

Education and Training for the Information Technology Workforce



Report to Congress From
the Secretary of Commerce

U.S. Department of Commerce
June 2003



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FOREWORD

Rapid advances in information technology have contributed greatly to our country's economic growth, low inflation, high-wage job creation, low unemployment, solid increases in productivity, and improvements in our quality of life. These technologies are spurring new product and service development; fostering new business formation; revitalizing existing products, services, and industries; and enhancing our ability to manage information, innovate, and improve productivity.

Widespread deployment of digital technologies throughout the Nation and our ongoing transformation to a knowledge-based economy have created strong demand for workers who can create, apply, and use information technologies (IT). The demand for these workers goes beyond the IT industry, cutting across manufacturing and services, transportation, health care, education, and government. The IT professions are among the fastest growing and highest paying jobs in our economy, and despite the downturn in IT-related industries, there is still demand for highly skilled technical workers.

Jobs in the IT field are varied, complex, and specialized, as are the knowledge, skills, and experience required to perform them. There is no single path to prepare a worker for a professional IT job. There is no "one size fits all" IT education and training solution, nor is there a simple answer to the question "what works?" Instead, there is a vast array of education and training opportunities, with different types of programs and curricula serving different purposes, such as programs that:

- provide deep fundamental knowledge of IT;
- train in a particular IT discipline, such as programming, database management, or networking;
- prepare workers for a specialized field, such as IT security, bioinformatics, or data mining;
- teach highly specific technical skills; and
- prepare IT workers for advancement to management.

While the education and training landscape is rich with consumer choice, it is also complex. In this report, we lay out the landscape, with the hope that policymakers in government, education, and business will find this information useful as they develop education and training policies and programs designed to ensure a world-class IT workforce for the United States. We also hope that the information will help make choices clearer for IT workers seeking skills and managing their careers, and for employers seeking training for their workforce.

Donald L. Evans
Secretary of Commerce

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Acknowledgments

The Department of Commerce expresses appreciation to the following individuals and organizations for their contributions in planning and convening roundtables for this review of IT education and training:

John Miano, Programmers Guild
Ira Hobbs and Meg Offut-Gold, Federal CIO Council
Marguerite Wilbur and Lisa Bruner, Joint Venture: Silicon Valley Network
The David and Lucile Packard Foundation for use of its conference facility
Peggy Luce, Chicagoland Chamber of Commerce
Susan Baker and Zuzana Steen, Northern Virginia Technology Council
Marcus Courtney, Washington Alliance of Technology Workers
Bellevue Community College for use of its conference facility
Joyce Plotkin and Bruce Holbein, Massachusetts Software and Internet Council
Daniel Halle, IBM Corporation
IBM Corporation for use of its conference facility
Dyan Brasington and Mark Streger, Technology Council of Maryland
Bill Carlson, MetroTech

The Commerce Department also expresses appreciation to the following individuals and organizations that provided assistance during the course of the research:

Lawrence Burton, Division of Science Resources Studies, National Science Foundation
Barbara K. DePaul, QRC Division of Macro International Inc., for extensive work in providing the 1999 SESTAT (Scientists and Engineers Statistical Data System) data on the education and employment characteristics of IT workers
Katie Kirkland and Mary Bowler, Division of Labor Force Statistics, Bureau of Labor Statistics, U.S. Department of Labor, for historical data on IT occupations from the Current Population Survey
Carolyn Veneri, Office of Occupational Statistics and Employment Projections, Bureau of Labor Statistics, U.S. Department of Labor, for review of OTP's analysis of data on IT occupations from the National Employment Matrix

In addition, the Commerce Department would like to note and express appreciation to other individuals who contributed significantly to this review and report:

Roundtable Leadership and Management

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EXECUTIVE SUMMARY OF FINDINGS

- **Jobs in the IT field are varied, complex, and specialized, as are the knowledge, skills, and experience required to perform them.**
- **Employers seek workers who possess a specific combination of technical skills and experience, often coupled with a college degree, soft skills, and business or industry knowledge. Typically, employers prefer job candidates with the exact skill fit who require no additional training.**
- **There is no single path to prepare a worker for a professional IT job.**
- **The IT education and training infrastructure has grown significantly in size and scope over the past decade. Today, there is a vast array of IT education and training opportunities, with different types of programs and curricula serving different purposes.**
- **The training landscape is complex and challenging to navigate.**

Growth in Professional-level IT Occupations

1. Rapid advances in digital technologies and their widespread deployment throughout the economy have fueled explosive growth in the demand for workers skilled in the development and use of information technology (IT). A high rate of growth in IT professional occupations is expected to continue. The 10-year occupational employment projections prepared by the U.S. Department of Labor's Bureau of Labor Statistics (BLS) indicate that, between 2000 and 2010, there will be 2.5 million new jobs for IT professionals resulting from growth in the occupations (2.2 million) and the need to replace those leaving the profession (331,000).¹

What Do Employers Want in an IT Worker?

2. The mix of required knowledge and skills can vary significantly from one IT job to another, in terms of formal education, specific technical skills needed, industry knowledge and experience, and other qualifications, such as project management, communication, and

¹ The most recent occupational employment projections produced by the U.S. Department of Labor's Bureau of Labor Statistics, covering the 2000 to 2010 period, were made prior to the downturn in IT-related industries and to the events of September 11, 2001. Thus the potential impact of these factors is not reflected in the current projections. The Bureau of Labor Statistics produces occupational projections on a biennial basis and is scheduled to release its next ten-year projections, covering the period 2002 to 2012, in November 2003.

organizational skills. Thus, IT workers qualified for one job often do not qualify for another.

3. Employers seek workers who possess a specific combination of technical skills, experience, and industry knowledge—often expressed by employers as the “right person with the right skills at the right time.” With almost limitless combinations of technical skills and types of experience, the IT labor market is comprised largely of a wide array of specialized jobs.
4. Employers prefer job candidates with the exact skill fit who require no additional training. Given fierce competitive pressures, employers seek to minimize their risk by hiring candidates with proven technical capabilities, demonstrated through work experience.

Formal Education

5. Employers generally seek candidates with postsecondary education for professional-level IT jobs. A four-year degree, especially a technical degree, helps an IT professional get a foot in the door and get promoted. BLS projects that, between 2000 and 2010, almost three-quarters of the job openings for professional-level IT workers will be in occupations that typically require at least a bachelor’s degree.
6. Two-thirds of IT workers have at least a four-year degree, and the percentage of college-educated workers is growing. There is great diversity in the types of degrees IT workers hold; however, the vast majority have degrees in science, math, or engineering disciplines.
7. Technical degrees—such as computer science or computer engineering, four-year and above—are preferred for IT workers whose main functions are research or developing new software, IT products, or enterprise-level applications, because these workers need the deeper and more theoretical knowledge required to create new hardware and software. Also, the deeper “foundational” knowledge of those with technical degrees is likely to prepare them for technological change and learning new technical skills when needed, rather than just knowing the “skill of the day.”
8. Surveys and analyses suggest that employers show some willingness to hire individuals without a bachelor’s degree—for example, those with a two-year degree—for tech support/call center jobs, Web development and administration, some database-related jobs, and some jobs in network design and administration, although there is often a requirement for previous work experience and/or a technical skill certification. However, further formal postsecondary education or even a four-year degree would typically be needed for advancement in the field, especially promotion to IT management.

Technical Skills

9. A rapidly growing array of general and specialized IT products and services for industries and consumer markets has created the need for IT workers who possess certain specific combinations of technical knowledge and skills. Employers place a high priority on these technical skills, which are often evaluated by assessing a candidate's work experience, certifications, certificates, and other credentials.
10. With IT skill sets closely linked to specific software and hardware technologies, ever-shortening product life cycles create frequent change in the IT skill mix in demand. Specific technical skills often lose value over time, sometimes in as little as 2 to 3 years. This means that IT workers must acquire new skills frequently in order to maintain their labor market viability and upward mobility.
11. Building on basic IT competencies, many workers specialize in a particular IT discipline, such as development tools and programming languages, Web development tools, database systems, operating systems, or networking protocols and applications. Within each broad discipline, there are numerous specific technical skills employers may seek in an IT worker.
12. Employers may also seek IT workers who possess certifications. Some certifications are more commonly recruited for in the IT labor market, including certifications from IT vendors Microsoft, Cisco, Novell, and Oracle. While such certifications may be viewed positively for lower level IT positions, such preparation alone is not considered adequate for mid- to high-level positions.
13. Many IT workers who provided comments for this review report that employer demand for IT workers whose technical skills are an exact match to a highly specific technical skill set is one of the biggest barriers IT workers face in getting a job.

Experience

14. Experience is a high, if not the highest, priority in employer hiring considerations. The experience requirement can extend to new workforce entrants, such as recent college graduates. IT workers also see great value in experience. This view is reflected in the high priority IT workers place on learning IT in a real workplace, with real projects and problems, through hands-on, on-the-job training.
15. Some employers are willing to take a chance on a candidate with recent IT education and training but no experience for lower skill jobs. In hiring for a trainee or entry-level position, employers may be willing to accept academic degrees, demonstrated soft skills, or IT certifications that closely match their needs in lieu of job experience.

16. Employer requirements for actual job experience in the application of technical skills present newly trained workers with a significant barrier to entry into the IT field. This barrier extends to current IT workers who, for purposes of seeking a new job, acquire new skills through training but have no experience in their application. IT workers who provided comments for this review cited lack of experience in a specific skill or skills as one of the largest barriers they face in getting an IT job.

Soft Skills

17. Today, IT is central to nearly all core business functions and to the overall operation of most companies, and IT professionals are integral to the core business team. Accordingly, “soft skills” (e.g., interpersonal skills, oral and written communications, teamwork, problem solving, and critical thinking) and business skills (e.g., needs analysis, project management, client/customer relations, understanding company financial information, and cost-benefit analysis), which have for many years been important to the advancement of non-technical professional workers, have become increasingly important for IT workers as well.
18. Given the importance employers place on business skills, seasoned IT professionals who have progressed in their careers doing technical jobs—such as programming and network administration—must acquire business skills if they want to advance into management positions. A number of IT workers specifically cited learning soft skills and business skills as being important to career advancement, a view shared by many employers.

The IT Education and Training Landscape

19. To meet the high demand for skilled IT workers, the IT education and training infrastructure has grown significantly in size and scope over the past decade. A wide range of education and training opportunities is available nationwide for workers who wish to:
 - train to enter the IT field as new workforce entrants or career changers;
 - update, expand, or deepen their skill sets;
 - move into a new IT discipline; or
 - prepare for career advancement.
20. Today’s IT education and training landscape is rich and diverse, characterized by familiar education models—such as four-year university-based computer science programs—and by a variety of newer training models, such as IT vendor-related training and certification programs, high school IT academies, boot camps, online learning, and more.

21. On the one hand, these models offer current and potential IT workers a variety of ways to acquire a wide and ever-changing array of IT knowledge and skills. On the other hand, this diverse collection of education and training options presents a challenge for those trying to ascertain what type of program, format, provider, or credential will best meet the needs of workers training to enter the field, current IT workers seeking to add to their skills, or employers seeking training for their workforce.
22. Different IT education and training programs provide different knowledge and skills. Some—such as formal college programs in computer science—provide deep foundational knowledge in IT that can be especially important for those working in complex IT systems and applications development. Other programs provide narrow training, such as training on a specific vendor’s technology, which may be useful to an IT worker who wants to expand his or her repertoire of IT skills.
23. In IT education and training, there is no “one size fits all,” and few roadmaps to guide workers in career development. Thus, given the wide variety and purposes of training options available, students or potential career changers may not have adequate knowledge to choose an appropriate IT education and training program.
24. Moreover, there is wide variability in cost, even among programs that purport to have the same purpose. The length of some programs purporting to have the same purpose also varies widely. The wide variability in the cost and length of IT training programs means workers and employers need good information to carefully review training programs for their objectives, content, skill level, depth of instruction, instructor credentials, quality, and value for the dollar in order to choose among them.
25. Many IT education and training programs could prepare workers who have good academic skills for entry-level IT positions. However, higher level, more advanced IT jobs would not typically be accessible to workers who do not possess at least a bachelor’s degree, often a technical degree.
26. Despite the availability of good training, employers place a higher priority on actual experience in the application of technical skills. Therefore, no matter how well-trained, a worker without practical, hands-on work experience may not be considered for most jobs involving the newly acquired technical skills. This underscores the need for training program elements such as work-study and internships, and for providing training in a hands-on format that teaches technical skills as they would be used on the job.
27. Some participants in the Commerce Department roundtables who had worked to develop internship-type programs said they had a hard time convincing employers to participate. Some employers believe that taking on interns takes up too much time, and that they will not receive an adequate return on the training they provide; that is, the interns will not seek regular employment with the company after the training and internship are com-

pleted. On the other hand, some employers who participated in cooperative work-study programs or developed long-term work relationships with students (i.e., repeated summer jobs) found that these efforts developed student loyalty, helped tie students' academic work to the company's needs, and often paid off with the company retaining them in regular employment after they graduated from college.

IT Bachelor's Degree Programs

28. Bachelor's degree programs in IT generally provide a broad, high-level conceptual understanding of IT in systems architecture, computer programming, and computer network systems. This broad understanding can be both an asset and a shortcoming from both employer and IT worker perspectives, depending on their needs. For some positions, employers prefer knowledge and hands-on experience in a particular software package, operating system, or networking technology over theoretical knowledge for their value in addressing practical business and organizational needs. For other positions, employers may prefer the theoretical knowledge provided by an IT bachelor's degree program for the analytical framework, deep technical knowledge, critical thinking skills, and systems approach it enables—tools and skills that are useful not only in IT development but also in addressing practical problems.
29. IT workers who participated in this review commented that traditional four-year technical degree programs produce well-rounded IT workers, and that the rigor and duration of these programs ensure lasting knowledge. On the other hand, traditional four-year technical degree programs offer less in terms of hands-on practical experience and do not typically provide business-related skills or link the learning to solving specific business problems. In addition, some programs at universities may be out-of-date because they are unable to match the speed of change in IT.

IT Minor

30. At many universities across the Nation, undergraduates from a wide range of academic majors seeking IT knowledge and skills can obtain an IT-related minor—generally referred to as a minor in computer science, information technology, or management information systems. IT minors can offer important complementary knowledge to those majoring in a natural science, engineering, business, or other discipline.

Combined IT Bachelor's/Master's Degree (BS/MS) Programs

31. Some universities offer a combined BS/MS program in computer science, computer engineering, or both, to encourage their students to seek higher level degrees by enabling them to earn them faster. These programs can reduce the time it takes to earn both degrees separately by as much as two semesters.

IT-Related Master of Science (MS) Programs

32. MS programs address a range of IT professionals' needs. Some programs offer preparation for advancement to higher level jobs, such as those in IT organization management and IT business management, or for more technically complex jobs, such as advanced IT development work. Other IT-related MS programs are geared toward expanding IT professionals' portfolios of skills into new IT disciplines, such as telecommunications, or toward preparing them for work in a highly specialized IT application area, such as bioinformatics.

Techno-MBAs

33. A new class of MBA programs has arisen in recent years, focused on the integration of management and technical knowledge. In contrast to an MBA with a technical concentration, these programs—often referred to as “Techno-MBAs”—focus on understanding the business value of technology, technology's contribution to the bottom line, and technology as a means rather than an end. Generally, these degrees are designed for people with technical backgrounds who want to advance into management positions.

Two-Year Degrees at Community Colleges

34. Community colleges offer a range of IT education and training opportunities. These programs are popular, in part, because they are convenient, economical, and offer training opportunities for both full-time students and working adults who are seeking to upgrade their skills or prepare for a career change by attending training on a part-time basis. Community colleges primarily provide preparation for low- and intermediate-level IT jobs, and their offerings focus more on practical applications of IT than on theoretical studies. Some programs are responding to employer demands for soft skills by adding group projects and writing requirements to the IT curriculum.
35. *Transfer track* programs, focused on computer science or computer information systems management, prepare students for transfer to an IT program at a four-year college or university; these students are working toward a bachelor's degree in computer science, computer engineering, or management information systems. *Terminal track* programs are designed for students who intend to move directly into the workforce after earning their two-year degree. These programs—which often focus on programming, network and database administration, and technical support—have a higher concentration of courses in the technical discipline. The curriculum typically places less emphasis on concepts and theory than do transfer track programs, and greater emphasis on practical knowledge.
36. Many community colleges provide training aimed at preparing students to assume entry-level IT jobs. These programs are viewed by many IT workers as having good value,

offering practical knowledge and skills and easy access. However, employers are concerned that two-year colleges do not provide the needed in-depth training, theoretical foundation, and critical thinking skills. Likewise, some IT workers said that some programs at community colleges are too simple and do not deal adequately with soft skills, and that teachers may not be up-to-date on the newest technologies.

37. Strong relationships between community colleges and employers (for example, through the establishment of program advisory boards) can provide a number of benefits to the school, its students, and employers. These relationships offer mechanisms to gain information on the changing needs of employers so that curricula can be developed and modified to more closely match employers' needs. Community colleges may be able to draw on employers' technical workers to teach classes. In addition, the college can enhance its reputation with employers, increasing the chance that the school will be able to place its students into IT jobs after they complete the program. Close connections can also bring investment and other resources into IT programs. Compared with universities, community colleges often can be more responsive to employer demands and technological change because of their focus on practical applications and on training people for employment, as well as, in some cases, their relatively close relationships with employers in the area.

IT Certificate Programs

38. IT certificate programs offer a wide range of opportunities for potential and current IT workers to acquire, upgrade, and expand their IT skills. These programs—designed for introductory, intermediate, and advanced skill levels—are offered at community colleges and universities at both the undergraduate and graduate levels.
39. These adult continuing education programs typically specialize in providing in-depth teaching in some particular IT specialty, such as networking, e-commerce, or IT security; in a specific technical skill, such as Java or C++ programming; or in a particular vendor's technology, such as Oracle databases. While IT certificate programs focus mainly on the provision of technical skills, some programs address knowledge and development in business skills and soft skills. These concentrated programs of study can add depth to an IT worker's knowledge and skill in a particular specialized IT discipline or help the worker expand his or her skills into new discipline areas. While certificate programs can vary significantly in length and cost, they are often less costly, faster, and more focused with more links to jobs and careers than advanced degree programs.
40. While IT certificate programs offer many choices for skill development, both IT workers and employers face a confusing maze of offerings and a credential—the certificate—that has no standard meaning of accomplishment across the academic enterprise. Variability in

program content, length, and cost—even when certificates have the same name—means that IT workers and employers face challenges in understanding and considering their IT certificate training options. Moreover, employers who are considering the qualifications of job candidates face the prospect of trying to understand what a particular certificate represents in terms of knowledge and skill when there are no standards to guide them.

Private, For-Profit IT Education and Training Institutions

41. Private, for-profit institutions offer a wide scope and varying levels of IT education and training to prospective and current IT workers. IT workers commented that programs at private IT schools often use the latest technologies and have industry instructors with current experience, but the programs are very expensive.

IT Certification

42. In the past decade, a new form of credentialing—certification—emerged in the IT profession and has grown increasingly popular. Approximately 300 IT certifications are sponsored by IT vendors and professional and industry associations. These certifications—awarded for passing exams—provide independent verification that the bearers have achieved a certain level of expertise in a particular IT discipline or a specific set of skills and knowledge that relates to a specific IT product or technology. The certifications do not represent a multidimensional assessment of knowledge, soft and business skills, or experience. These credentials may help entry-level or inexperienced IT job seekers convince an employer to give them a try. They also can expand a current IT worker’s portfolio of credentials and may help an experienced IT worker move into a new IT discipline.
43. Preparing for certification can represent a large investment of time and money. Certification preparation is available through commercial training providers (including those authorized by IT vendors that sponsor the certifications), at many universities and community colleges, online, and even in high schools.
44. IT workers said that vendor-authorized training programs are usually current and in step with industry directions. Instructors in these programs are typically up-to-date and often have worked in the industrial setting, but sometimes lack pedagogical skills. Some IT workers said that vendor certification preparation programs are often too focused on test preparation and spend inadequate time on teaching how to use the technology to address real-world scenarios, such as integrating the vendor’s technologies with other IT products. IT workers cited the high cost of certification preparation programs offered by private IT training providers as a barrier to acquiring such skills and certifications.
45. While these programs typically do not provide a worker with the foundation knowledge and skills needed to build a long-term career in IT, workers can train quickly in specific

skills related to specific IT products. Many IT workers who commented for this review reported that certification preparation programs gave them a way to get up to speed quickly in a new technology. These workers believed strongly that completing a four-year college degree program—especially a technical program—and a vendor certification training program would confer skills that were immediately marketable for obtaining an IT job.

46. Acquiring skills through certification can be valuable for an IT worker who plans to stay with his or her current employer. However, simply acquiring certain technical skills may not be enough to overcome a prospective new employer's preference for a candidate with experience using those skills. Students who participate in school-based IT academies, especially those that offer no work-study or internship experiences, may have difficulty finding jobs based on the skills they have acquired because they lack experience using them on the job.
47. If turnkey IT vendor-oriented programs constitute the major portion of a school's IT education and training offerings, the school may not be prepared to respond quickly with new offerings when skill demands in the labor market change.

Government-Sponsored and -Supported IT Education and Training Initiatives

48. The Federal Government has established programs for purposes of preparing workers for professional-level IT jobs. One program—the H-1B Skills Training Grant Program—is funded by fees employers pay to obtain visas for foreign temporary professional workers. This program has suffered from conflicting statements about its objectives, as well as ambiguity in the characterization of the types of occupations on which training should focus and the skill level to be achieved through the training. From the data available, it appears that few of the H-1B training grants from the first five competitions for grants would produce workers capable of assuming the professional-level IT jobs for which U.S. employers recruit foreign temporary professional workers. In addition, these grants have been insufficiently focused on the occupational areas of greatest demand for foreign temporary professional workers, as indicated by the occupational portfolio of those granted H-1B visas, in particular, training to prepare workers for IT occupations. However, the Department of Labor has made improvements to the program embodied in the Solicitation for Grant Applications (SGA) for the sixth competition. The new SGA identifies the target training audience as those who can be trained and placed directly in highly skilled professional-level IT occupations, while still allowing for training to prepare workers for positions on a career ladder leading to such occupations.
49. The Computer Science, Engineering, and Mathematics Scholarships (CSEMS) program is another federal effort funded by fees employers pay to obtain visas for foreign temporary professional workers. CSEMS provides grants to postsecondary academic institutions to

fund scholarships for students in need, enabling them to enter the high-technology workforce after completing an academic degree in computer science, computer technology, engineering, engineering technology, or mathematics. The CSEMS program is largely focused on providing education at the level of foreign temporary professional workers who enter the U.S. IT workforce.

50. Most IT workers who provided comments for this review said they were not familiar with federally supported IT training programs or that they were not eligible to participate in them.
51. Responding to the high demand for IT workers, state and local governments have undertaken a variety of initiatives—often in partnership with the Federal Government, industry, academia, and nonprofit organizations—to provide IT education and training to current and prospective IT workers, including students; those seeking to change jobs or careers; and the unemployed, underemployed, and disadvantaged. These initiatives have taken a variety of forms in the types of education and training offered, the types of institutions through which the education and training are delivered, and the ways in which these education and training efforts are supported financially. With the downturn in IT-related industries resulting in greater availability of IT workers, some of the initiatives have been disbanded. Nevertheless, they provide models that can be put to work in the future, if or when the demand for IT workers strengthens significantly.

Other IT Education and Training Opportunities

52. A diverse array of short-term intensive education and training programs has arisen to meet the demand for entry-level skills, continuing technical skills development, and industry-specific IT skills and knowledge.
53. Boot camp programs, typically lasting one to two weeks, are characterized by long classroom days (starting early and finishing late, often running 10 or more hours a day) followed by homework assignments. There is great variability in the quality of boot camps, depending on factors such as: access to class materials in advance of the camp; quality and accessibility of the trainer(s) before camp, during class, and after class; information and knowledge provided beyond that required simply to pass a test; classroom facilities with ready access to IT equipment to enable hands-on training; test preparation; class size; and the extent to which course topics are explained in the context of real-world situations. IT workers who provided comments for this review said that boot camp and other short-term training programs were often intensive, current, in step with industry directions, and time-effective. However, IT workers said these programs were very expensive.
54. Online learning is a rapidly growing method used to access knowledge, skills, and credentials by a wide range of workers, especially IT workers. Online offerings range from short tutorials and courses to complete academic degree programs.
55. Many IT workers participate in self-study, using computer-related books and manuals.

56. Another way IT workers expand their portfolio of skills and experience is by moving from one job to another. This enables them to apply their skills to new projects and in new business settings and industries, and to gain new work experiences that prospective employers may value. Moving to a new job may also offer the opportunity to acquire new technical skills based on the technologies the new employer uses. Analysis of data from the National Science Foundation shows that, of those holding IT jobs in 1997, more than one-third had changed employers or jobs with the same employer by 1999.

