at a bookbindery. After several years learning the printing business she made the jump to electronic publishing, joining a start-up company in this field. Being willing to "tackle anything," she rose in management until she was assistant to the President and Chairman.

Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Table 5-1

Two-year Colleges Awarding Computer and Information Science Degrees	
Year	Number of Institutions
1989-1990	632
1990-1991	625
1991-1992	696
1992-1993	697
1993-1994	709
1994-1995	727

Source: National Center for Education Statistics, *Digest of Education Statistics*, using preliminary data for 1990-91 and final data for all other years.

Table 5-2

Associate Degree Production in Information Technology	
Year	Number of Degrees Awarded
1992-1993	9,196
1993-1994	9,301
1994-1995	9,152

Source: National Center for Education Statistics, *Digest of Education Statistics*

Table 5-3

Number of Four-year Colleges Offering Programs in Computer and Information Science 1989-1995	
Year	Number of Institutions
1989-1990	1,059
1990-1991	1,042
1991-1992	1,036
1992-1993	1,039
1993-1994	1,042
1994-1995	1,068

Source: National Center for Education Statistics, *Digest of Education Statistics*, using preliminary data for 1990-1991 and final data for all other years.

Table 5-4

Number of Bachelors Degrees Awarded in Information Technology Fields 1992-1995

Academic Year	Computer Science	Computer Engineering	Management Information Science and Data Processing	Other Business Information Systems
1992-1993	24,000	--	6,174	396
1993-1994	25,200	2,237	5,434	405
1994-1995	24,404	2,345	5,788	378

Source: National Center for Education Statistics, *Digest of Education Statistics.*

Table 5-5

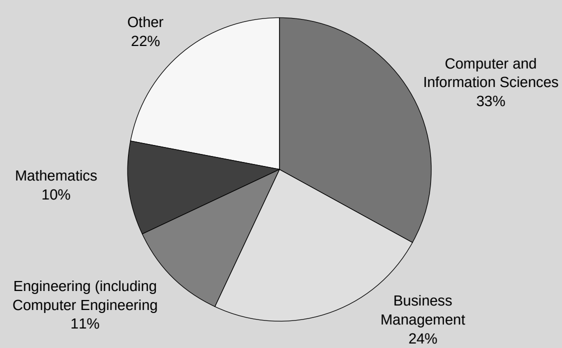
Career Faithfulness

Undergraduate Major	Percentage Working in that Field After 1-5 Years	After 20 Years
Computer Science	70	70
Engineering	50	50
Physics	50	40
Mathematics	upper 40's	35
Life Sciences	upper 40's	35

Source: National Center for Education Statistics, *Digest of Education Statistics*.

Figure 5-3

Degrees and Occupations in Computer Science 1992-1993



Source: National Science Foundation, National Survey of College Graduates.

Box 5-2

Academic Disciplines Other than the Computing Disciplines That Offer Strong Training for IT Careers

Mathematics - graduates ususally have an excellent background in logic and analysis, and often a strong background in scientific programming and modeling.

Statistics - graduates are usually very familiar with computer usage, relying heavily on statistical packages, and are comfortable with data analysis techniques.

Engineering (other than computer engineering) - graduates generally have good mathematics and science backgrounds that involve at least some computing. They are also trained in design and analysis.

Physics - graduates generally have a strong mathematics and science background and are usually familiar with computer hardware and some programming.

Chemistry - graduates have strong science and mathematics backgrounds, and they frequently have used computers.

Philosophy - graduates have strong logical thinking ability and may have taken courses in mathematical logic that provide good training for computer theory.

Business - graduates have knowledge of the organizational characteristics and issues involving the private sector, and modern business programs integrate computing into their courses to give graduates competence in computing.

Music - graduates have learned about the manipulation of patterns and themes within constraints, which often serves as good background for programming.

Instructional design - graduates are familiar with many aspects of computers as users and developers.

Graphics arts and industrial design - graduates are familiar with user interface and human-computer interaction issues.

Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.

Table 5-6

Graduate Programs in Computer Science		
Academic Year	Number of Master's Programs	Number of Doctoral Programs
1989-1990	311	100
1990-1991	314	100
1991-1992	319	103
1992-1993	316	112
1993-1994	325	117
1994-1995	339	119

Source: National Center for Education Statistics, *Digest of Education Statistics*, using preliminary data for 1990-1991 and final data for all other years. No statistics are available that break out professional from research-oriented master's programs.