Challenges Faced by IT Education and Training Providers

57. One challenge IT training providers must meet is keeping pace with technical change in a field characterized by short life cycles. For example, some IT workers who participated in this review said that universities and colleges—particularly public institutions—often have technical curricula, equipment, and software that are out of date.
58. IT education and training providers who participated in this review identified a number of methods they use to keep their programs up to date. These include ongoing faculty training and revision of training materials, employing practicing professionals as faculty, and requiring teachers to have strong ties to current practices. Some training programs use advisory boards or committees; survey, poll, or otherwise communicate regularly with employers; or contract out to external vendors. One academic provider said that, since it offers noncredit courses, it does not have to wait for time-consuming faculty committee approval of its courses. Another school offers a base set of courses, with technical electives that can be quickly changed to meet changing needs.
59. Another problem for IT education and training providers is getting and retaining instructors skilled in the latest or “hot” technologies who can teach these skills to students. Schools have difficulty competing for these instructors against private companies that can pay higher wages.
60. The highly specialized and fragmented nature of IT labor demand makes it more difficult to link IT education and training programs to employer needs than would be the case if the demand for skills were more homogenous.

Characteristics of Education and Training IT Workers Find Effective

61. IT workers who provided comments for this review showed a strong preference for on-the-job training, especially under the tutelage of an experienced mentor, and self-study.
62. IT workers cited a number of characteristics they prefer in formal IT education and training, including:
 - not cramming too much knowledge into too little time;
 - programs that are hands-on;

- up-to-date trainers with real-world experience who have applied what they teach in an industrial setting;
- a focus on teaching in the context of a project or solving a business problem, rather than teaching in the context of the IT tool itself; and
- the ability to apply skills soon after they are learned. If they don't use the new skills, they forget them.

Role of Employers and Workers in Meeting the Demand for IT Skills

63. Employers can obtain the skilled IT workers they need either by hiring workers who already have the skills or by training workers in those skills. However, as time has become an increasingly important competitive factor for many employers of IT workers, the time available to retrain current employees or train new employees in the skills needed for new projects or job openings has diminished. In this environment, many companies have concluded that they cannot afford the time, risk, and uncertainty associated with “making” the employees they need through training or retraining.
64. Instead, many employers of IT workers are pursuing a “buy” strategy, seeking employees who already have the needed skills and experience and can “hit the ground running.” While buying skills on the open market can require paying a premium for them, companies are often able to access the most current skills and get a fully trained worker while reducing or even eliminating the cost of training. Buying skills can also increase staff flexibility and reduce risks associated with uncertainty about future skill needs.
65. Surveys by the Information Technology Association of America and the WSA (a large state-wide technology trade association based in Seattle) suggest that, when faced with difficulties in finding workers with needed skills, employers often do not consider training a high priority as a coping strategy.
66. Employers can contribute to IT workforce training by providing financial support to pay the costs of training, allowing workers to participate in training on company time, and providing training resources. However, employers’ ability or willingness to provide this support varies. For example, some organizations do not have time to allow workers to train on company time, while others actively encourage and support training opportunities.
67. As with other investments, companies invest in training because they expect returns in the form of improved performance or greater worker retention. The downturn in IT-related industries has eased the demand for IT workers. However, as in the past, tight labor markets—in which employers compete for skilled workers—increase the risk of training investments and reduce the likelihood of capturing an acceptable return.

68. Factors that may be considered in a company's willingness to invest in training an IT employee include company skill needs, the need to offer benefits to attract and retain employees, and employees' career goals and talent. Employers appear more willing to provide financial support for training that dovetails with the company's short- to mid-term needs; for example, training for needed technical skills or teaching business skills to promising IT workers. While this approach creates opportunities for training and job progression that benefit the company, it may not provide the career development sought by the employee. Several employers reported that they look more favorably on making investments in training for employees identified as having "high potential."
69. Many employers do believe that creating training opportunities for their IT workers is important for recruitment, retention, and high-quality work, and many offer assistance to IT workers who wish to expand their education or technical skills. Generally, companies train IT workers in three areas: technical skills; soft skills (such as conducting effective meetings and conflict resolution); and IT management-related skills (such as strategic management, business processes, project management, and leadership). For IT training, companies increasingly rely on desktop training provided through CD-ROM or online.
70. Some companies who employ large numbers of IT workers make large investments in national and community technical education and training initiatives, including investments that contribute to the development of the U.S. technical workforce. However, participation appears to be lower in programs aimed specifically at training people for immediate hire into IT occupations.
71. Because of employer cost and time constraints, IT workers are increasingly responsible for their own skill development—often on their own time, sometimes at their own expense—as well as for their own overall career development. However, some employers are willing to reimburse workers for training they take on their own time.
72. The rapid rate of technical change in information technology and the continuous introduction of new IT products create shifts in the IT skill mix in demand. As a result, IT workers' education and training needs are ongoing throughout their careers. In addition, IT workers often seek training to broaden their portfolio of technical skills in order to move into other IT disciplines or advance in their careers.
73. IT workers take the lion's share of responsibility for their own education and technical skills development, and many have a strong inclination for independent self-study and training. IT workers who provided comments for this review said that they and their peers typically devote a significant amount of personal time to keeping their skills up to date. Of those specifying time spent, most reported spending 4 or 5 hours a week updating their skills.
74. Because a significant portion of the personal investment IT workers make in education and training does not lead to a credential, the investment and resultant skills may not be recognized by a potential employer who emphasizes credentials and work experience in

evaluating job candidates. Better ways are needed to demonstrate to employers the value of knowledge and skills IT workers acquire on their own, but for which they do not receive a credential.

75. In striving to keep their skills up to date, IT workers face challenges: the cost of training programs (which can range from a few hundred dollars to more than \$10,000); finding time for training; finding appropriate training; managing career development; and balancing the need for training with their personal life and family responsibilities. IT workers who participated in this review cited finding time to participate in training and the cost of training as the biggest barriers they face in acquiring new skills. Other barriers cited were difficulty in accessing some types of training because of the infrequency of offerings and the time of day and location of such training.
76. Among IT workers who provided comments for this review, many had received support for training from their employers, such as partial financial support or time off for training. But a significant number said that their employers did not provide support. Surveys confirm these responses.
77. For IT workers who are professional temporary workers or contract workers, there is no employer per se—neither the temporary agency nor the contracting employer—to provide support for training in terms of guidance on needed skills, training resources (such as online courses), or financial support. These IT workers must acquire all of these skill development resources on their own, and they may have fewer financial resources to invest in training than other IT workers due to more frequent periods of unemployment.
78. For IT workers, career progression often does not take the traditional form. Rather than moving step by step up a career ladder, IT workers often manage a portfolio of skills (“the skill set”). Acquisition of these skills can represent a step up or an expansion of the scope of the skill set. Individual technical skills in the portfolio may increase or decrease in value, depending on the skill currency or size of demand in the market. There is no common path to building the skill portfolio. In addition, frequent changes in technology and difficulties in forecasting future skill needs mean that IT workers are often left with little guidance on what training to acquire for long-term success in the IT field.
79. Many IT workers cited the challenge of identifying appropriate, high-quality training to make the best decisions about where to spend their personal funds for skill development. Many workers also expressed frustration and questioned the value of participating in training, pointing to employers’ strong preference for hiring individuals who have work experience in a particular IT skill. These IT workers fear that they will not get a return on their investment in training in the form of a better job or higher pay.
80. Another barrier cited was conditions that must be met to access Federal Government support for training, even if a worker is unemployed. These include income tests that excluded workers who earned too much in the previous 12 months and exclusions for certain kinds of training programs because of their length and cost.

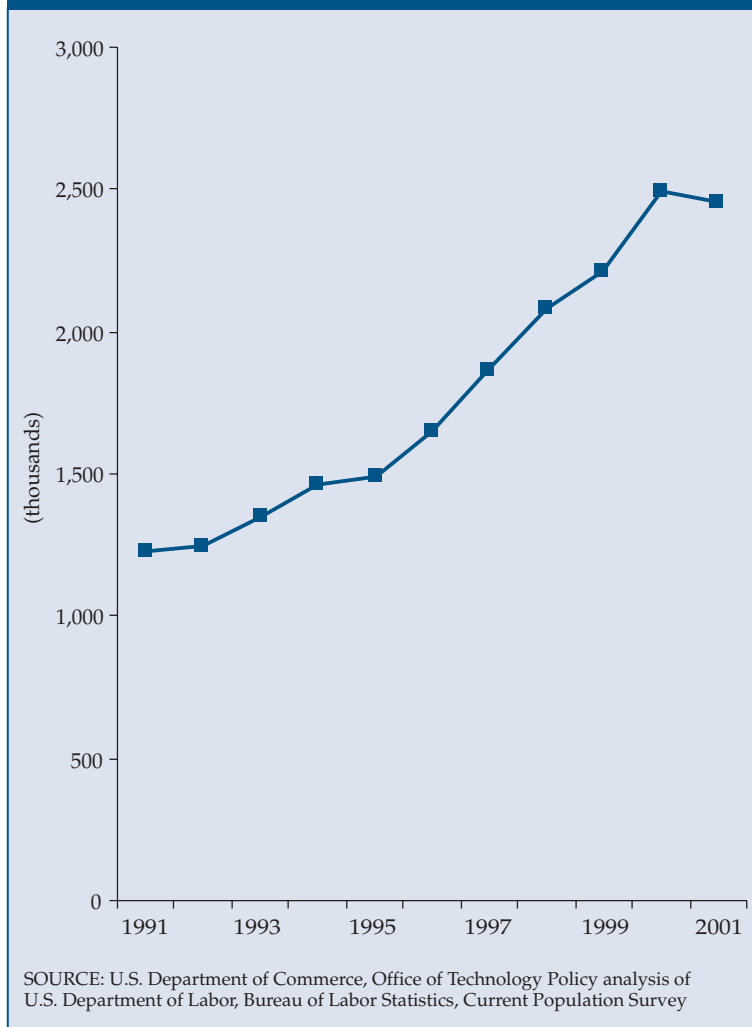
I. INTRODUCTION

Rapid advancements in digital technologies and their widespread deployment throughout the economy have fueled explosive growth in the demand for workers skilled in the development and use of information technology (IT). Between 1991 and 2001, the number of jobs in professional-level IT occupations doubled, expanding from 1.2 million to 2.5 million (figure 1). This translates into an annual growth rate of 7.2 percent for these IT occupations, compared with 1.4 percent for all occupations during the same period (figure 2).

A high rate of growth in these occupations is expected to continue. **The 10-year occupational employment projections prepared by the U.S. Department of Labor’s Bureau of Labor Statistics (BLS) indicate that, between 2000 and 2010, there will be 2.5 million new jobs for IT professionals resulting from growth in the occupations (2.2 million) and the need to replace those leaving the profession (331,000) (figure 3). IT jobs include the following:**

- Computer programmers
- Computer and information scientists (research)
- Computer systems analysts
- Computer software engineers (applications)
- Computer software engineers (systems software)
- Computer support specialists
- Database administrators
- Network and computer systems administrators
- Network systems and data communications analysts
- All other computer specialists
- Computer hardware engineers
- Computer and information systems managers

Figure 1. Growth of Professional-level IT Occupations
The Number of Professional-level IT Workers More Than Doubled Between 1991 and 2001



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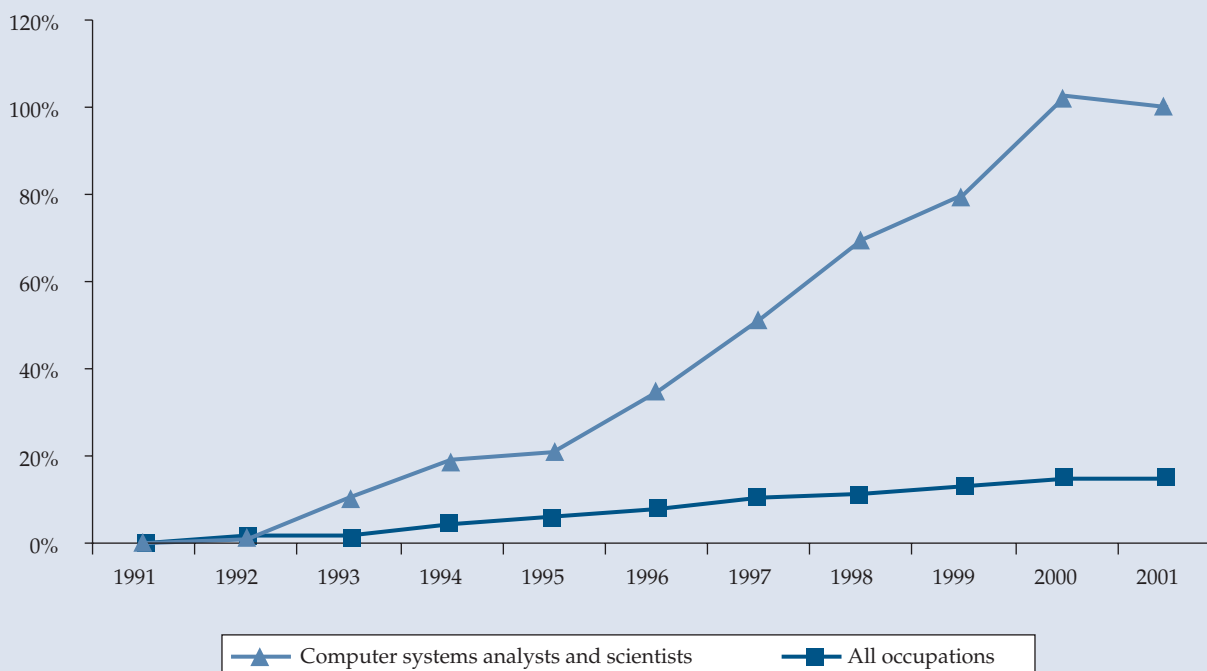
In the late 1990s, there was a significant market response to the high demand for skilled IT workers and to reports of employer difficulties in recruiting workers with needed IT skills. For example, after years of decline, enrollment at the bachelor's level in leading U.S. computer science and computer engineering programs nearly doubled between 1995 and 1997, growing by an additional 11 percent by 2001.² IT education and training infrastructure grew significantly. Community colleges responded to the need for increased IT training, and proprietary training and IT certification and certificate programs have grown in number and popularity. For example, in 1997, Cisco Systems established the Cisco Networking Academy, which grew to 4,757 U.S. academies by 2002.³ The number of IT workers certified as Microsoft Certified Systems Engineers grew from 35,000 in the fall of 1997 to 463,000 by July 2002.⁴ Some corporations have increased on-the-job training for their employees and joined industry-education-community partnerships to expand IT-related education and training at all skill levels. In addition, states and regional organizations have developed a variety of strategies for attracting and developing people with IT skills.

² Taulbee Survey 1996–2002, Computing Research Association, www.cra.org.

³ www.cisco.com/warp/public/779/edu/academy; e-mail from Julie Kaminkow, Cisco Systems, June 6, 2002.

⁴ Roger Moncarz, *Training for Techies: Career Preparation in Information Technology*, *Occupational Outlook Quarterly*, Fall 2002.

Figure 2. Growth Rate of Professional-level IT Occupations, All Occupations Since 1991



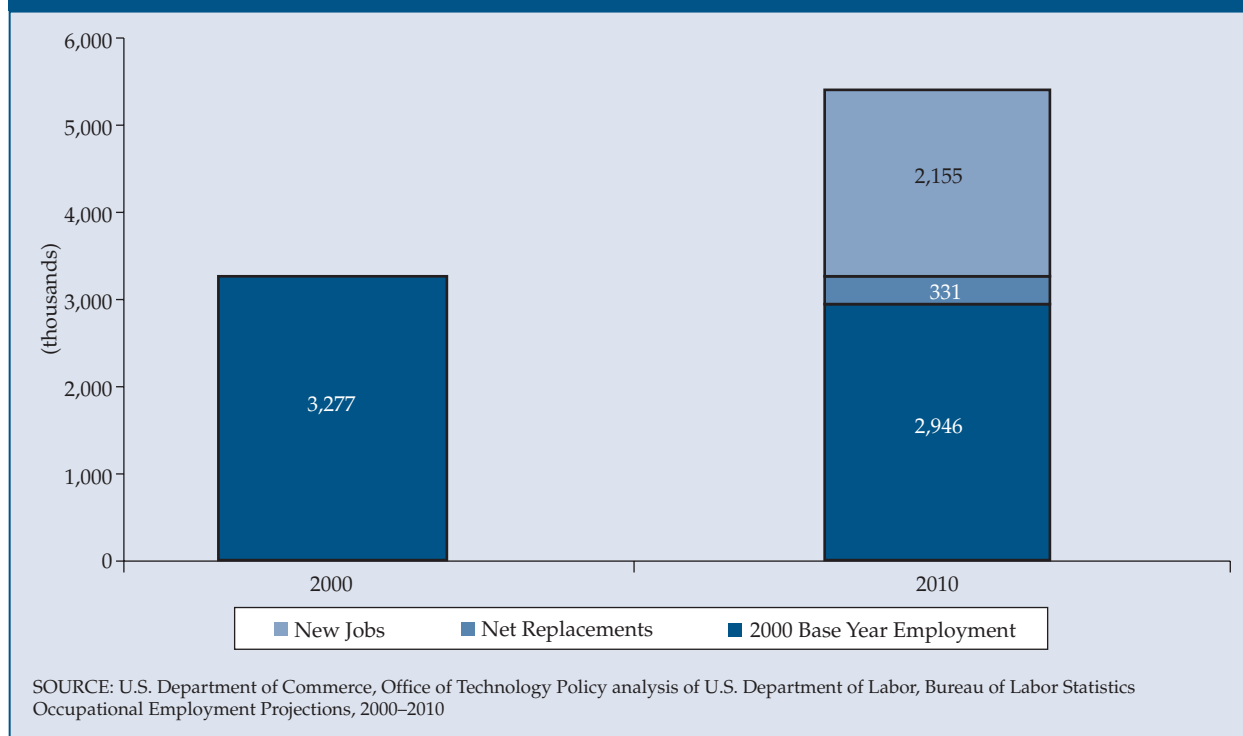
SOURCE: U.S. Department of Commerce, Office of Technology Policy analysis of U.S. Department of Labor, Bureau of Labor Statistics data, Current Population Survey 1990–2000, Household Data Annual Averages, Employed Persons

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Today's IT education and training landscape is rich and diverse, characterized by familiar education models—such as four-year university-based computer science programs—and by a variety of newer training models, such as IT vendor-related training and certification programs, high school IT academies, boot camps, online learning, and more. On the one hand, these models offer current and potential IT workers a variety of ways to acquire a wide and ever-changing array of IT knowledge and skills. On the other hand, this diverse collection of education and training opportunities can be challenging, as workers and employers try to ascertain what type of program, format, and provider will best teach the IT skills needed for entry or for lateral or upward mobility in the IT profession.

Given rising global labor competition for performing the world's IT work, U.S. IT workers need ready access to high quality education and training to help keep them globally competitive and on the leading edge of technology.

**Figure 3. BLS 2000–2010 Projections for Professional-level IT Occupations
Continued Rapid Growth Projected: 2.5 Million New IT
Workers Needed Between 2000 and 2010**



Study and Review of Training Programs

Section 115 of the American Competitiveness in the 21st Century Act of 2000 (Public Law No. 106-313, 114 Stat. 1262) requires the Secretary of Commerce to conduct a review of existing public and private high-tech workforce training programs in the United States, and submit a report to Congress setting forth the findings of the study. In response to this mandate, the U.S. Department of Commerce conducted a review to identify and analyze the education and training programs through which Americans prepare for IT jobs and maintain the skills needed in an ever-changing digital technology environment. Specifically, the review explored:

- demand for IT workers in terms of education and skill requirements, especially as articulated by employers;
- various models for providing IT education and skills training;
- which part of an IT worker’s knowledge and skill portfolio each of the models addresses;
- the role of employers in IT worker training; and
- other factors that bear on the success of efforts to educate and train IT workers.

This report contains the findings of this review.

Study Methodology

Numerous program models designed to educate and train highly skilled IT workers are carried out in thousands of education and training programs across the country. Cataloging and evaluating all these efforts is beyond the scope of this review, given the size of the landscape and its changing nature. Rather, this report seeks to add value to what is known about these programs today and provide IT workers, employers, and policymakers with information to support their decision making.

The Commerce Department used a variety of mechanisms to obtain information from a broad base of stakeholder groups: employers, IT workers, education and training providers, governments, and area and regional partnerships. Eight expert roundtables convened across the country and a formal request for comments made through the *Federal Register*, supported by an Internet-based questionnaire (a qualitative, nonscientific sampling of views), provided a rich and diverse array of knowledge and opinions. Overall, participants from all stakeholder groups were eager to offer their views for this review. Americans have a genuine interest in participating more directly in the policy process, and technology-based tools—such as e-mail and the Internet—are vehicles for them to do so.

Other sources of information included an extensive literature review, analysis of existing statistical data, review of material on company and IT training provider web sites, one-on-one discussions with a variety of experts, and site visits. Material used throughout this report was drawn from all these sources.

Formal Request for Comments

In the September 10, 2001, issue of the *Federal Register*, the Commerce Department issued a formal Request for Comments on Existing Public and Private High-Tech Workforce Training Programs in the United States (Appendix A). This request for comments included four sets of questions, each directed at a particular stakeholder group: employers, IT workers, education and training providers, and state/local government agencies and area/regional partnerships. Parties were invited to submit comments by mail or through a dedicated e-mail address. In addition, the Request for Comments was supported by an Internet-based questionnaire that could be completed and submitted online. Responses submitted via the Internet-based questionnaire were publicly posted daily to further stimulate respondent dialogue, to provide transparency to the review process, and to provide information for other researchers in the field. These responses are still available for review at www.ta.doc.gov/ittraining. In total, 297 sets of written comments were received in response to this formal request (Appendix B).

IT workers, especially, made use of the Internet-based questionnaire, submitting 200 sets of comments (plus an additional 10 sets of comments sent by mail). Reaching out to IT workers was important in conducting this review. Some groups of IT workers have complained of being excluded from providing input to government or government-supported studies and to government policies related to the IT workforce. **As evidenced by their answers to questions posed in the Request for Comments and at the Commerce Department's roundtables, the H-1B visa program is of particular concern to some U.S. IT workers, who believe that the steady stream of temporary foreign IT professionals working in the United States is costing American IT workers jobs and negatively affecting their wages.** At the same time, IT employers and producers continue to point to the H-1B program as essential for getting the best and brightest IT workers in a dynamic and globally competitive marketplace.

Beyond concerns about the H-1B program, IT workers provided a rich set of pertinent comments in response to the questions. Because they participate directly in the IT labor market, IT workers have a valuable perspective to bring to the policy process addressing IT workforce issues. Yet, they are a difficult group to reach out to due, in large measure, to the very small number of advocates and advocacy organizations that represent their views. **Given the importance of IT workers to the U.S. economy—today and in the future—better government mechanisms are needed to improve communication between IT workers and policymakers.**



Boston Roundtable

Roundtables

Between September 2001 and January 2002, the Commerce Department convened eight expert roundtables around the country to collect information, advice, and experiences related to IT worker education and training. The questions posed in the Request for Comments served as the foundation for roundtable discussions.

These roundtables were conducted with regional and local partners who were well-positioned to identify local contributors who could provide insight for the review and study. To collect a wide range of perspectives, the Commerce Department sought to convene roundtables involving:

- a range of geographical areas;
- a participant mix that represented employers, IT workers, and education and training providers;
- a participant mix that represented small, medium, and large IT-producing and IT-using employers; and
- a participant mix that represented a wide range of industries found in the United States.

The eight roundtables were convened in geographic areas that drew participants from 9 of the top 12 metropolitan statistical areas (MSAs) with the largest populations of professional-level IT workers. Participants were drawn from more than 25 U.S. IT-producing and non-IT-producing industries, with small, medium, and large employers represented. Employers included small dot-com start-ups, governments at all levels, and many of the Nation's largest and most respected companies. Six roundtables convened employer representatives and education and training providers, and two convened IT workers, gathering insights from a total of 145 individuals (Appendix B).

IT Education and Training Roundtables

Date	Location	Partner
September 24, 2001	Summit, New Jersey	Programmers Guild
October 19, 2001	Washington, DC	Federal CIO Council
October 26, 2001	Los Altos, California	Joint Venture: Silicon Valley
October 30, 2001	Chicago, Illinois	Chicagoland Chamber of Commerce
November 9, 2001	Herndon, Virginia	Northern Virginia Technology Council
November 14, 2001	Seattle, Washington	Washington Alliance of Technology Workers International Federation of Professional and Technical Engineers Local 17 Society of Professional Engineering Employees in Aerospace
December 20, 2001	Boston, Massachusetts	Massachusetts Software and Internet Council TechNet
January 9, 2002	Rockville, Maryland	Technology Council of Maryland/MetroTech

Report Overview

The remainder of this report seeks to characterize the IT labor market in qualitative terms, and describe the paths and programs through which IT workers gain their education and skills.

- **Chapter II** examines what employers want in an IT worker in terms of ability, knowledge, and experience. This section includes formal education, technical skills, job experience, soft skills, and business skills. These are the requirements that the IT education and training community is working to fulfill.
- **Chapter III** describes the rich and diverse IT education and training landscape. This section includes a variety of program types, formats, providers, and credentials available to meet a wide range of IT education and skill needs. In addition, real-world examples are given for each program type. *The Commerce Department does not endorse any of these education and training programs or institutions, but describes them for illustrative purposes only.*

- **Chapter IV** focuses on the role of employers and IT workers in meeting the demand for IT skills. This section includes a discussion of the dynamics of employer decisions related to their investments in IT worker education, training, and career development. It also describes the kinds of investments some employers make to “grow their own” IT workers or contribute to the development of the overall U.S. technical workforce. This section also discusses the challenges IT workers face in developing and maintaining a career in IT, the personal investment they make in their own training, and the barriers they face in accessing and participating in IT education and training programs.

Principal findings are highlighted in blue.

Government Data Sources on Professional-level IT Workers

In this report, several U.S. government data sources are used to provide a quantitative characterization of the IT workforce. Each of these data sources offers a unique perspective on the IT workforce, and they collect information and classify IT occupations in different ways. As a result, each source has strengths and weaknesses, and analysis of their different data leads to significantly different size estimates of the professional-level IT workforce. The following information on these sources is provided to aid in understanding the data used in this report.

Current Population Survey (CPS)

Source: A joint project of the U.S. Department of Labor’s Bureau of Labor Statistics (BLS) and the U.S. Department of Commerce’s Census Bureau.

Data collection method: The CPS is a national sample survey of households conducted monthly through face-to-face and live telephone interviews. Statistics for 2000 and earlier years were based on a survey sample size of 50,000 households; in 2001, the sample was 60,000. On average, about 93 percent of these households participated in the survey. Approximately half of all information gathered in the survey comes from so-called proxy reporters—household members who report information about other household members who aren’t readily available for interview.

IT occupations surveyed and reported: Computer systems analysts and scientists, computer programmers.

Strength: Most current data on the IT workforce.

Weaknesses: Secondhand collection of information; results might vary if each jobholder in the household identified his/her own occupation. CPS interviewers are trained to deal with this problem, but Census Bureau staff acknowledges limitations. Also, uses only two very broad occupational classifications to capture all professional-level IT workers; a third classification, electrical and electronic engineers, includes a mix of IT and non-IT workers.

Government Data Sources on Professional-level IT Workers, continued

Occupational Employment Statistics (OES) Survey

Source: Collected by the Occupational Employment Statistics Program of the Bureau of Labor Statistics in semi-annual surveys of 200,000 establishments. Compiled through a 3-year period into an establishment sample of 1.2 million establishments.

Data collection method: Approximately 90 survey forms tailored to distinct industry groups are mailed to establishments. Forms ask respondents to report the number of employees and wage rates for occupation's Standard Occupational Classification (SOC) system.

IT occupations surveyed and reported: Computer programmers; computer and information scientists, research; computer systems analysts; computer software engineers, applications; computer software engineers, systems software; computer support specialists; computer systems analysts; data base administrators; network and computer systems administrators; network systems and data communications analysts; all other computer specialists; computer hardware engineers; and computer and information systems managers.

Strength: Collection of data for all workers in 1.2 million establishments allows the production of employment and wage estimates at detailed industry and areas. Survey forms invite employer responses about new and emerging occupations.

Weakness: The OES survey does not cover self-employed workers.

Methodological change: The OES survey will begin publishing occupational employment and wage estimates by NAICS industry in September 2003.

National Employment Matrix

Source: Developed by BLS as part of its ongoing Employment Projections Program.

Data collection method: The 2000 Matrix was developed from data collected in the Occupational Employment Statistics (OES) survey, the Current Employment Statistics (CES) survey, and the Current Population Survey.

IT occupations surveyed and reported: Same as OES. Computer programmers; computer and information scientists, research; computer systems analysts; computer software engineers, applications; computer software engineers, systems software; computer support specialists; computer systems analysts; data base administrators; network and computer systems administrators; network systems and data communications analysts; all other computer specialists; computer hardware engineers; and computer and information systems managers.

Strength: It is the only well-established source for forecasts of occupational trends with very detailed breakouts for occupations and industries.

Weakness: Only updated biennially in odd-numbered years.

Methodological change: The 2000 Standard Occupational Classification (SOC) system, which forms the basis for the 2000–2010 Occupational Employment Projections, includes significant changes from previous years, including new occupations and more detailed components of previous occupations. For example, with respect to the professional-level IT workforce, the 2000 SOC adds: "Network and Computer Systems Administrators," and breaks out "Computer and Information Systems Managers" from its previous grouping with engineering and natural science managers. The 2002–2012 Matrix will reflect 2002 NAICS changes.

Scientists and Engineers Statistical (SESTAT) Data System

Source: The National Science Foundation, using a combination of three separate surveys: the National Survey of College Graduates, National Surveys of Recent College Graduates, and the Survey of Doctorate Recipients.

Data collection method: These surveys are conducted using a mix of mailed questionnaires and telephone interviews. Data from each are then combined to yield estimates for the entire scientific and engineering workforce. The SESTAT database is updated every two years.

IT surveyed and reported: Computer systems analysts; computer scientists, except systems analysts; information systems scientists and analysts; other computer and information science occupations; computer engineers—software; computer engineers—hardware.

Strengths: All data are from firsthand sources; each person in the SESTAT database has been contacted directly. SESTAT contains information on many characteristics of IT workers and supports the production of special tabulations for specific research projects.

Weaknesses: Lack of recent data; the most recent SESTAT data are from 1999. In addition, there are gaps in SESTAT's coverage of IT workers. The database does not include persons who do not have a U.S. bachelor's degree or experience before 1990 in a science or engineering job. The SESTAT database also omits those who earned nonscience or nonengineering bachelor's degrees after 1993 and did not have jobs in science or engineering before April of that year. NSF does not consider programmers to be scientists or engineers, so SESTAT yields only a partial count of those workers, limited to people with a bachelor's or higher degree (and, as noted above, not everyone with those degrees is included). For this reason, CPS provides a better estimate than SESTAT of the number of programmers.

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Variations in the Estimates of the Number of Professional-level IT Workers: A Comparison of Government Statistical Sources

There are three primary Federal Government data sources for information about the U.S. information technology workforce: the Occupational Employment Survey (OES), Current Population Survey (CPS), and the National Science Foundation's Scientists and Engineers Statistical (SESTAT) Data System. The National Employment Matrix (Matrix) is developed using CPS, OES, and other data.

Each source uses a different methodology for collecting data and arriving at estimates of the number of these workers (see box "Government Data Sources on Professional-level IT Workers," page 24). Some of the data differences can be accounted for by survey methodologies, disparities in the universe of workers covered in each database, and different occupational classification systems. For example, CPS data comes from a survey of households, and individuals identify their occupations. The OES data comes from a survey of establishments benchmarked to industry data from the Covered Employment and Wages Program. The National Employment Matrix (Matrix) is developed using staffing patterns from the OES survey, benchmarked to industry data from the Current Employment Statistics (CES) survey, and augmented with self-employed and unpaid family workers.

The table below compares the counts government data sources provide on professional-level IT workers.

Year and Source	Computer Programmers	Other Professional-level IT Workers [†]	Total ^{††}	Notes
2000 Matrix	585,000	2,691,000	3,276,000	Employment includes wage & salary, self-employed, and unpaid family workers. Matrix uses OES staffing patterns benchmarked to the CES.
2000 OES	531,000	2,459,000	2,990,000	Only wage and salary workers; some industries not covered (agriculture, forestry, fishing, and private households). OES data are benchmarked to ES-202. ^{†††}
2000 CPS	699,000	1,797,000	2,496,000	Some computer engineers are captured in the Computer Systems Analysts and Scientists occupation, and others (not accounted for in this table) are captured under the broad occupational title Electrical and Electronic Engineers.
1999 SESTAT	209,000	1,113,000	1,321,000	College graduates only. Programming is not treated as a science or engineering field by the National Science Foundation.

NOTE: Numbers rounded to the nearest thousand.

[†] **Matrix:** Computer and information scientists, research; computer systems analysts; computer software engineers, applications; computer software engineers, systems software; computer support specialists; database administrators; network and computer systems administrators; network systems and data communications analysts; all other computer specialists; computer hardware engineers; computer and information systems managers.

OES: Same as Matrix, less all other computer specialists; OES does not publish estimates for residual occupations.

Current Population Survey: Computer systems analysts and scientists.

SESTAT: Computer systems analysts; computer scientists, except systems analysts; information systems scientists & analysts; other computer & information science occupations; computer engineers—software; computer engineers—hardware.

^{††} Total may not equal sum of computer programmers and other professional-level IT workers because of rounding errors.

^{†††} The Covered Employment and Wages Program, commonly referred to as the ES-202 program, is a cooperative program involving the Bureau of Labor Statistics (BLS) of the U.S. Department of Labor and the State Employment Security Agencies (SESAs). The ES-202 program produces a comprehensive tabulation of employment and wage information for workers covered by State unemployment insurance (UI) laws and federal workers covered by the Unemployment Compensation for Federal Employees (UCFE) program.

II. WHAT DO EMPLOYERS WANT?

This chapter examines the attributes and qualifications employers seek in an IT worker and that the IT education and training community is working to develop.

The IT workforce, education, and skills are often discussed as if they are homogenous. In reality, the IT labor market is dynamic and complex. **The mix of required knowledge and skills can vary significantly from one IT job to another, in terms of the formal education, specific technical skills needed, industry knowledge and experience, and other qualifications such as project management, communication, and organizational skills. Thus, IT workers who are qualified for one job often do not qualify for another.**

Employers seek workers who possess a specific combination of technical skills, experience, and industry knowledge—often expressed by employers as the “right person with the right skills at the right time.” Employers prefer job candidates who have the exact skill fit and require no additional training. Faced with short product life cycles, customer deadlines, and competitive pressures that leave no time to spare, employers want workers with the right skills and experience who, as employers frequently put it, can “hit the ground running.” In a recent survey, less than 10 percent of firms indicated that they were willing to hire a partially qualified candidate for an IT job and provide training to the employee to become fully qualified.⁵

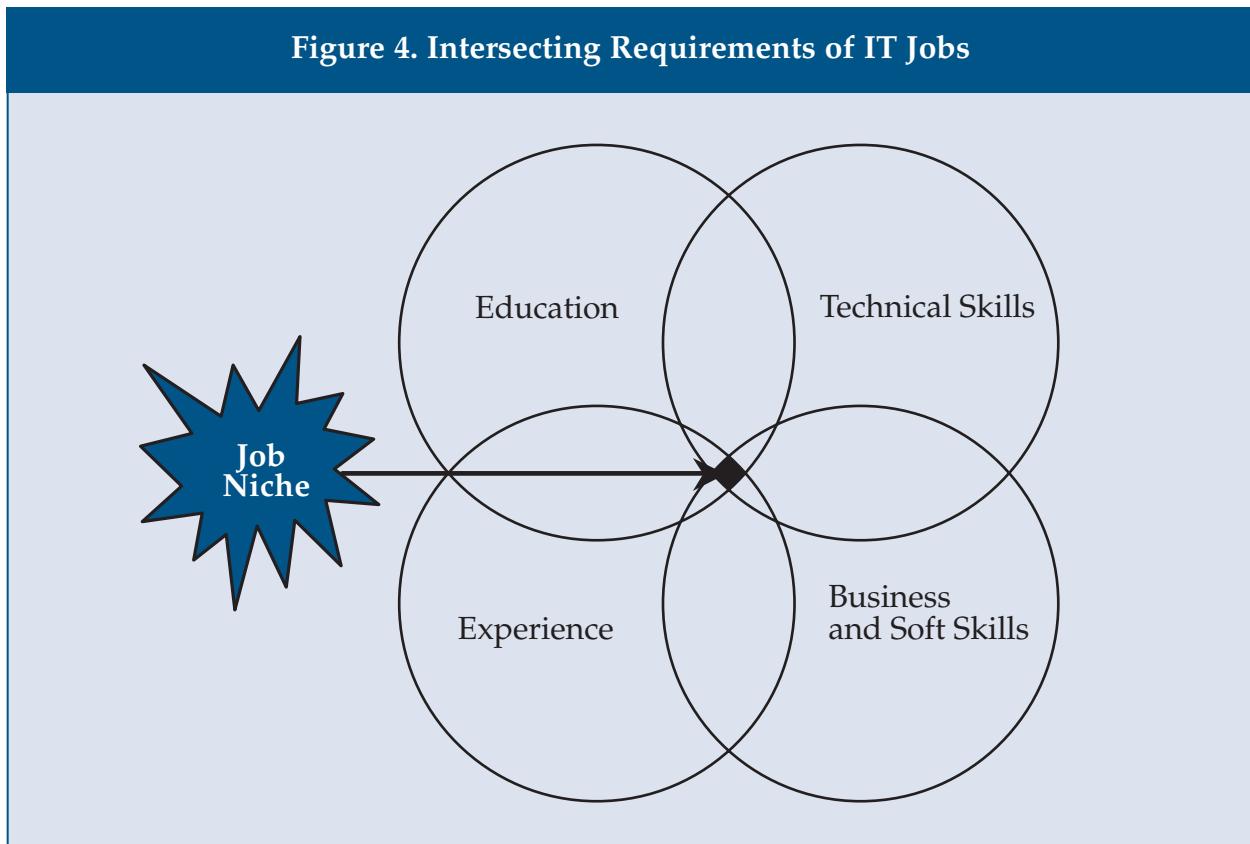
Employers seek to minimize their risk by hiring candidates with proven technical capabilities. Today, IT systems are mission-critical for most companies, whether those systems are managed inhouse or by a contractor, and IT developers have no time to spare in their ever-shrinking product development cycles. With much at stake, employers want to do everything they reasonably can to reduce the risk presented by new hires. A principal method for reducing risk is reliance on candidates with demonstrated job experience.⁶

With almost limitless combinations of technical skills and types of experience, the IT labor market is comprised largely of a wide array of specialized jobs. Figure 4 is a graphical representation of the job niche—in which employers seek candidates with some level of formal education (arena 1), some combination of technical skills (arena 2), business and soft skills (arena 3), and some level of experience, often both technology- and industry-specific (arena 4). Taken together, these requirements create a highly specialized niche that differs from one IT job to the next. Participants in the roundtables generally agreed that the **IT job Venn diagram model** reflects employers’ approach to IT job requirements.

⁵ When Can You Start? Building Better Information Technology Skills and Careers, Information Technology Association of America, April 2001.

⁶ Investing in the Future: Toward a 21st Century Information Technology Workforce, Virginia Governor’s Commission on Information Technology, September 1, 1999; When Can You Start?, April 2001.

Figure 4. Intersecting Requirements of IT Jobs



The specialization in IT worker demand is driven largely by the vast scope of IT technologies. A review of classified ads or Internet-based job recruiting boards shows job postings that include a list—variable but often extensive—of specific technical skills desired, commonly referred to as the “alphabet soup,” “laundry list,” “skill sets,” or “buzzwords.” For example, more than 1,000 specialties—most of them technical—can be used in job postings on the techies.com job web site. Workers who participated in the Commerce Department’s Web-based questionnaire cited employer demand for exact skill match as a major barrier they face in obtaining IT jobs.

In addition to highly specialized job requirements, frequent changes in technology and market conditions cause frequent changes in IT labor market demand, making job requirements a moving target for IT workers, employers, and IT education and training providers. For example, numerous major advances in IT were introduced in the past decade, including:

- The World Wide Web and its applications
- Networking technologies, particularly those based on Transmission Control Protocol/Internet Protocol (TCP/IP)
- Graphics and multimedia

- Relational databases
- Object-oriented programming
- Security and cryptography⁷

Certain technical skills may be in high demand or “hot,” like today’s Oracle, Visual Basic, Java, computer security, and enterprise integration specialties. Next year, a different set of skills may be hot. Or the need for technical skills may shift suddenly for other reasons, such as when the demand for COBOL programmers rose significantly in response to the Y2K problem.

Employers are reluctant to lower hiring standards even when labor markets are tight. In a recent survey, only one in nine employers said they had lowered their standards in order to fill IT jobs that were difficult to fill.⁸ However, private employers often ratchet up hiring standards in softer labor markets. They may ask for more skills, a four-year technical degree as opposed to a four-year degree, or more experience.⁹ Referring to the IT job market softness in 2001 and layoffs in the technology sector, several private-sector employers participating in the roundtables commented that they have more job candidates and can be more selective in making job offers. One reported that it had reduced its hiring of recent college graduates in favor of more seasoned hires. Employers said that in tighter labor markets they pay more attention to employee retention and are more willing to be generous in their support of employee training.

The shifts in employer hiring standards point to the need for tight feedback loops between employers and IT education and training providers, and for up-to-date labor market information for IT workers, so that those developing curricula and those seeking jobs can respond to these shifts.

The remainder of this chapter will focus on the four arenas—formal education, technical skills, business and soft skills, and experience—describing in detail what employers look for in each. Different jobs require a different mix of knowledge, skill, and experience, and there are differences in the relative importance a given employer places on each arena.

⁷ Computing Curricula 2001, The Computer Society of the Institute of Electrical and Electronics Engineers (IEEE-CS) and Association for Computing Machinery (ACM), December 2001, www.acm.org/sigcse/cc2001/cc2001.pdf.

⁸ The Ongoing Crisis in IT Management, CompTIA, August 2001, www.comptia.org.

⁹ Porter Anderson, Tech Careers Update: Skills Shifting, Demand Easing, CNN.com/Career, April 6, 2001; John P. Mello, Jr., Tech Jobs Abound, But Hiring is Slowing; Salaries, Perks Less Rich as Growth Pace Slackens, *Boston Globe*, July 15, 2001; Susan Stellan, The Long, Humbling Quest for a Job in Technology, *New York Times*, March 17, 2002.

Finding Out What Employers Want: Regional Approaches

Stakeholder organizations in areas of the country with high demand for IT workers have reached out to ascertain the knowledge and skills that employers want. Different models—focusing on different aspects of the IT worker portfolio of knowledge, skills, and experience—have been used. Here are brief summaries of some of these efforts.

Software and Computer Services Industry Cluster, A Labor Market Survey 2001. On behalf of the San Diego Workforce Partnership, Godbe Research and Analysis surveyed software and computer services firms in San Diego County online and by telephone. The survey determined the minimum educational and certification requirements for successful applicants for seven IT-related jobs—project managers, technical writers, software engineers, marketing managers, systems administrators, sales representatives, and customer support specialists. The survey also assessed a range of basic, technical, and soft skills for their importance and for the deficiencies of these skills in recent hires. The survey's education and skill assessments were designed to identify areas where education and training providers may need to improve their programs.

http://jobs.sandiegowork.com/Software_and_Computer_Services_Industry.pdf

Skills & Competencies Needed by Arizona's Workforce: The Software & Information Technology Industry, February 2001. On behalf of the Arizona Department of Commerce, Advancing Employee Systems, Inc., convened focus groups of representatives from Arizona employers to identify the levels of basic skills needed for entry into and effective performance in jobs in the software/IT industry at the technical support, technician, and advanced job levels. The basic skills covered—reading for information, applied mathematics, writing, and locating information—and detailed by skill level were those considered as providing the foundation for learning and performance on the job. In addition, the study identified behavior competencies most critical for success—such as customer focus, interpersonal savvy, problem solving, learning on the fly, and creativity—for each of the three job levels. This report (and similar reports focused on different industries) provides a blueprint for the state's education and training experts to, for example, initiate new courses and curricula or revise existing ones.

Skills Required by the Information Technology Sector in the Washington, D.C., Metropolitan Area, December 2000.

The Office of Institutional Research at Northern Virginia Community College (NVCC) collected and analyzed 182 IT job recruitment ads randomly selected from those published in the employment section in two Sunday editions of the *Washington Post*. For eight categories of IT jobs—database management/development, graphic design, help desk/technical support, management, network/systems administration, programming, training/instructional design, and other—the content of the ads was analyzed to ascertain for each IT job the education/certification, experience, and hardware/software skill requirements. Then the study identified the skill sets frequently required for each job category. This study was designed to learn more about the skills, education, training, and work experience that employers in the IT sector in the Washington, D.C., area seek in job candidates, for purposes of improving NVCC's ability to serve the education needs of students and the workforce needs of area employers.

www.nv.cc.va.us/oir/reports/itmatrix.htm

Preparing for a New Century: Information Technology Workforce Needs in Arkansas, April 1999. The University of Arkansas at Little Rock's Information Technology Committee conducted site visits with key executives at several IT companies in the region to identify the types of entry-level IT jobs in the companies, the kinds of software and programming languages used, and the soft skills and business concepts workers need. Building on these meetings, the committee developed common job clusters and an initial formulation of the knowledge, skills, and abilities for each type of job. Next, employee focus groups were convened for in-depth development of the knowledge, skills, and abilities. On the basis of the previous data collection, the committee developed a survey and posted it on the Internet to collect evaluations on the importance of a range of soft skills and business concepts IT workers need in general, as well as the technical knowledge needed for eight job clusters: computer programmers, systems/business analysts, computer engineers, database administrators, computer support specialists, network specialists, telecommunications analysts, and Internet specialists. The committee identified the technical, soft, and business skills that regional employers wanted for each of the job clusters.

www.ualr.edu/~itreport/

The Ohio Information Technology Competency Profile. Developed under the auspices of the Joint Council of the Ohio Board of Regents and the State Board of Education, the profile includes detailed competencies for four IT occupational clusters: information services and support, network systems, programming and software development, and interactive media. Representatives from Ohio business and industry identified the essential and recommended skills—technical, soft, and other—for current and future IT professionals, while secondary and postsecondary educators

Finding Out What Employers Want: Regional Approaches, continued

identified the point in the educational process and the depth to which these skills should be addressed. In addition, the business, industry, and educational representatives developed a crosswalk between the competency profile and several vendor and vendor-neutral certifications, including A+, Cisco Certified Network Associate, Microsoft Certified Professional, Microsoft Certified Systems Engineer, and Novell Certified Network Engineer. The competency profiles will serve as the basis for developing IT programs and courses in the state's secondary schools, colleges, and universities.

www.itworks-ohio.org

Greater Omaha Business Requirements for Educational Services in Information Technology, 1999 Update. The Applied Information Management Institute surveyed firms in Omaha, Nebraska, by questionnaire, asking them to rank the importance of nine broad IT academic disciplines. These included electronic engineering, telecommunications, systems integration, computer engineering and systems, systems development and business integration, technology management, technical marketing, e-commerce, and networking. Then the firms were asked to rank the importance of several applied areas within each of these IT academic disciplines. For example, in the category "networking," firms were asked to rank the importance of knowledge of: protocols; integration; unification and convergence; servers, bridges, routers, and hubs; security encryption; and continuity, interruption, and recovery. Firms were also asked to rank the importance of 12 crosscutting IT technologies such as client/server, human factors engineering, multimedia, and telecommunications, as well as to rank the importance of eight popular vendor certifications. The study helped to document present and future requirements for employment, training budgets, and curriculum.

www.aiminstitute.org/3/index.htm

A Study of Virginia's Information Technology Workforce, 1999. On behalf of the Center for Innovative Technology, Caliber Associates identified a common classification scheme to create a taxonomy of IT jobs in Virginia. The four largest categories of jobs were: IT management, IT marketing, and IT sales; software design and development and IT support; networking and telecommunications; and nontelecom hardware design and development. Focus groups were conducted with large and small IT companies as well as with companies providing training and placement services to IT companies to discuss staffing and retention issues, verify the IT job taxonomy, and identify how many IT jobs the companies had in each of the four categories. In addition, a Web-based survey was used to assess across the Commonwealth how many current and unfilled positions were in each of the IT job categories, as well as the: IT certifications desired; educational requirements, including acceptable degree types; experience requirements; and computer language and system/platform demands for these IT positions. On the basis of the data collected, recommendations for action by industry, educators/trainers, and government were developed.

Regional Information Technology Workforce Survey, 1998. The Center for Regional Analysis, Institute of Public Policy, George Mason University, on behalf of the Northern Virginia Regional Partnership (NVRP), conducted a survey of Northern Virginia technology firms by mail and telephone to identify vacant technology job clusters and the skill sets that were in greatest demand by the region's industry. The survey explored the types of technical positions difficult to recruit for in the region and examined the training needs and skill sets desired by Northern Virginia's technology companies. The survey reported on the formal education requirements for entry into 14 IT occupations and average years of experience required; the generic IT skills (i.e., programming, database administration, security, and consulting) and the specific technical skills that were in high demand and difficult to recruit for in the region; and the soft and business skills that were unavailable or of limited availability. This report was designed to serve as a benchmark to gauge NVRP's efforts to develop the Northern Virginia IT workforce.

Arena I. Formal Education

E*mployers Seek College Graduates.* Notwithstanding the occasional news of high school students succeeding in the IT field, **employers generally seek candidates with postsecondary education for professional-level IT jobs.** Of the 12 professional-level IT occupations for which the U.S. Department of Labor’s Bureau of Labor Statistics (BLS) collects information, BLS indicates that 10 of these occupations typically require at least a bachelor’s degree (figure 5).

Figure 5. Educational Requirements of Professional IT Occupations

Computer Programmer	Bachelor’s Degree
Computer Support Specialist	Associate’s Degree
Computer Systems Analyst	Bachelor’s Degree
Computer Software Engineer, Applications	Bachelor’s Degree
Computer Software Engineer, Systems Software	Bachelor’s Degree
Computer and Information Systems Manager	Degree Plus Work Experience
Network and Computer Systems Administrator	Bachelor’s Degree
Network Systems and Data Communications Analyst	Bachelor’s Degree
Database Administrator	Bachelor’s Degree
Computer Hardware Engineer	Bachelor’s Degree
Computer and Information Scientist, Research	Doctoral Degree
All Other Computer Specialists	Postsecondary Vocational Award

NOTE: According to BLS, demand for degree type (academic discipline) varies. For example, employers frequently require an engineering degree for computer engineering jobs, often prefer computer science degrees for systems programmers and software engineers, and show less preference for technical degrees for systems analyst and database administrator positions.