Table 5-7

Graduate School Enrollment in Computer Science	
Academic Year	Number of Students Enrolled
August 1990	34,000
August 1991	34,600
August 1992	36,300
August 1993	36,200
August 1994	34,100
August 1995	33,400
August 1996	34,600

Source: National Center for Education Statistics, *Digest of Education Statistics*, using preliminary data for 1990-1991 and final data for all other years.

Table 5-8

Non-U.S. Employment of Computer Science Doctorates Awarded in the United States	
Survey Year	Percentage
1994	18.0
1995	15.9
1996	9.0
1997	5.5

Source: Computing Research Association, Taulbee Survey.

Table 5-9

Number of Master's and Doctoral Degrees Awarded in IT Fields, 1992-1995

Master's Degrees

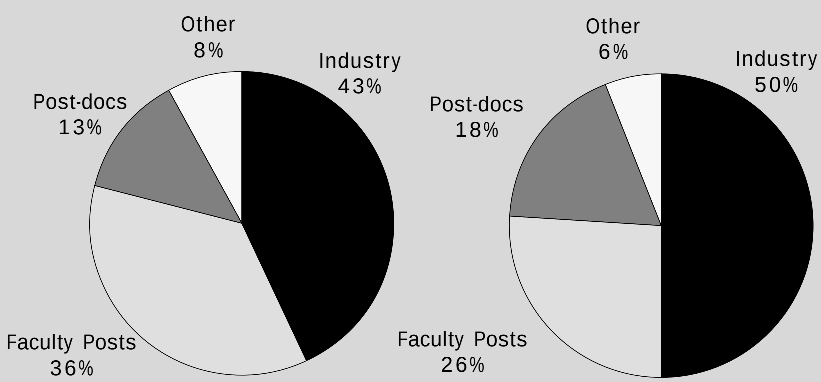
Academic Year	Computer Science	Computer Engineering	Management Information Science and Data Processing	Other Business Information Systems
1992-1993	10,163	--	1,592	208
1993-1994	10,416	1,071	1,877	263
1994-1995	10,326	1,040	2,012	394

Doctoral Degrees

Academic Year	Computer Science	Computer Engineering	Management Information Science and Data Processing	Other Business Information Systems
1992-1993	805	--	0	0
1993-1994	810	123	0	0
1994-1995	884	140	3	3

Figure 5-4

Career Choices of Computer Science Ph.Ds, 1994 and 1996



Source: National Center for Education Statistics, *Digest of Education Statistics*

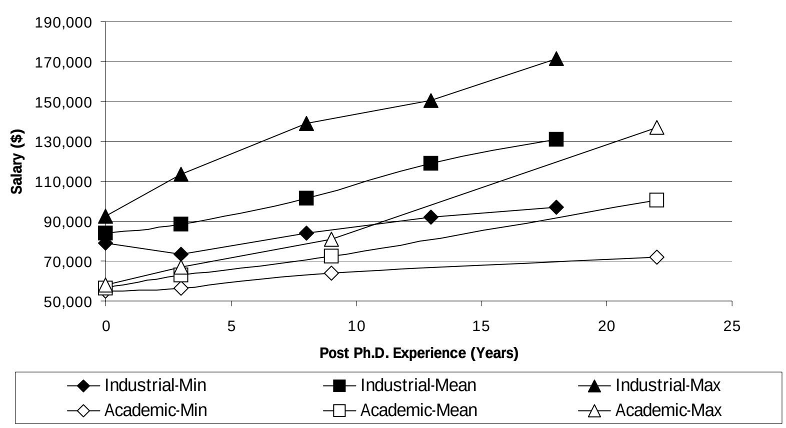
Table 5-10

Faculty Flight to Industry from Ph.D. Granting Departments of Computer Science and Computer Engineering	
Year	**Number**
1993-1994	40
1994-1995	44
1995-1996	44
1996-1997	53

Source: Computing Research Association, Taulbee Survey.