While a formal degree often does not substitute for job experience, **a four-year degree, especially a technical degree, helps IT professionals get their foot in the door and get promoted.** For example, in a recent survey of 1,400 IT workers, three-quarters said that companies are more likely to hire workers with a technology degree.¹⁰ Employers demonstrate a strong preference for higher levels of educational attainment.

A four-year degree is especially important for younger IT workers, who do not have the years of experience possessed by more seasoned IT workers.¹¹ Employers believe that those who

¹⁰ techies.com staff, Experience=Degree? Maybe Tech Degrees Are Important for Interviews and Management Positions, But Experience Rules, techies.com, My Career, March 2001, http://home.techies.com/Common/Content/2001/03/26mc_expvsdegree.html.

¹¹ No Degree, No Job: A Rule of the New, New Economy, Netslaves Community, Main Mosh Pit, Current Articles, www.netslaves.com/messages/pg-message_read.asp?tid=994445300&+Key=76, July 6–9, 2001.

have obtained a four-year degree have demonstrated that they are self-motivated and diligent. A person who has graduated from college is deemed to be well-rounded in terms of knowledge, has been adequately socialized, can spell and write, and will be comfortable in meetings with other professionals.¹² Individuals who have obtained a four-year degree are also assumed to possess adequate skills in logic, mathematics, structured thinking, and problem solving. Employers believe these attributes reduce their risk in hiring.

Employers may use the four-year degree as a standard to winnow the field when they receive many resumes for a particular job opening. However, while recognizing that four-year degrees are a credential valued by employers, IT workers have often expressed the view that raw talent or a natural aptitude for IT is more important for judging IT workers than possession of a degree.

The strong demand for IT job candidates with a bachelor's degree or higher is expected to continue. **BLS projects that, between 2000 and 2010, almost three-quarters of the job openings for professional-level IT workers will be in occupations that typically require at least a bachelor's degree.**

Educational Composition of Degreed IT Workers. The educational composition of the IT workforce is concentrated in those with four-year and higher level degrees (herein "degreed IT workers")—and their share is growing.

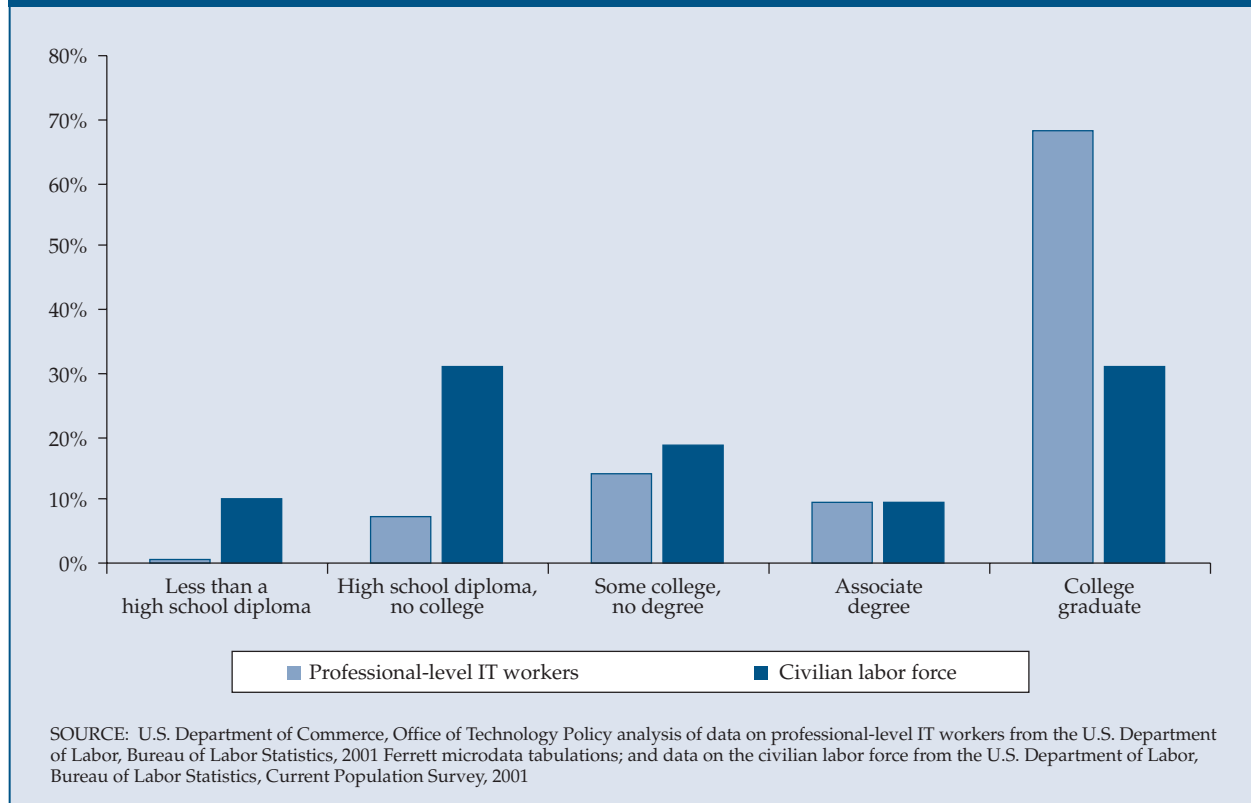
Figure 6 compares the 2001 professional IT workforce to the overall civilian labor force (CLF). While 30.5 percent of the CLF are college graduates, a much higher share—68.4 percent—of the IT workforce holds a bachelor's or higher level degree. In addition, the share of degreed IT workers is rising; in 1995, the share was 64.9 percent. This increase in educational level among IT workers likely results from two primary factors: (1) some people employed in IT occupations in 1995 subsequently earned bachelor's degrees, and (2) compared with the 1995 IT workforce, a higher percentage of those entering IT occupations after 1995 held a bachelor's degree.¹³

Among the two-thirds of IT workers who have college degrees, there is great diversity in the types of degrees they hold. However, the vast majority have degrees in science, math, or engineering disciplines. In addition, a substantial share—approximately 20 percent—of degreed IT workers have more than one degree. Given the enormous number of combinations of degrees that can exist, to simplify the analysis this report examines the data in two ways.

¹² No Degree, No Job, July 6–9, 2001.

¹³ A third, but likely less important, factor might be that the cohort of those in the IT workforce in 1995 who exited the profession after 1995 had a lower percentage of bachelor's degrees than did the 1995 IT workforce as a whole. The available data are inadequate to determine how much each of these factors contributed to the overall increase in the percentage of IT workers holding bachelor's degrees.

Figure 6. Educational Attainment of U.S. Civilian Labor Force Versus Professional-level IT Workers: 2001



First, figure 7¹⁴ shows that about 40 percent of degreed IT workers have IT degrees;¹⁵ 57.6 percent have an IT or engineering degree; and 87.5 percent—or 7 out of 8 degreed IT workers—hold a degree in science, engineering, or mathematics.

In figure 8, the degree composition is provided for each of the IT occupational specialties. The occupations with the highest percentage holding an IT degree are computer scientists (59.3 percent), computer software engineers (49.0 percent), and computer programmers (46.0 percent). There is a clear preference for IT and engineering degrees among computer hardware engineers (80.0 percent), computer software engineers (76.1 percent), and computer scientists (70 percent). By comparison, the occupations of computer systems analyst (49.4 percent), information systems

¹⁴ In figures 7 and 8, IT workers were limited to a single degree only. First, only those with IT degrees were counted; then those with engineering degrees who did not have IT degrees; then those with natural science degrees who did not have either IT or engineering degrees, and so forth for each of the other degrees (mathematics, social sciences, business, and “other,” in that order).

¹⁵ For this purpose, IT degrees include computer and information sciences, general; computer science; computer systems analysis; information services and systems; other computer and information sciences; computer and systems engineering; and computer programming.

Figure 7. Educational Background of Professional-level IT Workers

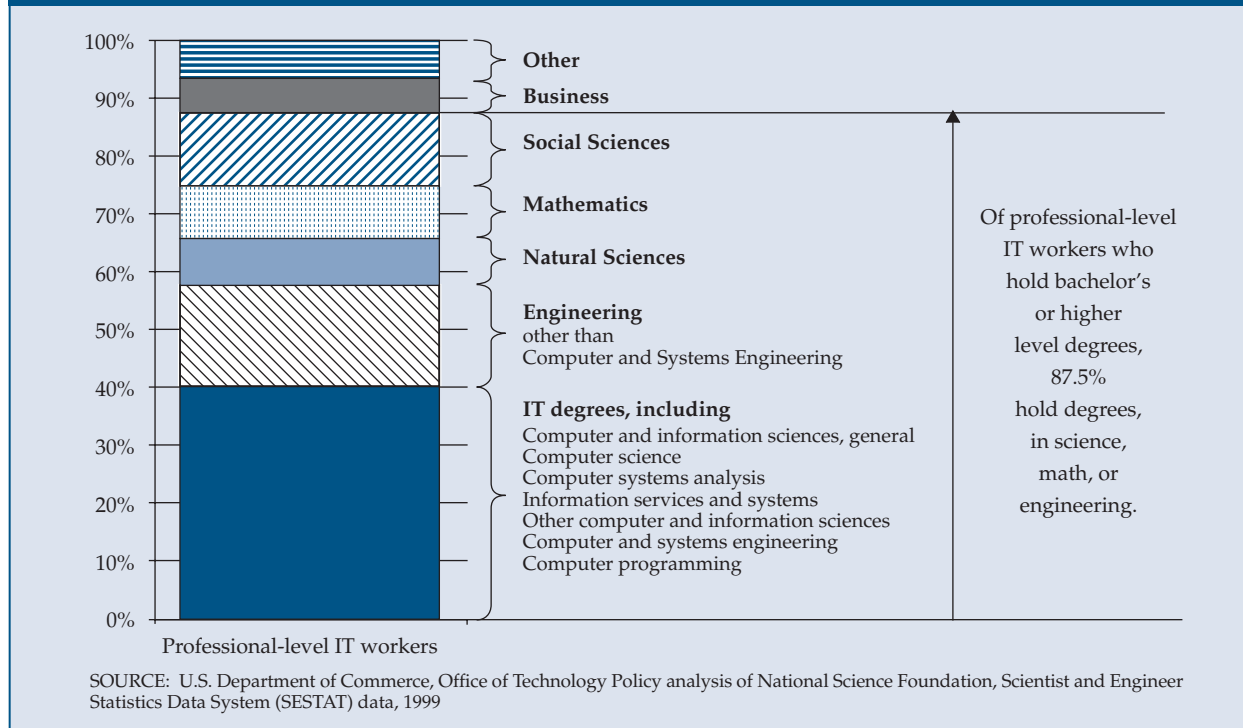
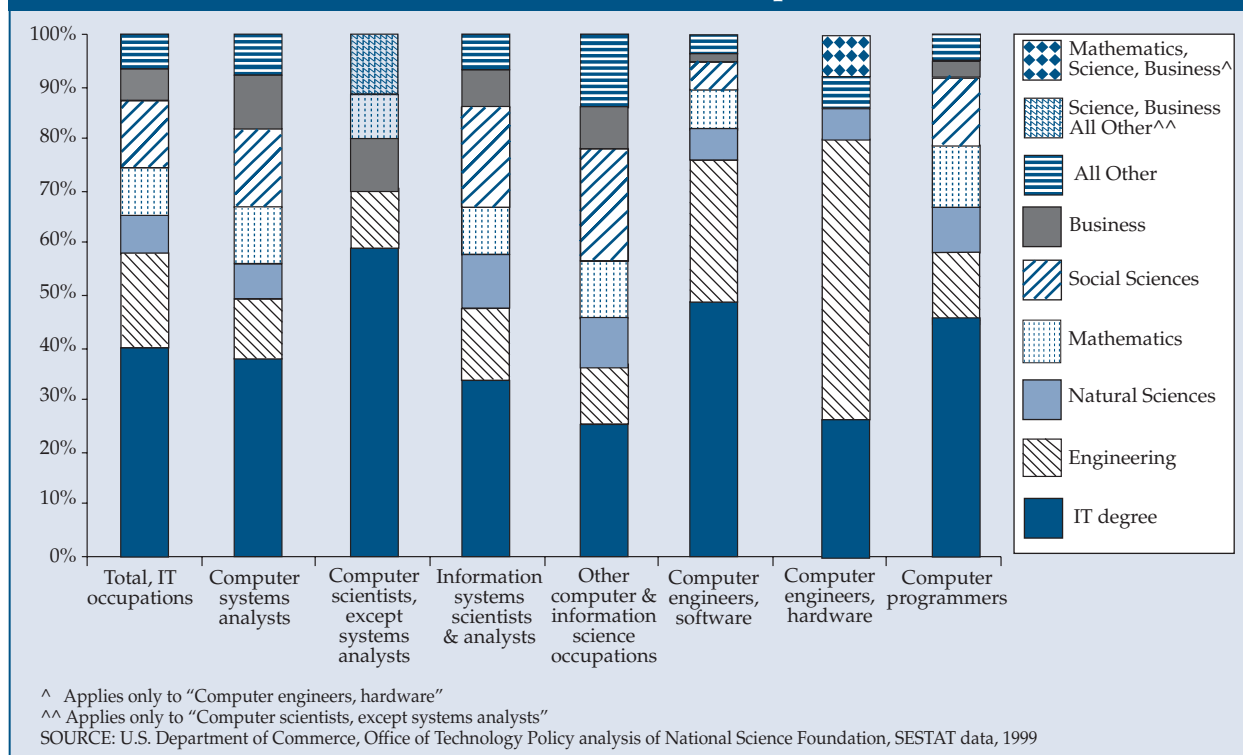


Figure 8. Degree Distribution of IT Workers in Specific Professional-level IT Occupations



scientist/analyst (47.6 percent), and other computer and information scientists (36.2 percent) relied least on IT and engineering degrees.

Second, figure 9¹⁶ shows the number and percentage of degreed IT workers with each degree type for all IT occupations collectively and for each occupational specialty. IT and engineering degrees dominate, with 40.2 percent of all degreed IT workers holding IT degrees, and 20.6 percent holding engineering degrees.

An examination of the degree composition by IT occupational specialty results in some telling differences. For example, 59.3 percent of computer scientists hold IT degrees, while only a third of those employed as “information systems scientists and analysts” and a quarter of “other computer and information scientists” hold IT degrees. Not surprisingly, the IT occupations with the highest share of engineering degrees (as a percentage of all degrees held by those in the specific occupation) are computer hardware engineer (59.9 percent) and computer software engineer (33.4 percent).

Technical Degrees. This degree composition partially reflects what IT workers do on the job. **Technical degrees—such as computer science or computer engineering, four-year and above—are preferred for IT workers for whom research or developing new software, IT products, or enterprise-level applications are major functions of the job, because these workers need the deeper and more theoretical knowledge required to create new hardware and software.**¹⁷ An employer participating in the Commerce Department’s review pointed to the value of the good analytical foundation often developed in IT workers who attain these degrees. Technical degrees may also provide an edge in getting an IT job initially and in upward mobility. In a March 2001 techies.com survey, three-quarters of the technology professionals who responded said companies are more likely to hire tech workers with a technology degree.¹⁸

The deeper “foundational” knowledge of those with technical degrees is likely to prepare them for technological change and learning new technical skills when needed, rather than just knowing the “skill of the day.” Foundational knowledge becomes increasingly important as the rate of technological change accelerates and technical complexity increases. For example, one IT worker who participated in the Commerce Department’s review explained that if you work on a wireless systems development team, your knowledge has to go beyond software to areas such as radio frequency and communications. The IT worker further explained that it is

¹⁶ For this table, IT workers were counted in each degree area in which they held the degree. Thus, an IT worker with a mathematics and IT degree would be counted in both degree areas. Accordingly, the number of degrees adds up to more than 100 percent, as approximately 20 percent of all IT workers hold two or more degrees.

¹⁷ Skills and Competencies Needed by Arizona’s Workforce: The Software and Information Technology Industry, Arizona Department of Commerce, February 2001; Career Planner: Software Development, techies.com, 2001.

¹⁸ Experience=Degree?, March 2001.

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unlikely that a person with skills from a commercial IT school or self-taught skills could work on simulation software for a submarine because, for such a project, the IT worker would work as part of a team that included physicists and mathematicians with high levels of theoretical knowledge and technical skill. One employer discussed the deeper knowledge required for positions dedicated to information security and indicated that this knowledge cannot be learned in a short IT class. In research-oriented positions, graduate degrees in technical fields are often required.

Business-Related Degrees. Employers and employees indicated that a business degree—coupled with a technical degree—was important for advancement to IT management positions. Some employers and some IT workers who participated in this review said that technical degree programs may lack a hands-on, commercially relevant focus. A worker with a management information systems or business degree brings knowledge of commercial considerations and business management to an IT job, and has an edge in opportunities for promotion to management. Participants in the Commerce Department roundtables commented that IT workers with just an undergraduate degree often do not grasp the business side. Therefore, employers are stepping up their recruitment of people with MBAs and master’s degrees who also have technical skills.

Figure 9. Distribution of Those Employed in IT Occupations, by Degree Held: 1999

Degree	Total, IT occupations		Computer systems analysts		Computer scientists, except systems analysts		Information systems scientists & analysts	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent
Total	1,347,734		399,108		19,193		168,579	
IT*	542,079	40.2	152,560	38.2	11,375	59.3	56,607	33.6
Engineering	278,086	20.6	50,161	12.6	3,770	19.6	27,575	16.4
Natural sciences	134,906	10.0	33,952	8.5	2,383	12.4	20,323	12.1
Mathematics	134,906	10.0	49,547	12.4	3,143	16.4	18,689	11.1
Social Sciences	195,263	14.5	66,396	16.6	1,799	9.4	36,771	21.8
Business	165,224	12.3	70,358	17.6	s	-	26,996	16.0
All Other	176,776	13.1	52,956	13.3	1,816	9.5	24,094	14.3

NOTES:
 "s" indicates cells suppressed due to low unweighted counts.
 A person may have more than one degree; therefore, details may not sum to the total.
 * IT degrees include computer and information sciences, general; computer science; computer systems analysis; information services and systems; other computer and information sciences; computer and systems engineering; and computer programming.
 SOURCE: National Science Foundation, SESTAT data, 1999

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Overall, one in eight (12.3 percent) degreed IT workers holds a business degree. The share is even larger among computer systems analysts (17.6 percent), information systems scientists and analysts (16.0 percent), and other computer and information scientists (15.0 percent). By contrast, the share of computer scientists holding a business degree is negligible; computer engineers (both hardware and software) and computer programmers also have a comparatively low share of business degrees (6 to 8 percent).

About 1 in 20 degreed IT workers have only a business degree; the greatest number and share are employed as computer systems analysts. In highly technical IT occupations (computer scientist or computer hardware or software engineer) the share holding only a business degree is less than 2 percent. Approximately 1 in 14 degreed IT workers (7.1 percent) have coupled their business degree with another type of degree. The most prevalent combinations are: business–IT (35,588), business–social sciences (20,659), and business–engineering (18,816). Business degrees are least likely to be paired with a natural sciences or mathematics degree, with less than 1 percent of degreed IT workers holding either combination.

Other computer & information science occupations		Computer engineers—software		Computer engineers—hardware		Computer programmers	
Number	Percent	Number	Percent	Number	Percent	Number	Percent
132,855		338,409		54,747		208,544	
33,736	25.4	165,676	49.0	14,456	26.4	95,862	46.0
16,626	12.5	112,871	33.4	32,788	59.9	29,553	14.2
15,617	11.8	33,341	9.9	4,741	8.7	21,823	10.5
15,881	12.0	41,788	12.3	2,068	3.8	30,469	14.6
29,429	22.2	24,146	7.1	2,242	4.1	32,131	15.4
19,928	15.0	20,951	6.2	3,708	6.8	15,861	7.6
33,413	25.1	28,955	8.6	5,438	9.9	21,677	10.4

Less Than a Four-Year Degree. Other surveys and analyses suggest that employers show some willingness to hire individuals without a bachelor's degree—for example, those with a two-year degree—for jobs in tech support/call center, Web development and administration, some database-related jobs, and some jobs in network design and administration, although there is often a requirement for previous work experience and/or a technical skill certification.¹⁹

However, further formal postsecondary education, even obtaining a four-year degree, typically is needed for advancement in the field, especially promotion to IT management. As one employer representative explained: “Very, very often we have folks that come in as system administrators or call center service reps and, after some period of time, of course folks want to know what’s my next career step, where do I go from here. And very often there are severe limitations if folks haven’t come in with a sufficient educational background.”

Employers appear more likely to invest their training dollars in workers who have higher levels of education, such as a four-year degree. Even companies that hire individuals as “IT trainees” place a high priority on a four-year degree because of the substantial investment of dollars and time needed to train someone in this field.²⁰ Also, an IT worker without a degree may not meet the requirements for entry into university education and training programs that teach IT management skills.

In summary, there are no hard and fast rules concerning a degree, or type of degree, as a prerequisite for a professional IT job. Two-thirds of all IT workers possess at least a four-year degree, and many of these possess technical—such as computer science—degrees. There is a wide range in the degree mix found in the IT profession—business, liberal arts, science and engineering, and two-year, four-year, and advanced. Some IT workers have no degree at all, but nearly three out of five hold at least a four-year science or engineering degree.

A four-year degree provides a distinct advantage for IT workers. It is required for many jobs, and the requirement appears to be increasing. In hiring, it gives job candidates a strong advantage over those who do not have a degree. It increases potential for upward mobility and is a necessity for assuming management positions. A four-year computer-related technical degree is important for IT developer and designer positions, and can provide an additional advantage in the competition for jobs and promotions over those who have nontechnical degrees. While some employers will accept a two-year degree for lower level IT jobs, opportunities are less prevalent than those for individuals who have a four-year degree, and further education would be needed for upward mobility in the field. In addition, employers look at a four-year degree as representing a set of attributes that signal “work readiness” for professional-level jobs.

¹⁹ When Can You Start?, April 2001; Findings of the 2000–2001 Workforce Study, WSA (formerly the Washington Software Alliance); Skills Required by the Information Technology Sector in the Washington, D.C., Metropolitan Area, Northern Virginia Community College, December 2000; Building a World-Class Information Technology Workforce for the Chicago Region, Council for Adult and Experiential Learning, 2001; Investing in the Future, September 1, 1999.

²⁰ No Degree, No Job, July 6–9, 2001.

Arena II. Technical Skills

The demand for specialized technical skills appears to play the largest role in the complexity of the IT labor market. A rapidly growing array of general and specialized IT products and services for industries and consumer markets has created the need for IT workers who possess certain specific combinations of technical knowledge and skills. Employers place a high priority on these technical skills, which are often evaluated by assessing a candidate's work experience, certifications, certificates, and other credentials.

IT product life cycles are already among the shortest, with competitive pressures and rapid technological advancements continuing to reduce the length of these cycles. **With IT skill sets closely linked to specific software and hardware technologies, these ever-shortening product life cycles create frequent change in the IT skill mix in demand. These technical skills lose value over time, sometimes in as little as two to three years. This means that IT workers must acquire new skills frequently in order to maintain their labor market viability.**

Rapid advances in information technology drive frequent changes in the types of IT skills in demand, which creates a labor market challenge. Education and training providers and IT workers need information on future employer skill needs in order to prepare for these changes. However, rapid technological change and uncertainty make it difficult for employers to project future skill needs. Nevertheless, to the extent that employers are able to project their skill needs, communicating these needs to education and training providers and IT workers would help the IT labor market work more effectively.

A Knowledge and Competency Baseline. Certain baseline technical competencies are deemed important for most IT professional workers. These competencies reflect basic knowledge of the computing environment and the skills needed to perform basic computer-related functions. *itworks.ohio* developed such a competency profile for several IT occupational areas, including programming and software development/applications, information services and support, and network systems.²¹ The profile identified basic, essential IT skills that cut across those three IT occupational areas:

- Proficiency in basic computer applications such as word processing, design and use of databases, spreadsheets, desktop publishing, and graphics.
- Proficiency in basic data communications, accessing information from electronic sources, and e-mail.
- Proficiency in basic computer user support, such as identifying technical support needed and providing technical assistance and training to users.

²¹ Ohio Information Technology Competency Profile, developed by the Joint Council of the Ohio Board of Regents and the State Board of Education for [itworks.ohio](http://itworks.ohio.org), www.itworks-ohio.org.

- Proficiency in installing and configuring software programs, including evaluating them for their utility in meeting user needs.
- Knowledge of the Internet, Internet access, and how to use Internet-based services.
- Knowledge of computer hardware design, operation, and maintenance, including knowledge of computer components and systems, ability to install a computer system, and troubleshooting.
- Knowledge of operating system components, computer memory, and computer security, and the ability to operate and maintain these systems.
- Knowledge of different networking systems, platforms, standards, and protocols, and knowledge of network connectivity.
- Knowledge of database systems and principles, and basic competency in their development and implementation.

IT Technical Disciplines. Building on basic IT competencies, many workers specialize in a particular IT discipline. While IT occupations have been classified in a variety of ways, there are several broad areas common to many of them. The following is a sample of these disciplines:

- *Programming and Software Engineering:* Design, development, testing, and evaluation of software and computer systems.
- *Database Development and Administration:* Use of database management systems software to store, organize, manage, and extract data.
- *Network Design/Administration:* Design, installation, and support of an organization's local area network (LAN), wide area network (WAN), network segment, Internet, or intranet system.
- *Technical Support:* Provision of technical assistance, support, and advice to customers and other users.
- *Systems Analysis and Integration:* Apply computer technology to meet the needs of an organization by planning, developing, and improving computer systems to maximize an organization's investment in equipment, personnel, and business processes.

Despite a softening of the IT labor market reported by numerous employers, especially during the economic downturn of 2001, demand for a number of these IT disciplines remains strong. The demand for database professionals remains strong, as companies must manage the data generated in their e-commerce initiatives. Security experts are in high demand as organizations work to protect their computer systems from viruses and other forms of intrusion and, since September 11, plan for disaster protection and recovery. Continued growth of

corporate networks and e-commerce has supported demand for network and Internet/intranet specialists.²²

In each of the broad disciplines, employers may seek numerous specific technical skills in an IT worker. These skills fall into broad categories—such as development tools and programming languages, Web development tools, database systems, operating systems, and networking protocols and applications. Some technical skills are based on the products of specific vendors, such as Oracle’s popular database systems. Others cut across disciplines, such as knowledge of Microsoft operating systems. (Figure 10 lists some of these technical skill areas, but only a few of the wide range of specific IT technical skills employers seek.²³)

Because of the system integration aspects of their work, systems analysts may need skill sets that cross discipline areas. Depending on the project, systems analysts/integrators may need a skill set that spans programming languages, database systems, operating systems, LAN/WAN, legacy systems, and hardware. They may also need skills in enterprise application packages such as those offered by Oracle, Peoplesoft, and SAP. A systems analyst may also need skills in IT technologies designed for particular industries—such as manufacturing, health care, and finance—coupling his or her technology knowledge with knowledge of business functions.

When certain technical skills emerge as a result of the introduction of a new IT product, or when certain technical skills are in widespread demand, they become “hot”; that is, employers have difficulty recruiting individuals who have these skills and may have to pay salary premiums to get them. For example, in the past two years, Unix, Java, C++, and SQL have been among the hot skills.²⁴ However, as more IT workers acquire them, these skills begin to lose their gold-plated status.

Certifications. Employers may also seek IT workers who possess certifications. Typically, IT workers qualify for such certifications after passing one or more examinations. (The structure of these certification programs is discussed in Chapter III under “The IT Education and Training Landscape.”)

More than 300 different IT-related certifications are offered by vendors, industry associations, and others, but some certifications are more commonly recruited for in the IT labor market. For example, certification is popular in the network design and administration field,

²² Lisa Vaas, Opportunity: Hot IT Jobs for 2002, *eWeek*, March 25, 2002; Deborah Radcliff, Hot Skills for a Cold Market, *Computerworld*, November 12, 2001; 2002 Salary Guide, RHI Consulting, 2001; Marianne Kolbasuk McGee, Employers Get Choosy with Skills, *InformationWeek*, October 1, 2001.

²³ Techies.com Career Planner Series, 2001; The Most Wanted Skills for 2001, *Computerworld*, December 4, 2000; Top Dollars for Top Skills, *Computerworld*, December 4, 2000; Skills Required by the Information Technology Sector in the Washington, D.C., Metropolitan Area, December 2000; 2002 Salary Guide; Hot Skills for a Cold Market, November 12, 2001.

²⁴ Nick Doty, Unix Tops Skills Index, My Career, techies.com, May 2002, http://home.techies.com/Common/Content/2002/05/10mc_skillsdemand.html#skillchart.

Figure 10. Commonly Demanded Technical Skills by IT Discipline in 2001–2002

Programming/ Software Engineering	Network Design and Administration	Web Development Subset
Java	Cisco Products	Java
C++	Novell Netware	JavaBeans
C	Windows NT/2000	Java Server Pages
Visual Basic	Unix	Active Server Pages
XML	Linux	Visual Basic
HTML	SNA	XML
Unix	IPX	HTML
Windows NT/2000	Routing	JavaScript
Linux	LAN/WAN	CGI
SQL	TCP/IP	Perl
Perl	Ethernet	Cold Fusion
Active Server Pages	Ethernet Switching	Technical Support
CGI	10 Base-T Switching	Windows NT/2000/98
JavaScript	Virus protection, firewalls	Unix
Solaris	Client/server technology	Microsoft Applications
Database Development and Administration	Data network protocols	LAN/WAN
Oracle	Internet connectivity	Novell Netware
SQL Server	Intranets	TCP/IP
DB2/UDB	Wireless	PC Hardware
Sybase		
Informix		
Access		

with employers looking for candidates who hold Cisco or Novell certifications. Oracle certifications are very attractive for database development and administration jobs. A+ (focused on basic knowledge of computer software and hardware installation and maintenance) is a vendor-neutral, entry-level certification that is popular with IT support and help desk workers. Certifications from IT vendors Microsoft, Cisco, Novell, and Oracle are among the most popular. Oracle and most Microsoft certifications are not designed for entry-level IT workers.

Employers and IT workers expressed mixed feelings about the value of these certifications. For example, in a recent survey, employers placed modest emphasis on these certifications, ranking vendor certifications between 3.1 and 3.4 on a 5-point scale of importance (with 5 being most important) and industry certifications between 3.4 and 3.7. IT-producing companies viewed these certifications more positively than did non-IT-producing companies.²⁵ In another survey, 3 out of 10 chief information officers (CIOs) and 1 out of 6 human resource professionals used these certifications as criteria in considering new hires or contractor-provided staff for jobs involving IT service and support.²⁶

²⁵ When Can You Start?, April 2001.

²⁶ The Ongoing Crisis in IT Management, CompTIA, August 2001, www.comptia.org.

While such certifications may be viewed positively for lower-level IT positions, they may not be considered adequate preparation for mid- to high-level positions.²⁷ In the absence of other education and training, certification holders may not have the depth of knowledge needed for the real IT world, for complex projects, or for learning new technologies, and, thus, may be limited in how well they can adapt to changing technology and how far they can advance. In addition, these certifications lose their value as the particular vendor technology matures and new technologies are introduced into the marketplace.

***Skill Sets.* Many IT workers, including those who provided comments to the Commerce Department, report that employer demand for IT workers whose technical skills are an exact match to a highly specific technical skill set is one of the biggest barriers IT workers face in getting a job.** An IT worker may have most of the technical skills employers seek but may not be considered for the job if he or she is lacking one or two technical skills. Many employers say they simply do not have the time to allow an IT worker to learn a new technical skill to complete the skill set the employer wants, even if it requires only a short time. An IT worker who provided comments for this review detailed actual requirements from a job recruitment—5+ years of C++, XML, Java, and Filenet+—and said that he had all the skills except Filenet+. He said, “The Filenet+ is just API calls. I can learn that in about five minutes, but I won’t even be considered for the job because I don’t have paid experience [in Filenet+].”

In addition, IT service providers and consultants, who operate in highly competitive markets, want workers who are “billable” on contracts right away. These employers cannot afford to have an IT worker on the bench earning a salary while learning new skills rather than generating revenues from customers. As one employer put it, “It’s a real-time, just-in-time market. You hire the skill you need when you need it. You don’t put it on the shelf and have it on the bench.” This is particularly true for small firms, as described by one employer: “If you’re a small business and you’re bidding jobs and you win the job and they want you to start within two weeks or 30 days, then you have to look for the skills that they need today. You can’t go out and find people that you can develop for tomorrow. If you’re a small businessman, you have no bench.”

Some IT workers believe that skill sets serve as a checklist for human resource personnel and recruiters, especially if they lack the technical knowledge needed to evaluate candidates’ skills and experience to ascertain whether they have the underlying skills for a particular job. As a result, candidates who may be capable of doing the job may be overlooked. An exacerbating factor may be the use of machine scanners to “read” resumes and identify only those that identically match the list of required skills. Thus candidates with close, but not identical, skill sets—or even typographical errors on their resumes—may be excluded from consideration.

²⁷ A Study of Virginia Information Technology Workforce, Caliber Associates for the Center for Innovative Technology, August 1999.

Examples of Technical Skill Sets

The following are examples of technical skill sets from actual recruiting announcements from the Monster.com job data bank (April 2002). These descriptions are for mid-level IT workers, with approximately three to five years of experience. Both IT-producing and non-IT-producing companies evaluate job candidates, in part, on technical skill sets. As these examples show, there is great variability in the amount and specificity of skill sets required.

Software engineer, e-commerce area, IT service company:

Skills required: Proficient in C/ProC, Java, J2EE, XML, Unix, and Perl. Development experience with ANSI SQL and Oracle/Oracle Forms required. Skills desired: Experience with Oracle application server, MS SQL Server, and commercial E-Commerce software package integration.

Programmer analyst, systems and programming support area, business solutions, insurance company:

Qualifications: Minimum of four years experience in systems design and experience with various software products such as Visual Interdev, Java, Business Objects (OLAP), Web development languages, Access, and Excel. General knowledge of DBMS and data warehouse concepts and functionality is highly desired.

Database software engineer, database and data collection systems area, communications and printing company: Minimum three years database administration and development. Project experience with deploying SQL Server data via Microsoft IIS using ASP server-side

scripting technologies. SQL Server 7.0 or 2000 tuning/optimization and performance metric measurement experience. Experience transitioning non-normalized Access, Foxpro, and Paradox database formats to SQL Server. Extensive Transact SQL experience. Good understanding of C programming in a Unix environment. Pluses: SQL Server DB Administrator certification. Experience with other DBMSs, including Oracle 7/8/8i, Sybase, Interbase, others. Microsoft VisualStudio.NET development experience, including Visual Basic and Crystal Reports. Experience with Windows 2000 system administration.

Web development manager, intranet, extranet and Internet site maintenance area, industry association:

Broad experience with Web site authoring software and Unix and NT Web server software is essential, including Netscape Enterprise Server, Apache, IIS, Active Server Pages, Cold Fusion, HTML, Java and JavaScript, C and C++, VB CGI, Perl, sh, ksh, ASP, and Active X.

Arena III. Experience

Among employers and IT workers, one area of unanimity about the IT labor market is the importance of work experience. Experience is a high, if not the highest, priority in employers' hiring considerations. In a 2001 survey of IT workers, 97 percent of respondents said experience was important or critical to their career plans; only about half said a degree or certification was as important.²⁸ Employers generally seek workers experienced in applying the specific technical skills needed for a job. In certain instances, employers also place a priority on industry-specific experience when IT work is specialized for an industry such as banking, health care, or manufacturing.

Research on IT job vacancies by the Virginia Governor's Commission on Information Technology showed that employers explicitly recruited experienced workers for 70 percent of IT job vacancies in the period studied. In 11 IT job categories that were examined, average required minimum years of experience ranged from 1.4 years for computer support specialists to 6.5 years for IT managers, with most of the job categories requiring an average minimum of two to three years of experience.²⁹ In a similar analysis, more than 70 percent of the IT job recruitment ads reviewed mentioned work experience as a requirement. For example, 70 percent of the ads for programming positions called for work experience, 70 percent for help desk/technical support, 78 percent for database administrators, and more than 80 percent for jobs in network/systems administration.³⁰ In a recent analysis of IT job listings in the techie.com job database, about 90 percent of jobs listed asked for three or more years of experience.³¹

The experience requirement can extend to new workforce entrants, such as recent college graduates. In a recent survey, hiring managers were asked what was the best way for a worker to obtain a job in eight IT occupational categories. Previous job experience was the top strategy for obtaining a job and the most desirable qualification for all workers for every category, even at the entry level.³² In another example, an IT company's announcement of on-campus student interviews for IT jobs after graduation stressed the qualifications the company desired, including experience in C++, Java, HTML, or XML; evidence of work (internship, summer job, or campus employment) in a professional programming capacity; experience in designing data structures and algorithms; and experience with software engineering and programming design methodologies, 2D and/or 3D computer graphics.³³ Even the popular entry-level IT certifica-

²⁸ Experience=Degree?, March 2001.

²⁹ Investing in the Future, September 1999.

³⁰ Skills Required by the Information Technology Sector in the Washington, D.C., Metropolitan Area, December 2000.

³¹ Unix Tops Skills Index, May 2002.

³² Bouncing Back: Jobs, Skills and the Continuing Demand for IT Workers, Information Technology Association of American, May 2002.

³³ http://usa.autodesk.com/adsk/files/848731_SoftwareEng_onsampus.pdf.

tion—the A+—is characterized as targeted for entry-level computer service technicians with “6 months on-the-job experience.”³⁴

Some employers are willing to take a chance on a candidate with recent IT education and training but no experience for lower skill jobs. In hiring for a trainee or entry-level position, employers may be willing to accept academic degrees, demonstrated soft skills, or IT certifications that closely match their needs in lieu of job experience.³⁵ Roundtable participants reported that inexperienced hires account for a modest percentage of new hires in large companies, perhaps only 10 to 20 percent, and many of these are recent college graduates. Among smaller firms, the preference for experienced candidates may be even greater, because smaller firms have less staff to take up the slack while an inexperienced hire gets up to speed or attends training.³⁶

The IT labor market places a high value on experience for several reasons. Employers insist on experienced job candidates as timesaving and risk reduction strategies. Employers believe that competency is best substantiated through a track record of getting things done, as demonstrated through actual job experience. Roundtable participants said that workers with deeper skills and more experience—for example, mainframe-experienced workers who also do Web programming, and IT workers who understand how software extracts information from a database—understand the basic structures of IT systems and can make such systems more robust. A more narrowly or superficially trained worker would not know that structure. Many IT workers who participated in this review share this view.

For IT service providers and consultants, experienced IT workers are more marketable to their customers, and some customers and contracts actually require experienced workers. In addition, many soft skills and business knowledge and skills are not acquired through education and training but rather developed experientially. Thus, an experienced IT worker is perceived to have some of these essential nontechnical skills.³⁷ An employer participating at a roundtable said, “We’re not too quick to go after new hires right after college. They aren’t seasoned, they aren’t mature....The kids we see coming out of school have got very good opinions and very good skills, but they don’t have the right blend of experience and skills, and they know how to be mavericks and hack things together and do some rapid prototyping, but when it comes down to sitting in an environment in a large team and planning an enterprise system—to design the deployment model, the user training, the long life-cycle maintenance, and so forth—they haven’t a clue.”

³⁴ This is A+, CompTIA, www.comptia.com.

³⁵ The Ongoing Crisis in IT Management, August 2001.

³⁶ Investing in the Future, September 1999; B. Lindsay Lowell, Information Technology Companies and U.S. Immigration Policy: Hiring Foreign Workers, Institution for the Study of International Migration, School of Foreign Service, Georgetown University, March 2000.

³⁷ When Can You Start?, April 2001.

IT workers also see great value in experience. Many who answered the Commerce Department's online questionnaire deemed experience to be more important than training or said that, after some initial formal education and training, experience was the best teacher for continuing in an IT career. **This view is reflected in the high priority IT workers place on learning IT in a real workplace, with real projects and problems, through hands-on, on-the-job training.** IT workers believe formal training leaves gaps; IT is learned well by getting in the trenches.

Lack of experience in a specific skill or skills was one of the largest barriers IT workers said they faced in getting an IT job. In addition, some IT workers expressed frustration that employers not only want job experience in specific technical skills, but that the experience requirement often extends to specific *versions* of that technology. For example, one respondent to our questionnaire said that he had experience in JavaBeans, but the employer was not interested because the employer wanted experience in Enterprise JavaBeans. Another said he had COBRA 1.1 and Java, but did not have CORBA 1.2 or JavaBeans, so his resume was ignored. Another IT worker pointed out that DB2 and Oracle databases both use SQL language to control data and programmers can easily move between them with little retraining, but employers and recruiters would be unlikely to see it that way. A few workers believed that having too much experience was a problem, because employers anticipated that the salary expectations of such workers would be beyond what the employer would be willing to pay.

Employer requirements for actual job experience in the application of technical skills present newly trained workers with a significant barrier to entry into the IT field. This barrier extends to current IT workers who, for purposes of seeking a new job, acquire new skills through training but have no experience in their application. An employer may not consider hiring a current IT worker for a job based only on course work in a desired technical skill. This presents a chicken-and-egg dilemma: Employers want to expand the IT workforce with new workers and new skills, but they do not often show a willingness to hire inexperienced entrants into the IT field. On the other hand, newly trained IT workers need a job to begin building the base of experience employers want.

Arena IV. Soft Skills and Business Skills

As IT has become ubiquitous throughout organizations and central to mission-critical operations, employers have placed an increasing emphasis on IT workers' business skills and soft skills, such as the ability to communicate effectively and to work in a collaborative environment.

In the early days of IT, soft skills and business skills took a back seat to technical skills. IT—or data processing, as it was known at the time—represented the leading frontier of scientific and engineering knowledge. Accordingly, the people who were bringing this technology into corporations and other organizations were leading-edge scientists and engineers with little knowledge, experience, or even interest in business, and many came from environments where little emphasis was placed on soft skills. Over the years, the lack of social skills contributed to their public reputation as “nerds,” “geeks,” “bit heads,” “propeller-heads,” and the like.

During this early period, data processing was an offline, stovepiped, backroom function. IT workers generally worked separately from their co-workers in mainline business functions such as accounting, production,

sales, marketing, and human resources. Accordingly, there was little need for strong communication skills across disciplines. While programmers needed to talk to other programmers, they spoke a technical language all their own that was generally inaccessible to those outside the profession. In addition, their academic preparation was primarily technical in nature and did not include extensive work in communication or business-related skills.

“In the past, [a company’s focus] used to be on the technology. The IT professionals were the ones with the pocket protectors. And they sat in their little cube and didn’t discuss anything. But now they’re critical. They need to understand what it means to interact with the customer. They need to know how to work across groups, because their job is so impactful on a number of other groups, that they have to be able to have those social skills and their soft skill set.”

—employer participant in the Silicon Valley roundtable

Early business applications of IT were mostly peripheral to the core business function, often involving an administrative function such as data processing for accounting, payroll, and records management. The high cost and rudimentary capabilities of IT in its early years—punchcards, batch processing, lack of connectedness, small memory and storage, slow processors, limited software availability—limited its ability to improve or revolutionize core business functions. Over time, as technology advanced, costs decreased, and personal and institutional barriers fell, IT became increasingly important to the overall function of business.

Today, IT is central to nearly all core business functions and to the overall operation of most companies, and IT professionals are integral to the core business team. IT’s centrality to business was accelerated in recent years by advances in local networking that enabled the sharing and

use of previously compartmentalized information; the development of large-scale networks through advances in information and communications technology that enabled the explosive growth of the Internet in the 1990s; the development of e-commerce applications; and the trend toward enterprise integration, both within a company's walls and with its supply chain and customers. Once confined to the back room, IT workers today are found throughout the organization.

Accordingly, soft skills (e.g., interpersonal skills, oral and written communications, teamwork, problem solving, and critical thinking) and business skills (e.g., needs analysis, project management, client/customer relations, understanding company financial information, and cost-benefit analysis), which have for many years been important to the advancement of nontechnical professional workers, have become increasingly important for IT workers.

Generally, higher level IT jobs require greater integration across business functions, requiring a deeper understanding of business issues and greater mastery of soft skills to interact with nontechnical personnel. IT professionals often spend more time with end users in business units—understanding their problems and needs, conceptualizing technical approaches to address their needs, and implementing solutions—than they do writing code.

A number of studies and surveys indicate that soft skills and business skills are viewed by senior executives as more predictive of success than are technical skills. The Virginia Governor's Information Technology Commission reported that "interpersonal and leadership skills,

"A programmer spends maybe 20 percent of his or her time actually working on code. The rest of the time is spent attending meetings with clients, giving presentations to clients or other members of the technical team, getting feedback from other programmers on code, and the like. A big problem for companies is finding technicians who have people skills to deal with clients or end users. Old-school programmers don't fit into the new world of strong service orientation and extensive interaction with customers."

—Building a World-Class Information Technology Workforce for the Chicago Region, 2001 (quoting a Chicago university computer science faculty member)
Council for Adult and Experimental Learning

along with adaptability and generic reasoning and problem-solving skills, were identified by the CEOs and CIOs in our focus group as better predictors of on-the-job success than technical experience."

One participant in the federal CIO roundtable stated that surveys of CIOs showed that "...we can really do without the techie skills. We want someone to be able to work in the team, to persuade, to be able to get buy-in....Leadership was at the top of their list [of desirable attributes in an IT worker]. This is for the chief information officer. You

would have thought that techie skills would have been at the top of that list." Federal IT managers may be focusing less on IT skills than on soft skills and business skills as a result of extensive IT outsourcing and the need to manage contractors rather than build IT systems.

A 1999 report of the University of Arkansas at Little Rock³⁸ concluded that people with both technical and soft skills enjoy “unlimited opportunities” with “knowledge-based” companies. Even those with substantial soft skills but limited technical skills have strong opportunities. Arkansas-area IT executives indicated a willingness to “make a place” for individuals with minimal technical skills who demonstrated initiative, leadership ability, and a willingness to learn and adapt.

A survey of IT company and non-IT company hiring managers by the Information Technology Association of America³⁹ showed that a range of soft skills—led by loyalty to organization, interpersonal skills, and oral and written communication skills—was considered important to advancement (see figure 11).

Figure 11. ITAA Survey of Employability Skills Deemed Important to Advancement

	IT Companies	Non-IT Companies
Loyalty to organization	98%	96%
Interpersonal skills	97%	96%
Oral and written communication skills	97%	94%
Ability to monitor and correct self	96%	91%
Analytical skills	91%	95%
Project management skills	91%	89%
Ability to select proper equipment and tools	81%	81%

In the course of the Commerce Department’s roundtables, many employers articulated the importance of soft skills and business skills for IT workers, and generally agreed that the need for these skills depends, in part, on the nature of the IT job.

One federal laboratory CIO said, “In many cases, for the job, you want to lock this person in the room. They take care of what they’ve got to do. It doesn’t matter whether they can talk to anybody else, because they’re getting the job done by themselves....In other cases, the soft skills are probably more important because if you can’t make that customer have that warm and fuzzy [feeling] and be happy that you’re accomplishing what they need to accomplish, it doesn’t matter really how good technically you are; they’re not going to be comfortable.”

This view was echoed by an IT worker at the Seattle roundtable, who said, “If you’re dealing with routers, perhaps the industry and the business skills don’t really matter and perhaps your

³⁸ Preparing for a New Century: Information Technology Workforce Needs in Arkansas, University of Arkansas at Little Rock, 1999.

³⁹ When Can You Start?, April 2001.

soft skills don't matter so much. If you're locked in a room doing wiring, it's not as important. If you're building business applications, then all of a sudden you're much more industry-sensitive, business-sensitive. Your soft skills are more important."

Overwhelmingly, though, employers believed that all IT professionals need to have some level of soft skills and business skills. "Even for our people that lock themselves in a room...there's a virtual communications piece and there's also an ethics and a new virtual world that are absolutely critical. Those are skills that need to be learned well," said one senior federal agency IT executive.

In addition to soft skills, CIOs expressed a desire for IT professionals to have a foundational understanding of core business functions (e.g., marketing, accounting, finance) and core business concepts (e.g., ability to read and comprehend a budget, a balance sheet, and an income and expense summary).

Information technology is supposed to enable business processes, said one human resources executive of a large IT-using (insurance) company, but "if you don't understand some of those core business processes, it's pretty difficult to enable them."

It is important for IT workers to have some understanding of business concepts to enable them to effectively communicate with line managers as they seek to wield IT as a tool to improve productivity and exploit real-world business opportunities. "We really see technology as what will make or break us. And so we look for opportunities for IT to provide revenue," added an IT executive from the banking industry.

Employers believe that undergraduate degrees often do not provide adequate preparation in business skills, and that attaining an MBA helps provide IT workers with the "needed business acumen, ability to assess, analyze, and follow where the markets are heading," in the words of an executive with a large IT-producing company. "It's not just about great technology; it's about great technology that you can generate revenue from."

While employers value formal business education, IT workers also need the practical experience that comes from applying that knowledge. According to a financial services industry executive, even those who have coupled an MBA with their undergraduate education and technical skills often have "no clue how to run a business or manage people," because they lack real-world business experience.

Business knowledge is needed primarily to enable effective interactions with other parts of the enterprise, but its absence can also be a problem in the way IT workers conduct their division's operations. For example, it may manifest as a lack of understanding of the planning, budgeting, and cost-benefit analysis that must be performed to justify equipment and software purchases. As one roundtable participant from the electronics industry asked, "Does anyone else

have an issue where your IT people maybe don't quite understand the concept of budgeting and finances? And they figure, 'But why can't I spend \$50,000 on equipment?'"