Figure 5-5

Twelve-Month Industrial Salaries Compared to Nine-Month Academic Salaries

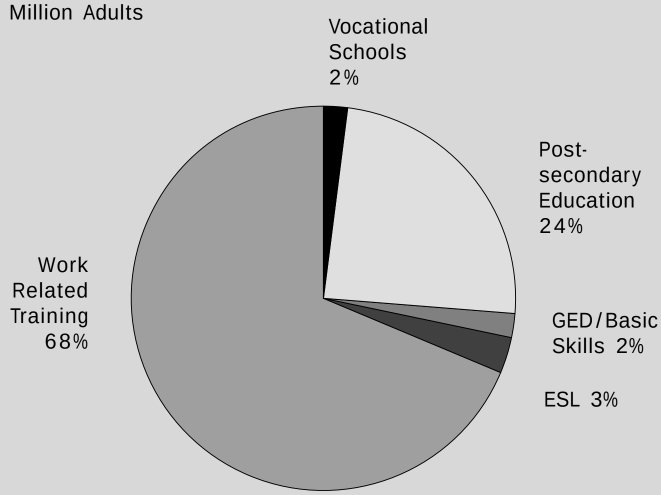


Source: The academic salary figures are taken from the 1997-98 CRA Taulbee Survey for the twelve top-ranked computer science departments, assuming that an assistant professor has an average of three years' experience, an associate professor has an average of eight years' experience, and a full professor has an average of twenty-two years' experience. The industrial salary figures are taken from the 1997 CRA Industrial Salary Survey.

Figure 6-1

Adult Education

Total=59.2 Million Adults

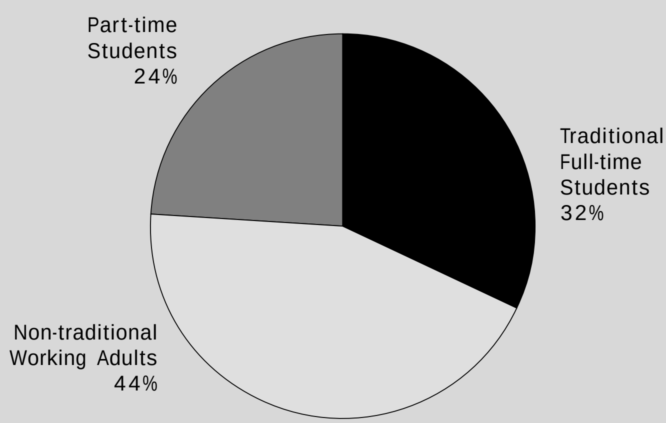


Lehman Brothers as taken from Jeanne C. Meister, *Corporate Universities: Lessons in Building a World-Class Work Force* (New York, NY: McGraw-Hill, revised and updated edition, 1998).

Figure 6-2

Post-secondary Education by Type of Student

Total=14.6 Million Adults



Lehman Brothers as taken from Jeanne C. Meister, *Corporate Universities: Lessons in Building a World-Class Work Force* (New York, NY: McGraw-Hill, revised and updated edition, 1998).

Table 7-1

Academic Year	Ph.D.s Awarded	% Women	MS Awarded	% Women	BA/BS Awarded	% Women
Number of Degrees Awarded in Computer and Information Sciences by Level and Gender						
1984-1985	240	10.0	6,942	28.9	38,589	36.8
1986-1987	374	13.9	8,481	29.4	39,590	34.7
1989-1989	551	15.4	9,414	28.0	30,454	30.8
1989-1990	627	14.8	9,677	28.1	27,257	29.9
1990-1991	676	13.6	9,324	29.6	25,083	29.3
1991-1992	776	13.8	9,534	27.8	24,578	28.7
1992-1993	808	14.7	10,171	27.1	24,241	28.1
1993-1994	810	15.4	10,416	25.8	24,200	28.4

Source: National Center for Education Statistics, *Digest of Education Statistics.*

Table 7-2

Academic Year	Ph.D. Awarded	% Women	MS Awarded	% Women	BA/BS Awarded	% Women
Degrees Awarded in Computer Science By Level and Gender						
1984-1985	326	11.0	--	--	--	--
1985-1986	412	12.1	--	--	--	--
1986-1987	559	9.7	--	--	--	--
1987-1988	744	9.0	5,159	--	12,687	--
1988-1989	807	13.3	5,457	--	10,606	--
1989-1990	907	12.6	5,116	--	9,681	--
1990-1991	1,074	12.1	4,993	--	9,353	--
1991-1992	1,113	11.3	5,121	--	9,813	--
1992-1993	997	13.3	4,523	--	8,218	--
1993-1994	1,005	15.6	5,179	19.1	8,216	17.9
1994-1995	1,006	16.2	4,425	19.7	7,561	18.1
1995-1996	915	11.7	4,260	20.0	8,411	15.9
1996-1997	894	14.4	4,430	22.3	8,063	15.7

Source: Computing Research Association, Taulbee Survey. 1984-86 Ph.D. numbers for CS&CE departments, all other years CS departments only.