Another key business skill mentioned repeatedly by employers in all sectors is project management. This skill is in high demand because of the nature of IT projects, which are often complex, expensive, and multidisciplinary. In addition, these projects are often mission-critical; that is, the organization's ability to conduct its business depends in large measure on the success of the project. Employers need project managers who can plan and execute projects effectively, on time and within the budget. Project managers need strong conceptual, interpersonal, financial, time-management, and problem-solving skills. In the Commerce Department's roundtable with federal IT managers, several stressed the need for contract management skills, as federal agencies increasingly outsource their IT operations.

Roundtable participants also identified the outsourcing of IT functions as a driver of demand for communication and business skills. As companies and government agencies contract outside their organization for IT services, the need for hands-on technical skills is reduced while the requirement for skills to articulate needs, negotiate contracts, and manage relationships with IT service providers increases. "You need to understand technology, but you need the financial skills, the acquisition skills, the [program management] skills," said a federal agency executive.

Similarly, at the Commerce Department's Boston roundtable, a marketing executive from a large software company illustrated the importance of communication skills to effective outsourcing: "Take the car. Ten years ago, 15 years ago, 80 percent of it was built inside GM, Ford, Mercedes, etc. Now, 80 percent of it is outsourced. So the engineer has to have communication skills to work with the suppliers, manufacturing, finance folks, marketing, etc., and if they don't have those skills, then their ability to create innovative products is going to be severely limited."

Given the importance employers place on business skills, seasoned IT professionals who have progressed in their careers doing technical jobs—such as programming and network administration—must acquire business skills if they want to advance into management positions. "There's an intensive need for that kind of shot in the arm—of giving them context, giving them the capability of understanding how they fit into the business," said one roundtable participant.

Key Soft Skills

Communication Skills

The soft skill mentioned most often by employers is the ability to communicate effectively. Employers want IT professionals who can communicate well with a variety of stakeholders (e.g., corporate executives, line business managers, end users, clients/customers, other technical workers), both inside and outside the company, with widely varying degrees of technical knowledge.

IT workers need to be able to communicate orally and in writing; formally and informally; and one on one, in small groups, and with large audiences. As communication is a two-way street, IT workers need to have good listening and reading comprehension skills, and must be able to understand not only what is said but what is implied or intended. In addition, employers value IT workers who:

- Are able to effectively engage in and facilitate conversations;
- Clearly and concisely articulate their ideas to clients, senior executives, and managers who will make go/no-go decisions, and to other technical workers who will participate in building systems (programmers, network engineers, software engineers, etc.);
- Have a command of the English language, including grammar, composition, and vocabulary;
- Effectively translate technical ideas into plain English for non-IT people, avoiding the use of confusing techno-lingo, buzzwords, and acronyms;
- Develop and deliver multimedia presentations that effectively employ video, graphics, and other media to support their communications; and
- Understand how to use a variety of communication styles to accommodate the international, racial, and ethnic diversity of today's global labor and business markets.

The importance of communication skills to the success of IT professionals came as a surprise to some: "One of the things this [survey] did find is that soft skills really did play a much more important part than I think anybody really thought they did," said an IT industry association executive, adding, "The technical aspects were wonderful and absolutely needed as a baseline, but if they [the IT professionals] couldn't communicate internally or externally, there was a real problem." A manufacturing consulting executive at the Chicago roundtable said that "techno-speak"—the use of complex, confusing terms and acronyms that have meaning only to those immersed in the technology—is a significant barrier to IT professionals' effective communication. "They need to realize they're talking to mere mortals and kind of talk to us that way," he said.

Interpersonal/Team Skills

Today, IT employees often work with people from a variety of professional backgrounds (including other IT workers with complementary skill sets, accounting,

"The technology has become more complex and more ubiquitous, especially in mission-critical applications, forcing system development to occur in a team environment; the needs of the end user play an increasingly important role in defining system performance requirements, forcing developers to better understand a user's needs (even when he does not understand them himself); and the methodology of development has changed in many cases, now emphasizing the use of cross-functional work teams that must interact with each other."

—Building a Workforce for the Information Economy,
October 2000
National Research Council



Chicago Roundtable

financing, sales, marketing, training, and other specialists) and with a variety of demographic characteristics, such as gender, ethnicity, national origin, and religion.

Accordingly, employers want IT workers with two closely interrelated skill sets: **interpersonal skills** (such as negotiation and conflict management skills, and the ability to engender confidence and trust and to influence people) and **team skills** (such as interteam communication; working cooperatively with others; working toward a common goal; partnership/team building; willingness to share one's knowledge with other team members; and sensitivity to others of different backgrounds, learning styles, and approaches to work).

In a survey conducted by the Information Technology Association of America, 77 percent of IT companies and 68 percent of non-IT companies rated interpersonal skills as being "of most importance in evaluating job candidates."⁴⁰

Systems Thinking

Employers want IT workers with the ability to see the big picture, to understand how everything fits together and the relevance of their work to the organization's mission—whether it's a company's bottom line or a federal agency's mission. Employers discussed this skill in our roundtables as "the enterprise view," "systems thinking," "the ability to strategically envision a project from the beginning to the end," and "integrative product and process development." While this is a useful skill for all workers, it is especially important for IT workers, because their work often spans the full scope of an organization's activities and is often central to its success.

⁴⁰ When Can You Start?, April 2001, p. 31.

Creative, Critical, and Analytical Thinking Skills/Problem Solving

One of the most valued skills in IT workers is the ability to apply information technology to real-world situations—to take advantage of opportunities, solve problems, aid in management, improve productivity, reach customers, and so on. In addition to business and technical skills, this requires skills often broadly associated with intelligence: critical thinking, problem solving, and analytical skills. A worker must apply logic and reason to understand the challenge or opportunity, develop options, assess the best course of action, and execute it. “The key skill that one needs for success in IT is good analytical ability. The knowledge of XYZ language is only 5 to 10 percent. The ability to solve a problem and communicate that solution, that’s very important,” said one IT worker at the Department’s New Jersey roundtable.

Employers identified a number of specific skills that support this broader skill set: ability to visualize and conceptualize; ability to set up a process to solve a problem; investigative, diagnostic, and troubleshooting skills; logical and deductive reasoning; mathematical skills

“In terms of learning pace, verbal skills, numerical abilities, and reasoning capacity, successful performers in these positions comprise the top 30 percent of the population.”

—“Final Report on a Benchmarking Pilot Study for the Governor’s Commission on Information Technology”
The Leadership Edge, September 1999

and reasoning; graphical interpretation skills; and ability to transfer theoretical knowledge to real-world applications.

Some employers expressed the view that the rapid pace of change in IT makes it difficult to identify skill needs years in advance. Therefore, to assess

IT workers’ potential for future success, employers often look to strength in this suite of skills—critical thinking, problem solving, analytical skills, ability to “think outside the box”—as well as their flexibility, adaptability, and ability to learn quickly.

Ability to Learn Quickly/Adaptability

The rapid pace of technological change in information technology—in operating systems, programming languages, hardware, commercial software, etc.—means that IT workers must be able to learn quickly and adapt to change. In addition, the information technology—both hardware and software—available or required for a particular company or application may vary significantly from project to project. Time and cost constraints often do not permit formal training. As a result, IT workers must be able to learn “on the fly” as they do the job, which implies a high level of self-directed learning. IT workers must be able to use a variety of resources to learn: training manuals, textbooks, computer-based training, online courses, colleagues, and user groups.

Change Agent/Initiative/Leadership

Information technology can lead to significant improvements in productivity and profitability. However, to achieve these benefits, it is often not enough to automate existing processes; the organization’s business model, structure, products, and processes may have to be wholly

Business Skills and Soft Skills

Business Skills

"Be the customer" mentality
 Identify customer needs
 Conduct requirements analysis
 Customer service
 Develop relations
 Meet needs
 Evaluate satisfaction
 Handle irate customers
 Ability to apply technology to business problems, opportunities
 Project management/organizational skills
 Ability to accurately assess time, cost, and resources required for a project
 Ability to lead change
 Ability to develop, implement, and evaluate work processes and procedures
 Ability to establish and maintain schedules
 Understanding business functions
 Sales and marketing
 Finance and accounting
 Human resources
 Production/manufacturing
 Understanding business concepts
 Ability to read a balance sheet
 Ability to read a profit and loss statement
 Cost-benefit analysis
 Strategy/strategic positioning
 Company security

Soft Skills

Oral and Written Communication Skills
 Oral communication
 General writing
 Technical writing
 Presentation skills
 Use of visual media/graphics
 Reading comprehension
 Oral comprehension/active listening
 Ability to communicate with nontechnical people
 Command of English language, including grammar, composition, and vocabulary

Creative, Critical, and Analytical Thinking/Problem Solving
 Idea initiation
 Investigative skills
 Identifying (diagnosing) problems
 Testing/troubleshooting
 Logical and deductive reasoning
 Problem-solving process

Transferring knowledge to application
 Ability to visualize/conceptualize
 Mathematical reasoning/mathematical skills
 Critical thinking/analytical abilities
 Ability to synthesize knowledge
 Systems thinking
 Graphical interpretation
 Resourcefulness

Ability to Learn Quickly/Adaptability
 Ability to learn quickly/"on the fly"
 Ability to undertake self-directed learning
 Ability to identify and use educational resources
 Interest/desire to learn
 Adaptability to change (new technology, new languages, etc.)

Interpersonal/Team Skills

Approachability
 Leadership
 Ability to engender confidence and trust
 Ability to motivate others
 Ability to influence
 Ability to negotiate
 Conflict management
 Collaborative problem solving
 Ability to communicate with team members
 Ability and willingness to work as a member of a team
 Partnership/team building
 Willing to share knowledge with team members
 Sensitivity to others with different backgrounds, learning styles, and approaches to work

Personal Skills/Attributes

Ability to prioritize and track multiple projects
 Stress management/ability to perform under stress and time restrictions
 Time management
 Curiosity
 Self-confidence
 Ability to work independently
 Perseverance/commitment
 Creativity
 Patience
 Self-starting, but able to follow instructions
 Ability to think quickly/on their feet
 Ability to deal with ambiguity
 Action oriented
 Follows up
 Self-motivated
 Ability to meet deadlines

revised. In these cases, information technology can drive fundamental change throughout the organization. Such change is often associated with significant resistance from managers and workers alike who are invested in the status quo. (“We tried that, it doesn’t work.” “We’ve always done it this way.” “Why should I have to adapt to the technology?”) Often, employers want their IT professionals to serve as change agents: identifying, conceptualizing, and implementing improvements to existing processes; creating new ones; and driving their implementation. The initiative and leadership skills related to this change agent function are highly valued by employers.

Putting It All Together

In recruiting IT workers, employers look for a combination of:

- *Formal Education*—Generally at least a four-year degree, often a technical degree.
- *Technical Skills*—A highly specialized technical skill set related to specific programming languages; database, networking, and operating systems; and other technologies. These technical skills can be combined in many ways.
- *Experience*—Hands-on, real-world experience in the application of the technical skill set; sometimes, experience related to the application of IT in a particular industry setting.
- *Soft and Business Skills*—A range of soft skills and business skills, such as oral and written communication skills, ability to work in teams, and project management skills.

These requirements differ from IT job to IT job, and are especially diverse in the technical skills arena. Taken together, they create a profile for which a candidate would need a highly specialized set of education, skills, and experiences that collectively meet the recruitment parameters for a certain job. Several roundtable participants referred to this niche as “the sweet spot.”

Other requirements—such as obtaining a security clearance or passing a drug test—may be added, and some employers in the roundtables also discussed their desire for a range of personal attributes, such as ability to perform under stress, curiosity, self-confidence, perseverance, resourcefulness, high energy, and action orientation.

Brian Jaffee of *PCWeek* describes the specialization of IT jobs this way:

“It is not about the size of the IT labor pie. Instead, it’s a reflection of the fact that there are so many ways to slice that pie that hiring managers may only be left with a crumb after they carve out their needs.

For example, a database administrator is not simply a DBA. There are different data base products—Oracle and Informix, for example. Each has several versions in widespread use and different versions of those offerings for different technology platforms

and operating systems. If you prefer a DBA who has experience with other key technologies in your environment, your options are further reduced.

Perhaps you want specific project experience, say, building a data warehouse. Throw in other parameters such as environment size, industry, years of experience, communication or supervisory skills, certification, and salary range, and the grains of sand quickly slip through your fingers.”⁴¹

Even if a company receives many resumes from which to fill its job (and many employers and technical recruiters do receive numerous resumes), the right candidate, with the right skills and experience, may not be in the resume mix, which often results in low selection rates.⁴²

Using the Venn diagram to model formal education, technical skills, soft/business skills, and experience, figure 12 shows real IT job recruitment announcements from the Monster.com database, illustrating the highly specialized or “niche” nature of IT jobs. Figure 13, drawn from BLS information, shows these categories of knowledge and skills more generically for a sampling of IT occupations.

IT workers and employers have different perspectives on how well employers’ stated requirements—in terms of education, skills, and experience—match the actual requirements of the jobs advertised. By a factor of about 5 to 1, IT workers who provided comments for this review said that there was not a close match. In contrast, nearly every IT employer believed that the advertised skill requirements closely matched the actual skills required.

Most IT workers said they believe employers often overstate the requirements, often referring to employer expectations as “wish lists.” These workers cited a variety of reasons for the mismatch, including these: (1) human resources personnel do not understand the technologies, the technical skill requirements, or the ability of a competent IT worker to transfer skills from one application to a similar application; (2) the farther up the management chain, the more likely an IT manager will not know how to do the job and will not understand the technology or skill requirements; (3) employers try to eliminate U.S. candidates through overspecification of requirements to enable them to hire lower cost foreign workers; (4) employers overstate the requirements to hide the unpleasant reality of a job (dead-end, tedious work; onerous user support expectations); (4) the dynamic nature of IT projects results in unexpected changes in directions, requiring new knowledge and skills; (5) employers ask for more than they need because they don’t want to allow for any on-the-job training; and (6) the downturn in demand for IT workers has enabled employers to get overqualified candidates at a low cost.

⁴¹ Brian D. Jaffee, *I’ve Looked at Life from Both Sides Now*, *PCWeek*, March 8, 1999.

⁴² Norman Matloff, *Debunking the Myth of a Desperate Software Labor Shortage*, University of California at Davis, 2001, http://heather.cs.ucdavis.edu/itaa.real.html#tth_sEc4.1; Marcus Stern, *Some Can’t Find Work Despite Computer Skills, Yet Industry Says It Must Hire Foreigners*, *San Diego Union-Tribune*, March 7, 1998.

Figure 12. Requirements in Recruitment Ads

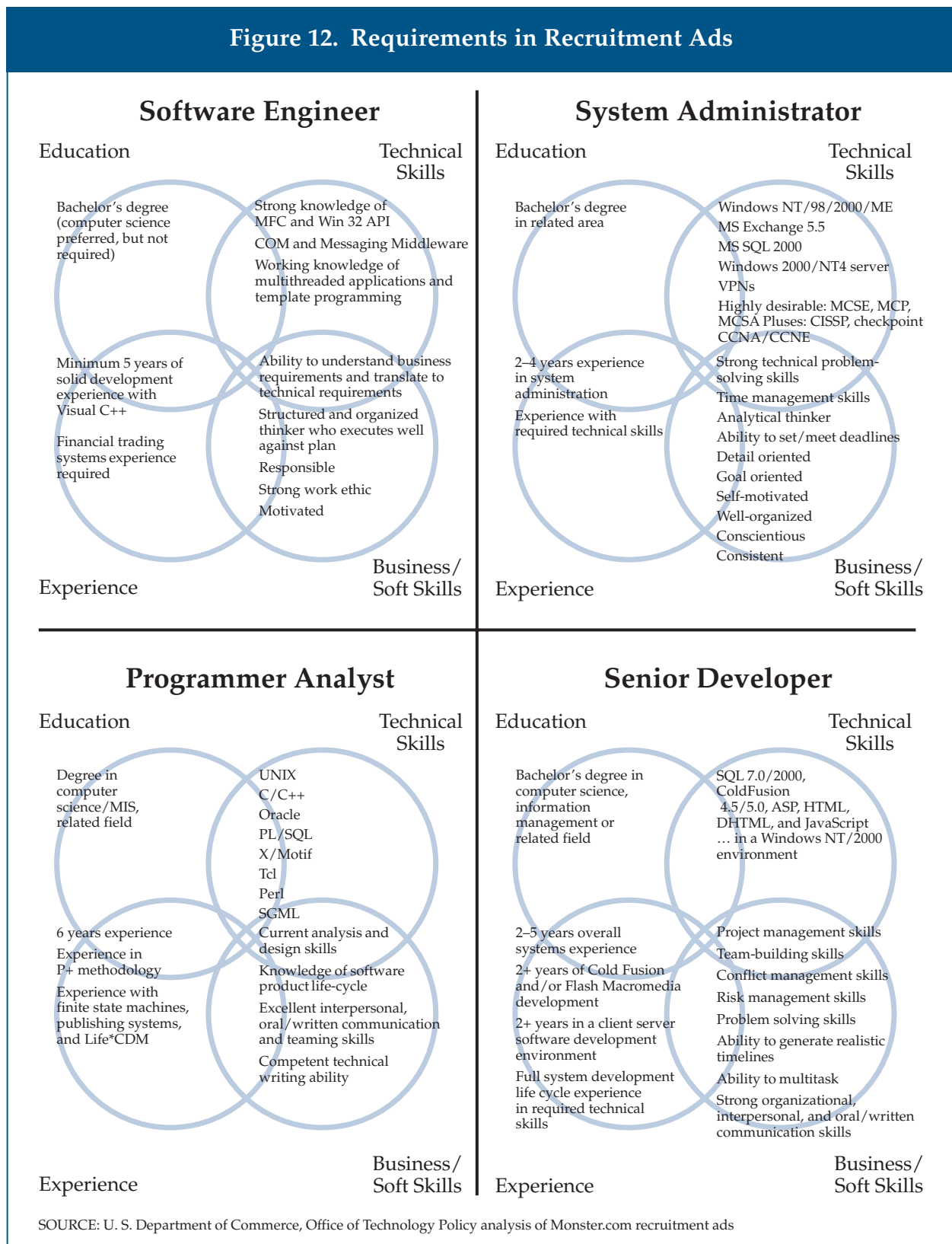


Figure 13. IT Worker Knowledge, Skills, and Experience

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
Computer Hardware Engineers	<p>A bachelor's degree in engineering is required for almost all entry-level engineering jobs.</p> <p>In a typical 4-year college curriculum, the first 2 years are spent studying mathematics, basic sciences, introductory engineering, humanities, and social sciences. In the last 2 years, most courses are in engineering.</p> <p>Some engineering schools and 2-year colleges have agreements whereby the 2-year college provides the initial engineering education and the engineering school automatically admits students for their last 2 years.</p> <p>A few engineering schools have arrangements whereby a student spends 3 years in a liberal arts college studying preengineering subjects and 2 years in an engineering school studying core subjects, and then receives a bachelor's degree from each school.</p> <p>Some 5- or even 6-year cooperative plans combine classroom study and practical work, permitting students to gain valuable experience and finance part of their education.</p> <p>All 50 states and the District of Columbia usually require licensure for engineers who offer their services directly to the public.</p>	<p>Beginning engineering graduates in large companies may receive formal classroom or seminar-type training.</p>	<p>Beginning engineering graduates usually work under the supervision of experienced engineers.</p>	<p>Engineers should be creative, inquisitive, analytical, and detail-oriented.</p> <p>They should be able to work as part of a team and to communicate well, both orally and in writing.</p>	<p>Engineers may advance to become technical specialists or to supervise a staff or team of engineers and technicians. Some may eventually become engineering managers or enter other managerial or sales jobs.</p>

Figure 13. IT Worker Knowledge, Skills, and Experience, continued

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
Computer Software Engineers	<p>Most employers prefer to hire persons who have at least a bachelor's degree and broad knowledge and experience with computer systems and technologies.</p> <p>Usual degree concentrations for applications software engineers are computer science or software engineering; for systems software engineers, usual concentrations are computer science or computer information systems.</p> <p>Graduate degrees are preferred for some of the more complex jobs.</p> <p>Academic programs in software engineering emphasize software and may be offered as a degree option or in conjunction with computer science degrees.</p>	<p>Inexperienced college graduates may be hired by large computer and consulting firms that train new hires in intensive company-based programs.</p> <p>For systems engineering jobs that place less emphasis on workers having a computer-related degree, computer training programs are offered by systems software vendors, including Microsoft, Novell, and Oracle. These training programs usually last from 1 to 4 weeks but are not required in order to sit for a certification exam; several study guides also are available to help prepare for the exams. However, many training authorities feel that program certification alone is not sufficient for most software engineering jobs.</p>	<p>Students seeking software engineering jobs enhance their employment opportunities by participating in internship or co-op programs offered through their schools. These experiences provide students with broad knowledge and experience, making them more attractive candidates to employers.</p> <p>Computer software engineers must continually strive to acquire new skills if they wish to remain in this extremely dynamic field. To help them keep up with the changing technology, continuing education and professional development seminars are offered by employers and software vendors, colleges and universities, private training institutions, and professional computing societies.</p>	<p>Persons interested in jobs as computer software engineers must have strong problem-solving and analytical skills.</p> <p>They also must be able to communicate effectively with team members, other staff, and customers.</p> <p>And because they often deal with a number of tasks simultaneously, they must be able to concentrate and pay close attention to detail.</p>	<p>Entry-level computer software engineers are likely to test and verify ongoing designs.</p> <p>As they become more experienced, computer software engineers may be involved in designing and developing software.</p> <p>They eventually may advance to become a project manager, manager of information systems, or chief information officer.</p> <p>Some computer software engineers with several years of experience or expertise find lucrative opportunities working as systems designers or independent consultants or starting their own computer consulting firms.</p>

Figure 13. IT Worker Knowledge, Skills, and Experience, continued

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
Computer Programmers	<p>Bachelor's degrees are commonly required, although some programmers may qualify for certain jobs with 2-year degrees or certificates.</p> <p>While there are many training paths available for programmers—mainly because employers' needs are so varied—the level of education and experience employers seek has been rising due to the growing number of qualified applicants and the specialization involved with most programming tasks.</p> <p>About 3 out of 5 computer programmers had a bachelor's degree or higher in 2000. Of these, some held a degree in computer science, mathematics, or information systems, whereas others had taken special courses in computer programming to supplement their study in fields such as accounting, inventory control, or other areas of business. Required skills vary from job to job, but the demand for various skills generally is driven by changes in technology.</p> <p>Employers using computers for scientific or engineering applications usually prefer college graduates who have degrees in computer or information science, mathematics, engineering, or the physical sciences. Graduate degrees in related fields are required for some jobs.</p> <p>Employers who use computers for business applications prefer to hire people who have had college courses in management information systems (MIS) and business and who possess strong programming skills.</p> <p>Systems programmers: Most systems programmers hold a 4-year degree in computer science.</p>	<p>Because technology changes so rapidly, programmers must continually update their training by taking courses sponsored by their employer or software vendors.</p> <p>Employers are primarily interested in programming knowledge, and computer programmers can get certified in a language such as C++ or Java.</p> <p>College graduates who are interested in changing careers or developing an area of expertise may return to a 2-year community college or technical school for additional training.</p> <p>Although knowledge of traditional languages is still important, increasing emphasis is placed on newer, object-oriented programming languages and tools, such as C++ and Java. Additionally, employers are seeking persons familiar with fourth- and fifth-generation languages that involve graphical user interface (GUI) and systems programming.</p> <p>Technical or professional certification is a way to demonstrate a level of competency or quality. In addition to language-specific certificates that a programmer can obtain, product vendors or software firms also offer certification and may require professionals who work with their products to be certified. Voluntary certification also is available through other organizations. Professional certification may provide a job seeker with a competitive advantage.</p> <p>Systems programmers: Extensive knowledge of a variety of operating systems is essential. This includes being able to configure an operating system to work with different types of hardware and adapting the operating system to best meet the needs of a particular organization. Systems programmers also must be able to work with database systems, such as DB2, Oracle, or Sybase.</p>	<p>In the absence of a degree, substantial specialized experience or expertise may be needed.</p> <p>Even if the worker has a degree, employers appear to be placing more emphasis on previous experience for all types of programmers.</p> <p>Students can improve their employment prospects by participating in a college work-study program or by undertaking an internship.</p>	<p>Employers prefer applicants who have general business skills and experience related to the operations of the firm.</p> <p>When hiring programmers, employers look for people with the necessary programming skills who can think logically and pay close attention to detail.</p> <p>The job calls for patience, persistence, and the ability to work on exacting analytical work, especially under pressure.</p> <p>Ingenuity and imagination also are particularly important when programmers design solutions and test their work for potential failures.</p> <p>The ability to work with abstract concepts and to do technical analysis is especially important for systems programmers, because they work with the software that controls the computer's operation.</p> <p>Because programmers are expected to work in teams and interact directly with users, employers want programmers who are able to communicate with nontechnical personnel.</p>	<p>Entry-level or junior programmers may work alone on simple assignments after some initial instruction or on a team with more experienced programmers. Either way, beginning programmers generally must work under close supervision.</p> <p>For skilled workers who keep up to date with the latest technology, the prospects for advancement are good. In large organizations, programmers may be promoted to lead programmer and be given supervisory responsibilities.</p> <p>Some applications programmers may move into systems programming after they gain experience and take courses in systems software.</p> <p>With general business experience, programmers may become programmer analysts or systems analysts or be promoted to a managerial position.</p> <p>Other programmers with specialized knowledge and experience with a language or operating system may work in research and development areas, such as multimedia or Internet technology.</p> <p>As employers increasingly contract out programming jobs, more opportunities should arise for experienced programmers with expertise in a specific area to work as consultants.</p>

Figure 13. IT Worker Knowledge, Skills, and Experience, continued

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
Computer Support Specialists and Systems Administrators	<p>While there is no universally accepted way to prepare for a job as a computer support specialist, many employers prefer to hire persons with some formal college education. A bachelor's degree in computer science or information systems is a prerequisite for some jobs; however, other jobs may require only a computer-related associate degree.</p> <p>For systems administrators, many employers seek applicants with bachelor's degrees, though not necessarily in a computer-related field. Many companies are becoming more flexible about requiring a college degree for support positions because of the explosive demand for specialists.</p>	<p>Certification and practical experience demonstrating their skills are essential for applicants without a degree. Completion of a certification training program, offered by a variety of vendors and product makers, may help some people qualify for entry-level positions.</p> <p>As technology continues to improve, computer support specialists and systems administrators must keep their skills current and acquire new ones. Many continuing education programs are offered by employers, hardware and software vendors, colleges and universities, and private training institutions. Professional development seminars offered by computing services firms also can enhance one's skills.</p>	<p>Relevant computer experience may substitute for formal education.</p>	<p>A person interested in becoming a computer support specialist or systems administrator must have strong problem-solving, analytical, and communication skills, because troubleshooting and helping others are a vital part of the job.</p> <p>The constant interaction with other computer personnel, customers, and employees requires computer support specialists and systems administrators to communicate effectively on paper, via e-mail, and in person.</p> <p>Strong writing skills are useful for preparing manuals for employees and customers.</p>	<p>Beginning computer support specialists start out at an organization dealing directly with customers or inhouse users.</p> <p>Then, they may advance into more responsible positions in which they use what they learn from customers to improve the design and efficiency of future products. Job promotions usually depend more on performance than on formal education.</p> <p>Eventually, some computer support specialists become applications developers, designing products rather than assisting users. Computer support specialists at hardware and software companies often enjoy great upward mobility; advancement sometimes comes within months of initial employment.</p> <p>Entry-level network and computer systems administrators are involved in routine maintenance and monitoring of computer systems, typically working behind the scenes in an organization. After gaining experience and expertise, they often are able to advance into more senior-level positions in which they take on more responsibilities. For example, senior network and computer systems administrators may present recommendations to management on matters related to a company's network. They also may translate the needs of an organization into a set of technical requirements, based on the available technology.</p> <p>As with support specialists, administrators may become software engineers, actually involved in designing the system or network, not just the day-to-day administration.</p>

Figure 13. IT Worker Knowledge, Skills, and Experience, continued

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
System Analysts, Computer Scientists, and Database Administrators	<p>While there is no universally accepted way to prepare for a job as a systems analyst, computer scientist, or database administrator, most employers place a premium on some formal college education. A bachelor's degree is a prerequisite for many jobs; however, some jobs may require only a 2-year degree. For more technically complex jobs, persons with graduate degrees are preferred. Despite the preference for technical degrees, persons with degrees in a variety of majors find employment in these computer occupations.</p> <p>For systems analyst, programmer-analyst, and database administrator positions, many employers seek applicants who have a bachelor's degree in computer science, information science, or management information systems (MIS). MIS programs usually are part of the business school or college. These programs differ considerably from computer science programs, emphasizing business- and management-oriented course work and business computing courses. Many employers increasingly seek individuals with a master's degree in business administration (MBA) with a concentration in information systems, as more firms move their business to the Internet.</p> <p>For some networks systems and data communication analysts, such as webmasters, an associate degree or certificate generally is sufficient, although more advanced positions might require a computer-related bachelor's degree.</p> <p>For computer and information scientists, a doctoral degree generally is required because of the highly technical nature of the work.</p> <p>Most community colleges and many independent technical institutes and proprietary schools offer an associate degree in computer science or a related information technology field.</p>	<p>The level of education and type of training employers require depend on their needs. As demonstrated by the current demand for workers with skills related to the Internet, employers often scramble to find workers capable of implementing "hot" new technologies.</p> <p>Technological advances come so rapidly in the computer field that continuous study is necessary to keep skills up to date. Employers, hardware and software vendors, colleges and universities, and private training institutions offer continuing education. Additional training may come from professional development seminars offered by professional computing societies.</p> <p>Technical or professional certification is a way to demonstrate a level of competency or quality in a particular field. Product vendors and software firms also offer certification and may require professionals who work with their products to be certified. Many employers regard these certifications as the industry standard. For example, one method of acquiring enough knowledge to get a job as a database administrator is to become certified in a specific type of database management.</p> <p>Voluntary certification also is available through other organizations.</p> <p>Professional certification may provide a job seeker with a competitive advantage.</p>	<p>Relevant work experience also is very important. Job seekers can enhance their employment opportunities by participating in internship or co-op programs offered through their schools.</p>	<p>Companies are looking for professionals with a broad background and range of skills, including not only technical knowledge but also communication and other interpersonal skills. This shift from requiring workers to possess only sound technical knowledge emphasizes workers who can handle various responsibilities.</p> <p>Employers usually look for people who have broad knowledge and experience related to computer systems and technologies, strong problem-solving and analytical skills, and good interpersonal skills.</p> <p>Because many people develop advanced computer skills in one occupation and then transfer those skills into a computer occupation, a related background in the industry in which the job is located—such as financial services, banking, or accounting—can be important.</p> <p>Others take computer science courses to supplement their study in fields such as accounting, inventory control, or other business areas. For example, a financial analyst proficient in computers might become a systems analyst or computer support specialist in financial systems development, while a computer programmer might move into a systems analyst job.</p> <p>Systems analysts, computer scientists, and database administrators must be able to think logically and must have good communication skills.</p> <p>They often deal with a number of tasks simultaneously; the ability to concentrate and pay close attention to detail is important.</p>	<p>Computer scientists employed in private industry may advance into managerial or project leadership positions.</p> <p>Those employed in academic institutions may become heads of research departments or published authorities in their field.</p> <p>Systems analysts may be promoted to senior or lead systems analysts.</p> <p>Those who show leadership ability also may become project managers or advance into management positions, such as manager of information systems or chief information officer.</p> <p>Database administrators also may advance into managerial positions, such as chief technology officer, on the basis of their experience managing data and enforcing security.</p> <p>Computer specialists with work experience and considerable expertise in a particular subject area or application may find lucrative opportunities as independent consultants or may choose to start their own computer consulting firms.</p>

Figure 13. IT Worker Knowledge, Skills, and Experience, continued

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
System Analysts, Computer Scientists, and Database Administrators	<p>Many of these programs are geared toward meeting the needs of local businesses and are more occupation-specific than those designed for a 4-year degree. Some jobs may be better suited to the level of training these programs offer.</p> <p>Courses in computer science or systems design offer good preparation for a job in these computer occupations. For jobs in a business environment, employers usually want systems analysts to have business management or closely related skills, while a background in the physical sciences, applied mathematics, or engineering is preferred for work in scientifically oriented organizations. Art or graphic design skills may be desirable for webmasters or Web developers.</p>			<p>Although these computer specialists sometimes work independently, they often work in teams on large projects. They must be able to communicate effectively with computer personnel, such as programmers and managers, as well as with users or other staff who may have no technical background.</p>	

Figure 13. IT Worker Knowledge, Skills, and Experience, continued

	Formal Training	Technical Skills	Experience	Soft Skills/ Business Skills	Employment Path
Computer and Information Systems Managers	<p>Strong technical knowledge is essential for computer and information systems managers, who must understand and guide the work of their subordinates yet also explain the work in nontechnical terms to senior management and potential customers. Therefore, these management positions usually require work experience and formal education similar to that of other computer occupations. Many computer and information systems managers have experience as systems analysts; others may have experience as computer support specialists, programmers, or other information technology professionals.</p> <p>A bachelor's degree is usually required for management positions, although employers often prefer a graduate degree, especially a master's degree in business administration (MBA) with technology as a core component. This degree differs from a traditional MBA in that there is a heavy emphasis on information technology in addition to the standard business curriculum. This becomes important because computer and information systems managers make not only important technology decisions but also important business decisions for their organizations.</p> <p>A few computer and information systems managers may have only an associate degree, provided they have sufficient experience and were able to learn additional skills on the job.</p>			<p>Opportunities for obtaining a management position are best for workers who have an MBA with technology as a core component, advanced technical knowledge, and strong communication and administrative skills.</p> <p>In high-technology firms, managers in nontechnical areas often must possess the same specialized knowledge as do managers in technical areas.</p> <p>In addition to technical skills, employers seek managers with strong business skills. Employers want managers who have experience with the specific software or technology to be used on the job, as well as a background in either consulting or business management. The expansion of electronic commerce has elevated the importance of business insight, because many managers are called upon to make important business decisions.</p> <p>Managers need a keen understanding of people, processes, and customers' needs.</p> <p>Computer and information systems managers must possess strong interpersonal, communication, and leadership skills, because they are required to interact not only with their employees but also with people inside and outside the organization.</p> <p>They must also possess team skills to work on group projects and other collaborative efforts. Computer and information systems managers increasingly interact with persons outside the organization, reflecting their emerging role as members of a firm's executive team.</p>	<p>Computer and information systems managers may advance to progressively higher leadership positions in their field. Some may become managers in nontechnical areas such as marketing, human resources, or sales.</p>

SOURCE: U.S. Department of Labor

III. THE IT EDUCATION AND TRAINING LANDSCAPE

To meet the high demand for skilled IT workers, the IT education and training infrastructure has grown significantly in size and scope over the past decade, and continues to expand. A wide range of education and training opportunities is available nationwide for workers who want to train to enter the IT field and for IT workers who want to expand, upgrade, or update their skills.

Workers who wish to acquire IT skills can choose from a rich and diverse education and training landscape. However, this diverse collection of education and training opportunities presents a challenge in trying to ascertain what type of program, format, provider, or credential will best meet the needs of workers training to enter the field, IT workers seeking to add to their skills, or employers seeking training for their workforce. Different IT education and training programs provide different knowledge and skills. Some—such as formal college programs in computer science—provide deep foundational knowledge in IT that can be especially important for those working in complex IT systems and applications development. Other programs provide narrow training, such as training on a specific vendor’s technology, which may be useful to an IT worker who wants to expand his or her repertoire of IT skills. In short, in IT education and training, there is no “one size fits all” and no easy way to navigate the maze of IT education and training offerings. Moreover, there are few career roadmaps to guide workers in career development.

Unquestionably, IT education and training are widely available. For example, a search of the New Jersey Training Resources database produces records for approximately 1,600 IT training programs or courses offered by nearly 170 training providers, including universities, community colleges, vocational training schools, private IT colleges, commercial IT schools, consulting firms, and more. Offerings range from 20- to 30-hour introductory courses in IT skills such as C++, Visual Basic, and Java, costing a few hundred dollars; to programs in programming, Oracle database, and other vendor-specific technologies that are several hundred hours in length and cost several thousand dollars; to programs that are over a thousand hours in length, including full three-year IT education programs at private IT colleges costing tens of thousands of dollars. Using other training databases to identify specific IT skills training programs, one can find at least 22 courses on Unix in Maryland, 11 on Perl in Texas, and 200 Microsoft-related programs in New York.⁴³ Skillsnet, a web site devoted to the development of digital media skills, offers a training database that lists 158 training programs in digital media, including degree, professional, and certificate programs, as well as training seminars.⁴⁴

The cost of IT training for ostensibly the same purpose can vary significantly, as can the length of such training. For example, in research for this report, training provider databases in three states were searched to identify training programs for the popular Microsoft Certified

⁴³ www.computeruser.com and www.wdsny.org.

⁴⁴ www.skillsnet.net.

Systems Engineer (Windows 2000) (MCSE) certification. There was wide variation in the cost of this training, from a low of \$2,000 to a high of \$13,907. A similar search for training for the networking entry-level Cisco Certified Network Associate (CCNA) certification yielded a low of \$899 to a high of \$6,230.

Seven of the MCSE programs spanning three states were described as 240 hours in length, but they varied in cost by as much as 100 percent: \$3,657, \$4,074, \$5,124, \$6,500, \$6,900, \$7,275, and \$8,000. Similarly, in a search of only the New Jersey database, which provides information on program length in “clock hours,” cost per hour of training for the MCSE credential ranged from a low of \$8.27 to a high of \$58.82—seven times higher in cost. For the CCNA credential, cost per hour ranged from \$9.33 to \$65.00—again, seven times higher in cost.

The wide variability in the cost and length of IT training programs means that workers and employers need good information to carefully review training programs for their objectives, content, skill level, depth of instruction, instructor credentials, quality, and value for the dollar in order to make sound decisions about the programs in which they choose to participate. Training program information systems, like those being developed by some states as part of their participation in Workforce Investment Act initiatives, are promising (figure 14).

Figure 14. Making It Easier to Find IT Training

New Jersey Training Sources (www.njtrainingsources.org) offers a database of work-related training programs that can be searched by occupational area (such as computer programming or computer science), by type of training (such as information technology), or by key word (such as MCSE or CCNA). The database returns a list of training programs, including provider name, program name, location, length in hours, and cost. Each training program listed links to additional information, including description of the program, Workforce Investment Act (WIA) funding eligibility, onsite child care, wheelchair accessibility, career counseling, languages spoken by staff, evening courses, job placement assistance, any costs above tuition (such as fees, books, and other materials), prerequisites, degree or other credential offered, contact for further information, and more. In addition, the training program database record is designed to eventually contain training program results (such as training completion rates and job placement) and to record comments from program participants.

New York State’s Workforce Training Provider list (www.wdsny.org/provider/) offers similar information on individual training programs, with additional information such as skill level, training objective, instructor credentials, class size, and training schedule. Pennsylvania’s database of training providers (www.pacareerlink.state.pa.us) has established a format for collecting performance measures on training provider services to those eligible for assistance under WIA and other clients. These measures focus on training program completion, job placement, employment retention, wages received, and program graduate credentials.

IT Bachelor’s Degrees

As IT knowledge has broadened and deepened, so, too, has the diversity of IT programs. Computing Curricula 2001 (CC2001)⁴⁵—a joint undertaking of the Computer Society of the Institute for Electrical and Electronic Engineers (IEEE-CS) and the Association for Computing Machinery (ACM) to develop curricular guidelines for undergraduate programs in computing—finds that

⁴⁵ www.computer.org/education/cc2001/final/es.htm.

IT knowledge has grown and specialized so dramatically over the past decade that it is no longer practical to establish a single, fundamental body of knowledge encompassing the whole of information technology that is essential to all IT workers. Accordingly, CC2001 has established four categories of knowledge for purposes of preparing collegiate IT curricula: computer science, computer engineering, software engineering, and information systems.⁴⁶ The Accreditation Board for Engineering and Technology (ABET) established curriculum accreditation requirements in each of these areas, as well as in computer engineering technology, which is offered at both the associate and bachelor's levels. See Appendix C for a description of these accreditation criteria.

Academic Settings for IT Bachelor's Programs. IT degree programs in colleges and universities can be found in a variety of settings within the institutions. For example:

- At the **University of California at Davis**, the Computer Science Department resides within the College of Engineering and offers majors in computer science and computer science and engineering, as well as a minor in computer science.
- At the **University of Illinois at Urbana-Champaign**, undergraduate degrees are offered by the Department of Computer Science in the College of Engineering and can be combined with the fields of mathematics, statistics, or teaching in the College of Liberal Arts and Sciences. Thus, you can earn a bachelor of science degree in computer science or computer engineering from the College of Engineering, or you can earn a BS in mathematics and computer science, statistics and computer science, or the teaching of computer science from the College of Liberal Arts and Sciences. The university also offers a degree in computer science and accountancy through a joint program of the Department of Computer Science and the College of Commerce and Business Administration.
- **Georgia Tech** has a separate College of Computing that offers a bachelor's in computer science.
- At the **University of Virginia**, the computer science department (which offers a major and minor in computer science) and the electrical and computer engineering department (which offers a bachelor's in computer engineering) are both part of the School of Engineering and Applied Sciences, while a concentration in management information systems is offered through the McIntyre School of Business.
- The **University of Michigan** has created a new computer science program that is available to students in both the College of Engineering (which offers a bachelor's in computer science) and the College of Literature, Science, and Arts (which offers a bachelor's in engineering-computer science).

⁴⁶ The developers of CC2001 decided to publish the document in four volumes, one dedicated to each of the four categories of knowledge. To date only the Computer Science Volume of CC2001 has been approved and published; the other volumes are currently under development.

Academic Prerequisites for Admission into an IT Bachelor's Program. Because IT bachelor's degree programs are found in a variety of institutions within a college (e.g., stand-alone computer science school, business/commerce school, engineering school, college of arts and sciences), academic prerequisites for admission are often the same as those for other degree programs. In fact, students may not even be required to declare a major until they have completed their second year of college. However, some schools have additional academic requirements in mathematics and science for entry into an IT degree program. This is particularly likely to be the case when the degree is offered as part of an engineering school.

According to the Department of Education,⁴⁷ typical admissions requirements for four-year colleges include:

- 4 years of English (grammar and composition, American literature, English literature, world literature)
- 3–4 years of mathematics (algebra I and II, geometry, trigonometry, precalculus, calculus)
- 2–3 years of history and geography
- 3–4 years of laboratory science (biology, chemistry, physics)
- 2–3 years of foreign language
- 1 year of the visual and performing arts
- 1–3 years of appropriate electives (computer science)

Higher levels of preparation in mathematics and laboratory sciences may aid in admission to some colleges' IT bachelor's programs.

In some university programs, the number of applicants significantly exceeds the number of openings.^{48,49} And while there has been a rapid expansion in computer science bachelor-level enrollments in recent years, there is some evidence that computer science programs in some

⁴⁷ U.S. Department of Education, www.ed.gov/Family/agbts/Questions/career.html.

⁴⁸ For example, the number of applications for computer science at the University of Massachusetts rose 307 percent between 1991 and 2000, while the acceptance rate fell from 73 percent to 30 percent. http://www.umass.edu/oapa/dept_pro/dp/ad/nsm/adnsm04.pdf.

⁴⁹ Even a reduction in overall applications to computer science programs has not eased competition for admission. Despite a 28 percent drop in applications to Carnegie Mellon University's computer science program between 2001 and 2002, Mike Steidel, director of undergraduate admissions at the university, says that out of more than 2,000 applications for Fall 2002, Carnegie Mellon expects to admit only 130 students to its computer science program (Computer Science Attracting Fewer Applicants, Education Week on the Web, May 1, 2002, www.edweek.org/ew/newstory.cfm?slug=33computer.h21).

schools may have reached a saturation point, with various factors constraining further growth.⁵⁰ In this competitive environment, the number and degree of difficulty of courses taken in high school, especially math and science courses, may be used to differentiate among candidates for admission.

Academic Requirements for Completion of an IT Bachelor's Degrees. In practice, requirements for a bachelor's degree in an IT field generally require completion of 120–130 semester hours of courses. Approximately one-third to one-half of these semester hours are specifically in IT courses (computer science, computer engineering, information science, electronics); one-third are in mathematics or natural sciences (physics, chemistry, biology) or general engineering; and one-fourth to one-third are in humanities (including writing and communications), social sciences, and electives. Computer engineering curricula tend to have higher IT-specific credit hour requirements and higher total credit hour requirements.

Specific academic requirements for IT bachelor's degrees vary depending on the institution and the specific IT discipline. This variety is driven by several factors: the growing body of IT knowledge and the accompanying need for specialization, the response to rapid changes and advances in information technology, the response to employers' needs and requirements, and accreditation requirements.

Program Accreditation. Universities' desire for accreditation is a driving force in the development of curricula leading to IT degrees. Until 1998, two leading organizations accredited IT degree programs: the Accreditation Board for Engineering and Technology, recognized as the organization responsible for the accreditation of U.S. engineering, engineering technology, and engineering-related educational programs, and the Computer Science Accreditation Board (CSAB), the primary accreditation organization for U.S. computer science programs.

In October 1998, CSAB merged with and became a part of ABET, which both organizations and the education community lauded as an important step in unifying the computing science and engineering communities.

Many universities offer accredited bachelor's degrees in one or more IT disciplines. Other programs, including those in some of the most prestigious universities, are not accredited. At some universities, one IT degree offering may be accredited while another is not. In the past, computer engineering programs were more likely to be accredited than computer science programs, although some universities whose programs were previously unaccredited are now seeking or planning to seek accreditation.

⁵⁰ The 2000–2001 Taulbee Survey of the Computer Research Association reports that "...some programs may be operating in 'saturation' mode, where they simply cannot accept more undergraduate majors given their teaching resources." (www.cra.org/statistics/survey/01/01.pdf).

Currently, 131 universities have accredited computer engineering programs.⁵¹ A handful of these institutions offer two distinct computer degrees. For example, the Massachusetts Institute of Technology (MIT) offers bachelor's degrees in computer science and engineering, and electrical engineering and computer science. In computer science, 166 universities have accredited bachelor's programs, and some offer two distinct degrees.

In response to the rapid changes and advances in information technology, ABET and CSAB departed markedly from their past accreditation approaches, proposing new criteria in 2000 that provide universities with increased flexibility in building their IT degree programs while requiring them to provide a coherent rationale for their curriculum and demonstrate that the curriculum meets its stated goals.⁵²

Changing Body of Knowledge. Professional societies also play a significant role in shaping scientific and engineering curricula. In the IT arena, the Computer Society of the Institute of Electrical and Electronics Engineers (IEEE-CS) and the Association for Computing Machinery (ACM), working together, have played a lead role in identifying, organizing, and prioritizing the body of knowledge that constitutes information technology. Their most recent development effort, Computing Curricula 2001 (CC2001), identifies some of the challenges facing undergraduate education in IT.

The rapid pace of change in information technology has significantly affected the content and delivery of IT undergraduate education. In the past decade, advances in information technology have added to or increased the importance of many curriculum topics, such as programming languages, graphics and visual computing, and networking. Since the advent of computer science and computer engineering departments in universities in the 1960s, there have been many efforts to identify the core knowledge students need for IT-related occupations and to develop curricula and courses to ensure that all the important concepts are taught during the course of an undergraduate education in these fields. As information technology has gone through evolutionary and revolutionary changes, the scope of IT-related knowledge has grown enormously and, in the process, engendered the establishment of a wide range of IT specialists with in-depth knowledge in unique areas of IT. At the same time, the hours available to impart this knowledge in an undergraduate curriculum have remained constant. This situation has created a daunting task for those charged with trying to identify the core knowledge that should be imparted in an undergraduate IT education. In developing CC2001, IEEE-CS and ACM concluded that such differentiation existed in IT specialties that a single core curriculum could not be established that met the needs of all. As stated in the CC2001 report:

“Computing has changed dramatically over that time in ways that have a profound effect on curriculum design and pedagogy. Moreover, the scope of what we call *computing* has broadened to the point that it is difficult to define it as a single discipline.

⁵¹ Digest of Educational Statistics, 2001, National Center for Education and Statistics, U.S. Department of Education.

⁵² Computing Curricula 2001, Computer Science vol., ch. 3, p. 11, December 2001.

Past curriculum reports have attempted to merge such disciplines as computer science, computer engineering, and software engineering into a single report about computing education. While such an approach may have seemed reasonable 10 years ago, there is no question that computing in the 21st century encompasses many vital disciplines with their own integrity and pedagogical traditions.”⁵³

Accordingly, IEEE-CS and ACM decided to focus their initial CC2001 effort on computer science and to create committees to undertake similar efforts in other areas, including computer engineering, software engineering, and information systems.⁵⁴ The establishment of a separate core curriculum for each area addresses a key criticism of CC1991 (the previous IEEE-US/ACM curriculum development effort): the need for a smaller set of common core requirements.

CC2001 identifies 14 knowledge focus groups for computer science that encompass the full scope of core knowledge requirements. Within these areas, CC2001 identifies 132 units that constitute the body of knowledge for computer science. Then CC2001 identifies 64 core units, which it defines as “the set of units for which there is a broad consensus that the material is essential to an undergraduate degree in computer science.”⁵⁵ These core units account for approximately 280 hours of instruction, representing the minimum number of hours required to cover the material in a lecture format.

Discrete Structures	43 core hours
Programming Fundamentals	38 core hours
Algorithms and Complexity	31 core hours
Architecture and Organization	36 core hours
Operating Systems	18 core hours
Net-Centric Computing	15 core hours
Programming Languages	21 core hours
Human-Computer Interaction	8 core hours
Graphics and Visual Computing	3 core hours
Intelligent Systems	10 core hours
Information Management	10 core hours
Social and Professional Issues	16 core hours
Software Engineering	31 core hours
Computational Science	0 core hours ⁵⁶
Total	280 core hours

(See Appendix D for a matrix of the body of knowledge for computer science identified by CC2001.)

⁵³ Computing Curricula 2001, Computer Science vol., ch. 1, p. 1, December 2001.

⁵⁴ The reports of these groups will form, collectively, CC2001; the first volume, covering computer science, was published in December 2001.

⁵⁵ *Ibid.*, Executive Summary.

⁵⁶ While there are units (numerical analysis, operations research, modeling and simulation, and high-performance computing) within the “computational science” knowledge focus group that are a part of the body of knowledge for computer science, none of these units were identified as part of the core units.