Table 7-3

Ph.D. Degrees Awarded in Computer Science and Engineering By Minority Ethnicity

Academic Year	Ph.D. Awarded	African-American		Hispanic		Native American		Asian or Pacific Islander		Other	
		#	%	#	%	#	%	#	%	#	%
1984-1985	326	3	1.0	7	2.1	-	-	-	-	92	28.2
1985-1986	412	6	1.5	6	1.5	-	-	-	-	151	36.7
1986-1987	559	3	0.5	9	1.6	-	-	-	-	197	35.2
1987-1988	744	6	0.8	8	1.0	-	-	-	-	281	37.8
1988-1989	807	0	0.0	12	1.5	-	-	-	-	299	37.0
1989-1990	907	4	0.4	11	1.2	-	-	281	31.0	148	16.3
1990-1991	1,074	8	0.7	26	2.4	-	-	349	32.5	151	14.0
1991-1992	1,113	11	1.0	17	1.5	-	-	412	37.0	131	11.8
1992-1993	997	7	0.7	13	1.3	-	-	319	32.0	118	11.8
1993-1994	1,005	14	1.4	9	0.9	0	0	154	15.3	76	7.6
1994-1995	1,006	9	0.9	28	2.8	1	0	149	14.8	92	9.1
1995-1996	915	11	1.2	27	3.0	5	0	143	15.6	59	6.4
1996-1997	894	6	0.6	3	0.3	0	0	107	12.0	60	6.7

Source: Computing Research Association, Taulbee Survey.

Box 10-1: Recommendations

Federal and State Governments

1.1. Data-collection practices must be improved.

1.2. A new system for tracking the demand for and supply of IT workers should be created.

1.3. Data collected must be comprehensive to be useful for policy deliberations.

1.4. The Standard Occupational Classification (SOC) categories for information technology occupations need to be reviewed and refreshed on a regular basis.

1.5. Federal and state governments, with industry involvement, should improve IT-related mechanisms at the K-12 educational levels and keep them current. Counseling, teacher training, curricula, and computing facilities all need improvement relative to information technology.

1.6. The federal government, and especially state governments, should help to strengthen traditional higher educational programs in IT-related areas.

1.7. Government can help faculty and educational staff adapt to the new demand for IT-trained students.

1.8. Government should help to attract more students into graduate programs in IT-related disciplines..

1.9. Government should help faculty and staff cope with the greatly increased demand in the IT area.

1.10. The federal government, and NSF in particular, must be vigilant and prevent a seed-corn problem in IT-related disciplines.

1.11. Federal and state governments must enhance the research climate in the universities.

1.12. Federal and state governments should actively encourage universities and industry to form a variety of partnerships to train the IT workforce.

1.13. The government should encourage the development of programs in academia and industry that attract underrepresented groups to IT careers.

1.14. Special efforts should be made to utilize the skills of older workers.

Higher Education

2.1. Colleges and universities should keep their focus on providing strong basic education.

2.2. Universities must recognize that there is a fundamental IT-related shift occurring in the economy and in most professions, and that they must reallocate resources for better and more extensive training in this area.

2.3. Higher education should provide faculty support to revise their curricula to provide more and better paths in the training of IT workers, as well as to provide better IT education for all students.

2.4. Faculty in IT-related disciplines need to rethink their introductory under graduate courses.

2.5 IT-related departments should increase rather than restrict access to their courses and programs.

2.6. IT-related departments should develop graduate-level programs.

2.7. University practices should be adjusted in order to be more supportive of the education of IT workers.

2.8. New ways are needed to improve the articulation between different levels of educational institutions.

Industry

3.1. Industry should make data available regarding the demand for IT workers.

3.2. Companies should invest more in entry-level training and the retraining of existing personnel.

3.3. Companies outside of the IT sector need to recognize that information technology may become a core competency for them.

3.4. Industry should work closely with the higher education system to improve education for IT workers.

3.5 Industry should not take actions that in the long run harm the supply system.

3.6 Companies should hire for diversity and tap aggressively into groups that are underrepresented in the IT profession.

Professional Societies

4.1 The professional societies should provide greater assistance in the retraining and continuing education of IT professionals.

4.2. The professional societies should take a more proactive role in the certification of IT professionals.

4.3 Professional societies should continue to play a strong role in curriculum development.

4.4. The professional societies should take considerably greater interest in non-degree programs that train IT professionals.

4.5. The various IT professional societies should communicate, cooperate, and collaborate more with one another on issues of worker supply and demand.

Individuals

5.1. Workers should recognize that they must take responsibility for remaining individually competitive.

5.2. Individuals must commit themselves to life-long learning in order to remain technically current and competitive.

5.3. Individuals should do their part to see that people with appropriate skills enter the IT workforce.

5.4. Individuals should help to build up the IT profession through its professional organizations.

Source: Computing Research Association, Intersociety Study Group on Information Technology Workers, April 1999.