Cost of an IT Bachelor's Degree. The cost of a four-year IT bachelor's degree is generally equivalent to the cost of a bachelor's degree in any other field. According to a 2002–2003 College Board survey of undergraduate tuition and fees,⁵⁷ the average cost of tuition, fees, books, and supplies for in-state students at four-year public institutions is \$4,867 per year, or approximately \$19,500 for four years. For out-of-state students the cost is \$11,214 per year, or approximately \$44,900 for four years. The average cost of tuition and fees at four-year private institutions is \$19,080, or approximately \$76,300 for four years. These costs do not include room or board.

What IT Bachelor's Degrees Provide and Don't Provide. **Earning an IT bachelor's degree prepares a student for an entry-level IT professional position, career mobility, and pursuit of higher level education in the profession.**

IT degrees generally include course work in theory, software, and hardware. For computer engineers, the curriculum also includes electronics. Depending on the university or degree program, the curriculum may focus on microcomputer, mainframe, or distributed processing systems.

Broad Theoretical Understanding

Bachelor's degree programs in IT generally provide a broad, high-level conceptual understanding of IT—in systems architecture, computer programming, and computer network systems. This conceptual understanding can be both an asset and a shortcoming. A common criticism of recent college graduates with IT degrees is that they lack practical knowledge in developing and implementing software and systems. For some positions, employers prefer knowledge and hands-on experience in a particular software package, operating system, or networking technology over theoretical knowledge for the value of experience in address-

Maryland Applied Information Technology Initiative (MAITI)

MAITI is a statewide initiative with the goal of doubling the number of IT graduates from Maryland's institutions of higher education by 2004 to meet the needs of the state's IT companies. Ten higher education institutions participate in the initiative: four campuses of the University of Maryland, Johns Hopkins University, Morgan State University, Bowie State University, Towson University, University of Baltimore, and Frostburg State University. MAITI is also working with the Maryland Association of Community Colleges to ensure that the IT educational programs of the state's 16 community colleges are coordinated with those of the MAITI partners. More than two dozen corporate supporters have donated resources to this initiative.

Examples of MAITI efforts include increasing the number of IT faculty and teaching assistants, adding 80 new IT-related courses, establishing new IT instruction laboratories, establishing master's degree programs in applied IT and information systems, launching an online master's of education specializing in instructional technology, adding online courseware to nursing informatics, and significantly expanding the computer engineering program at the University of Maryland's College Park Campus. Made possible by private sector donations, MAITI has awarded more than 330 undergraduate scholarships in IT disciplines such as computer science, computer engineering, electrical engineering, and information systems at seven MAITI partner institutions.

Since 1998, undergraduate-level IT enrollments have increased by 58 percent and graduate-level enrollments by 39 percent. IT undergraduate degree production is on the rise, and IT graduate degree production has increased by 48 percent.

www.maiti.org

⁵⁷ Trends in College Pricing, the College Board, based on data collected in its Annual Survey of Colleges, 2002–2003, www.collegeboard.com/press/cost02/html/cost02a.html.

ing practical business and organizational needs. Many IT worker respondents to the Commerce Department's online survey agreed with this perspective. One said, "Many formal educational programs are too ivory-tower. Often they are out of date or too basic. More often, they are esoteric to the point of uselessness." Another worker said, "Formal degrees tend to place too much emphasis on theory and too little on real-world experience."

However, for some positions, employers may prefer the theoretical knowledge provided by an IT bachelor's degree program for the analytical framework, deep technical knowledge, critical thinking skills, and systems approach the degree enables, tools that also can be applied to addressing practical problems.

The **University of California at Davis** extols the value of theoretical knowledge on its web site:

"The role of theory is often underappreciated. Good insight into theory courses will have a positive impact upon other courses. While the theoretical material may not be used explicitly in "practical" activities, theory teaches students to think in certain manners which have concrete benefits in practical applications."⁵⁸

Several Commerce online survey respondents agreed with the value of broad, theoretical knowledge:

- "For the most part, I found myself most helped by the truly theoretical. When professors talk about practice, they usually get it wrong."
- "Basic, good, thorough computer science curricula as was done 20 years ago... If you know what a database does and how it works, you can switch from SQL to Excel to any system and just pick up the particular syntax."
- "A strong undergraduate degree is probably the best foundational long-term IT career skill."

Ideally, an IT worker should have a combination of theoretical and practical knowledge, combined with real-world experience. However, in terms of cost to the employer, this can be overkill in some positions. Hiring the people with the correct knowledge for a particular job is important. In some cases, the preferred knowledge seems clear from an employer's perspective. Just as it makes sense to employ a mechanical engineer to design a car's suspension system and a licensed auto mechanic to change the shock absorbers, an employer may choose to hire an IT worker with a bachelor's degree in computer science to design and implement an enterprise-wide database while retaining an IT worker with hands-on experience and an Oracle certification to manage the database.

Still, with employers seeking skills that enable entry-level IT professionals to "hit the ground running," some universities are seeking to address the perceived shortcomings of an IT bache-

⁵⁸ University of California-Davis, College of Engineering, Department of Computer Science, www.cs.ucdavis.edu/undergrad/degree-prog.html.

lor's degree by also providing courses on proprietary software and systems, and by providing practical hands-on experience in addressing real-world challenges through cooperative programs with employers (e.g., internships, externships, work-study, summer employment) and IT team projects in support of actual businesses.

Adaptability

The broad, high-level knowledge obtained through an IT bachelor's program also provides an IT worker with the fundamental knowledge to adapt more readily to changing technologies.

Conversely, IT workers with only proprietary knowledge can find themselves essentially back at the beginning of the learning curve if there is a shift in the software package, operating system, networking technology, or hardware in which they have expertise.

"I think the undergraduate degree is the best-suited tool for assisting someone in learning to adapt."

—Commerce online survey respondent

Broad Technical Knowledge, Soft Skills, Societal Impact

A bachelor's degree curriculum is also designed to shape a well-rounded IT worker. In its accreditation standards, ABET recognizes the need for computer scientists and computer engineers to have not only technical knowledge and skills in their areas of specialty but also the soft skills that are increasingly important in today's workplace.

For computer engineers, ABET's technical requirements include:

- an ability to apply knowledge of mathematics, science, and engineering;
- an ability to design and conduct experiments, as well as to analyze and interpret data;
- an ability to design a system, component, or process to meet desired needs;
- an ability to identify, formulate, and solve engineering problems; and
- an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

On the soft skills side, ABET requires that engineering graduates have:

- an ability to function on multidisciplinary teams;
- an understanding of professional and ethical responsibility; and
- an ability to effectively communicate, both orally and in writing.⁵⁹

⁵⁹ Criteria for Accrediting Engineering Programs, 2002–2003, Accreditation Board for Engineering and Technology, November 2001.

The ABET requirements for accrediting computer programs state:

“The curriculum is consistent with the program’s documented objectives. It combines technical requirements with general education requirements and electives to prepare students for a professional career in the computer field, for further study in computer science, and for functioning in modern society. The technical requirements include up-to-date coverage of basic and advanced topics in computer science as well as an emphasis on science and mathematics.”⁶⁰

For computer scientists, ABET’s technical requirements include the following:

- All students must take a broad-based core of fundamental computer science material, consisting of at least 16 semester hours.
- The core materials must provide basic coverage of algorithms, data structures, software design, concepts of programming languages, and computer organization and architecture.
- Theoretical foundations, problem analysis, and solution design must be stressed in the program’s core materials.
- Students must be exposed to a variety of programming languages and systems and must become proficient in at least one higher level language.
- All students must take at least 16 semester hours of advanced course work in computer science that provides breadth and builds on the core to provide depth.⁶¹

On the soft skills side, ABET requires that computer science graduates have “at least 30 semester hours of study in humanities, social sciences, arts, and other disciplines that serve to broaden the background of the student” and stresses the need for oral and written communication skills.⁶²

Some universities have established written and oral communication requirements beyond passing specific courses and/or semester hour requirements. For example, at **Carnegie Mellon**, a bachelor’s candidate must satisfy a written communication skill requirement by writing a scholarly document that is “at least the quality of a Carnegie Mellon technical report.” The student obtains written final approval of the document from at least two faculty members and one graduate student. To satisfy the oral communication skill requirement, each student must give a public talk at Carnegie Mellon that is understandable to a general computer science audience. Members of a standing committee of faculty and graduate students, known as the Speakers Club, attend and evaluate the student’s talk and provide feedback to the student. A rating of “good” or higher by two faculty members and one graduate student member of the club is required for completion of this requirement.⁶³

⁶⁰ Ibid.

⁶¹ Ibid.

⁶² Ibid.

⁶³ Carnegie Mellon University, Computer Science Department, www-2.cs.cmu.edu/csd/phd/node15.html.

Broader Social and Economic Context

Though the research and development work of scientists and engineers is often conducted in a laboratory or other controlled environment, ABET recognizes that the products of these efforts are diffused throughout and have an impact on society. **Accordingly, ABET requires that engineering students have:**

- **the broad education necessary to understand the impact of engineering solutions in a global and societal context;**
- **a knowledge of contemporary issues; and**
- **an ability to conduct their work within “realistic constraints,” including economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political considerations.⁶⁴**

For computer scientists, ABET requires “sufficient coverage of social and ethical implications of computing to give students an understanding of a broad range of issues in this area.”⁶⁵

And finally, recognizing that the technological arena is a rapidly changing environment in which workers must continuously acquire new skills and knowledge, ABET requires graduates to recognize the need for, and have an ability to engage in, lifelong learning.

Top HATS Scholarship Program and Academy Scholars Advancement Program

Top HATS Scholarship Program

To address the high demand for technology professionals in Northern Virginia, George Mason University formed a partnership with local industry and other educational institutions to establish a program to recruit high-achieving transfer students who have demonstrated academic excellence during their first two years of college. The Top HATS (High Ability Transfer Students) program targets students with a grade point average of 3.5 or higher who have done advanced course work in calculus, computer science, physics, or chemistry.

Under the program, employers provide Top HATS students with full tuition support, summer employment, paid internships, and postgraduation employment opportunities. Students receive a leading-edge education in information technology and develop a close relationship with their sponsoring corporation.

Top HATS students enroll in one of six undergraduate programs: civil and infrastructure engineering, computer engineering, computer science, electrical engineering, information technology, or systems engineering. In addition, the students are members of the Dean’s Scholars, a select group that has the opportunity to participate in faculty research programs, honors colloquia series, and other challenging educational experiences.

Academy Scholars Advancement Program

George Mason University’s School of Information Technology and Engineering formed a unique partnership with the local Fairfax County High School Academies (Engineering and Scientific Technology, Health and Human Services, Chantilly; International Studies and Business, Engineering and Scientific Technology, Edison; Communication and The Arts, Fairfax; International Studies and Business, Engineering and Scientific Technology, Marshall; and Communication and The Arts, Health and Human Services, West Potomac) to provide an opportunity for talented Academy graduates to interact with the Northern Virginia business community and participate in the Top HATS internship program while completing a four-year degree program.

<http://ite.gmu.edu/workforce/employers/internships.htm>

⁶⁴ Criteria for Accrediting Engineering Programs, 2002–2003, November 2001.

⁶⁵ Ibid.

Shortcomings

In addition to the lack of practical knowledge discussed earlier, Commerce online survey respondents also identified several shortcomings in four-year IT degree programs: professors often have little or no recent industry experience, schools use outdated equipment and software, the programs are too expensive, and the process of getting a degree is too time-consuming. Said one respondent, “College education and training courses that extend more than six months are of no use, as technology changes so fast.”

Four-year IT programs were criticized for being out-of-date and too slow to adapt curricula to changing technologies. This lag is, in part, due to the complex and lengthy processes most universities have in place for developing, reviewing, and approving new curricula—some a result of self-imposed rules, others resulting from accreditation processes. Anecdotally, community colleges appear to be more adroit than four-year degree programs at adapting their curricula to the changing IT environment. Private institutions appear to be able to adapt the most quickly to changing needs and opportunities.

IT-related Minors

At many universities across the Nation, undergraduates from a wide range of academic majors seeking IT knowledge and skills can obtain an IT-related minor, generally referred to as a minor in computer science, information technology, or management information systems. IT minors can offer important complementary knowledge to those majoring in a natural science, engineering, business, or other discipline.

Many universities have prerequisites for IT-related minors, such as higher level mathematics requirements (e.g., calculus). In many cases, students who wish to obtain an IT-related minor must first complete 100- and 200-level classes in computer science at or above a particular grade point average to establish a strong academic foundation for higher level IT courses and to demonstrate capability. Some universities have a selective admissions process for the IT minor program.

Many universities offer IT-related minors to students who are pursuing a bachelor’s degree in any field. For example, a student at the **University of California at Davis**, majoring in English in the College of Letters and Science, can earn a minor in computer science. Some universities emphasize that their IT-related minor would be most appropriate for those majoring in science, mathematics, engineering, economics, or business. Still other universities restrict the IT minor to students with specific majors.

There are a variety of IT-related minors. Minors in computer science and information technology tend to be technically focused. Minors in management information systems tend to focus on business-related applications of IT and may include course requirements in business,

accounting, or management, in addition to IT courses. Even among universities that offer a minor in computer science, there is enormous diversity in curriculum content.

For an IT-related minor, most universities require the student to have met or exceeded a specific grade point average in the courses taken to meet the minor requirements. In addition, some IT minors that are designed to prepare students to teach IT at the secondary level may require completion of the program at a higher grade point average to earn teacher certification.

In most cases, the course work for these minors is substantial, and universities go out of their way to emphasize this point. **George Mason University** states that “This minor is not a ‘computer literacy’ program; all the courses are the same as those taken by CS majors.”⁶⁶ Other universities state that basic IT courses (such as *The Internet for Everyone*⁶⁷ and *HTML for Poets*⁶⁸) may not be used to fulfill elective requirements.

In general, requirements for an IT-related minor include approximately 15 to 23 semester hours of courses. Since minors are awarded in conjunction with a student’s pursuit of a bachelor’s degree, the cost of the minor is built into the overall cost of an undergraduate course of study.

A typical IT-related minor program includes core requirements that account for half to two-thirds of the required credit hours. These required courses generally provide an introduction to IT, covering areas such as programming concepts and languages, algorithms, data structures, computer architecture, operating systems, and networks. In addition, students can select from a range of electives to complete the minor requirements, providing the opportunity to deepen their knowledge in a particular area (e.g., theory, systems), learn an additional programming language, or complement the major (e.g., computer graphics, artificial intelligence, scientific computing, methods of teaching computer science in secondary schools).

Generally, universities say that students with IT-related minors are prepared to pursue careers in computer science or related fields upon graduation, or to pursue a higher level education in IT. The **University of Utah** puts it this way:

“Since nearly all businesses rely heavily on computers, this knowledge will be valuable in almost any career CS [computer science] minors pursue. CS minors will be able to write scripts and programs to make their own work tasks easier or build tools for their entire company. They will be able to communicate effectively with software engineers and computer professionals. They will gain a better understanding of how computer programs work, which will help them use software programs more effectively and learn new software more quickly and easily. CS minors’ knowledge of Java will provide them a foundation for learning other programming languages.

⁶⁶ <http://cs.gmu.edu/minor.html>.

⁶⁷ University of Colorado at Boulder, www.cs.colorado.edu/ugrad/minor/minor.html.

⁶⁸ University of Massachusetts, www.cs.umass.edu/csinfo/uginfo/underminor.html.

The knowledge gained through a CS minor can also be combined with knowledge students gain in their major to open new career possibilities. Linguistic majors minoring in CS, for example, will be able to combine their knowledge of human languages with their knowledge of computer languages and programming to work in areas such as web searching, data mining, and voice recognition and understanding.”⁶⁹

IT-related Minors Offer Knowledge Complementary to Other Disciplines

Minor in Computer Science, State University of New York at Stony Brook: This minor is open to all students not majoring in computer science or information systems. IT minor candidates must first complete a course in the foundations of computer science and an introductory course in procedural and object-oriented programming methodology with a grade of C or higher. The minor requires seven courses for a total of 22 to 24 credit hours, each of which must be passed with a grade of C or higher. Four required courses account for 13–14 hours of the total requirement, with the balance chosen from more than 30 upper division computer science/information science courses, covering a wide range of subjects, including software engineering, artificial intelligence, advanced multimedia techniques, virtual reality, and scientific visualization.

<http://naples.cc.sunysb.edu/CAS/ubdepts2.nsf/pages/cse>

Minor in Computer Science, George Mason University: This minor is intended for students attending non-IT undergraduate degree programs who want to pursue computer science to complement their other studies. The prerequisite for the minor is math placement indicating preparation to take calculus. The minor requires 17 credit hours; a student may not count more than 3 hours with the grade of “D” toward the minor requirements. Due to the sequential nature of the courses, four semesters are required to complete the minor. George Mason also offers a minor in information technology that requires 15 credit hours, including 9 required hours and 6 elective hours.

<http://cs.gmu.edu/minor.html>

Minor in Computer Science, University of Massachusetts—Amherst: The university states that this minor is most appropriate for students in math, science, engineering, or business, although it is open to all students at the university. The program has prerequisites that include Calculus I and II, Introduction to Problem Solving Using the Computer, and Programming with Data Structures. The minor includes three mandatory courses—Architecture and Assembly Language Programming, Introduction to Computation, and Programming Language Paradigms—as well as two electives at the 300 level or higher, but not HTML for Poets.

www.cs.umass.edu/csinfo/uginfo/underminor.html

In 2002, **UMass—Amherst** launched a new multidisciplinary IT minor to produce IT generalists from many academic fields. This new minor was created as a result of the UMass system’s efforts to be more responsive to the IT workforce needs of the state’s key industries. The IT minor will be the only campus-wide, interdisciplinary minor at the university—generally, minors are linked to specific departments. The university sees the IT minor as a unique approach “to empower students from every discipline to use information technology in new combinations that make each grow.” The minor requires completion of a minimum of five 3-credit courses. Some of the courses have been specifically designed for students who want to gain skills in IT but are majoring in something other than computer science, engineering, or information systems.

www.umass.edu/newsoffice/archive/2002/051602it.html

Minor in Computer Science, University of Massachusetts—Lowell: This minor is intended primarily for students in “science, engineering, or any field with a substantial quantitative component who are trying to acquire a fairly deep background in CS to complement their major.” The minor requires 22 credit hours, composed of four required courses and two computer science electives at the 300 level or higher.

www.cs.uml.edu/curriculum/CSMinor.html

⁶⁹ www.cs.utah.edu/research/factsheets/minorscrn.pdf.

IT-related Minors Offer Knowledge Complementary to Other Disciplines, continued

Minor in Computer Science/Minor in Computer Information Systems, Union University: These minors are intended for students interested primarily in pursuing a career in computer science or a related field immediately upon graduation. Both minors require 21 credit hours. The computer science minor includes six required courses and one elective at the 400 level. The computer information systems minor includes three required courses and four elective courses.
www.uu.edu/catalogue/pdfs/0203mathcsc.pdf

Minor in Computer Science, University of California at Davis: The university says that this minor is “for students who wish to complement their major areas of study with a background in computer science.” The minor requires 24 units, including 4 units in computer organization and machine-dependent programming, 4 units in data structures and programming, and 16 elective units. The Computer Science Department warns potential minor candidates that access to many computer science courses is restricted to computer science majors because of high enrollment demands.

www.cs.ucdavis.edu/undergrad/minor.html

Minor in Computer Science, University of Colorado at Boulder: This minor can be earned in conjunction with any major in the College of Arts and Sciences as well as in conjunction with some majors in other colleges. Students seeking admission to the minor program must have a grade point average (GPA) of 2.5 or better. Students are then evaluated based on a combination of their GPA (20 percent), grade in Computer Science 1: Programming (40 percent), and grade in calculus (40 percent). The minor in computer science requires 21 credit hours, including three mandatory courses totaling 13 hours—Computer Science 1: Programming, Computers as Components, and Computer Science 2: Data Structures—as well as two of the following four upper-division classes: Algorithms, Principles of Programming Languages, Database and Information Systems, and Operating Systems.

www.cs.colorado.edu/ugrad/minor/minor.html

Minor in Computer Science, York College of The City University of New York: This minor is open to all students but “most beneficial to students in mathematics, physics, chemistry, biology and economics.” The minor requires 16 credit hours, including two mandatory 4-hour courses (Data Structures and Machine Organization), as well as two additional 4-hour courses in computer science.

www.york.cuny.edu/~math/csminor.html

Minor in Computer Science, Stanford University: This minor is offered through the university’s School of Engineering. Prerequisites include math courses covering materials through linear algebra and differential multivariable calculus, and a 2.0 minimum GPA. Minor candidates must complete two introductory programming courses, as well as four other required courses: Discrete Mathematics for Computer Science, Discrete Structures, Programming Paradigms, and Object-Oriented Systems Design. In addition, minors must complete two additional courses in systems, theory, artificial intelligence, or human-computer interface.

<http://cse.stanford.edu/resources/CourseAdvisor/answers/relatedmajors.html>

Minor in Computer Science, University of Utah: This minor provides a foundation in the fundamentals of computer programming. The university says the minor is valuable in virtually all career paths because of the ubiquitous use of computers in the workplace. The minor requires completion of 18.5 semester hours. Mandatory courses include Introduction to Unix, Introduction to Computer Science, and Software Practice. Students compete for admission to the program on the basis of grades in Math 1210 or 111, English writing, and Computer Science 2010/2020 or 201/202/2030. Admission is restricted to students whose GPA in these courses exceeds the GPA of students admitted into full-major status that year. Maximum enrollment in the minor program is set annually by faculty and is currently approximately 10 students. The College of Computing also offers a teaching minor in computer science in conjunction with the College of Education for students who wish to teach computer science at the secondary level.

www.cs.utah.edu/dept/handbooks/1998/cs-ug/node8.html

Minor in Computer Science, U.S. Air Force Academy: This minor is designed to prepare cadets for the technical demands they will face in the 21st century Air Force. The required and elective courses for the minor are designed to build on the education that all cadets receive in the core computer science curriculum in the areas of computer programming, algorithms and data structures, information warfare, database management systems, computer simulation, computer networks, and operating systems. According to the Academy, the minor curriculum prepares cadets for positions as local area network (LAN) administrator, database administrator, and computer systems administrator. In these positions, the individual is responsible for providing and protecting computer resources in support of Air Force missions.

www.academyadmissions.com/academics/majors/minor_descriptions/computerscience.htm

IT-related Minors Offer Knowledge Complementary to Other Disciplines, continued

Minor in Information Technology, University of Arkansas at Little Rock: This minor program is designed to teach students how to use technology to solve real-life problems and work productively in a team environment. Students master essential technical, business, and professional knowledge and the skills deemed important by knowledge-based companies. The program begins with an overview of IT, proceeds through knowledge acquisition and skill development, and concludes with a practical field-based capstone experience. The IT minor is offered for students in disciplines that lack an intensive computing component in their curricula. Applicants do not need to have an extensive background in computers or technology, but they should demonstrate problem-solving skills, leadership ability, oral and written communication skills, and an interest in IT. The minor requires three 6-hour courses: Introduction to Information Technology and Applications, Guided Applications in Information Technology and Industry Processes, and Project Development and Portfolio Defense. Students in the first IT minor class landed jobs in the IT field with starting salaries of \$40,000–\$51,400.

<http://itech.uarl.edu>

Minor in Data Storage Systems Technology, Carnegie-Mellon University: This minor, intended for engineering majors in the university's Electric and Computer Engineering School, requires completion of five courses. Students must complete two of the following three courses: Introduction to Data Storage Systems Technology, Data Storage Systems Design, and Introduction to Solid State Physics. In addition they must complete three elective courses chosen from the following five concentration areas: Materials and Chemistry; Physics of Data Storage; Dynamics, Control, and Signal Processing; Computer Systems; and Circuit Design. Two of the electives must be from the same concentration area. The university says that "Completing the courses from a concentration will guarantee that a student will have developed sufficient skill and knowledge to be useful for either employment in industry or for further study at the graduate level."

www.ece.cmu.edu/undergrad/primer/details/dsminor.shtml

Combined IT Bachelor's/Master's Degree Programs

Some universities offer a combined BS/MS program in computer science or computer engineering to encourage their students to seek higher level degrees by enabling them to earn them faster. These programs can reduce the time it takes to earn both degrees separately by as much as two semesters. Both the **University of Colorado at Boulder's** combined program in computer science and the **University of California—Santa Cruz's** combined program in computer engineering can be completed in five years. In general, the time required to earn both a bachelor's and a master's degree is shortened by enabling students to take graduate-level courses that can be applied to the requirements for both degrees.

The financial advantages of these programs vary from university to university and from student to student. At some universities, students are charged the lower undergraduate tuition throughout the program. Other institutions begin to charge the graduate student tuition rate immediately upon entry into the program, which can result in a financial burden to the student. However, these students can be eligible for tuition assistance that would not be available to them as undergraduates, such as graduate fellowships and graduate assistantships in research, teaching, and administrative areas that offer stipends, as well as tuition and fee waivers.

Admission to these programs is often stringent. **Ohio State University's** BS/MS program in computer and information science requires completion of 135 undergraduate quarter hours, a GPA of 3.5 or higher, and letters of reference.

IT-related Master of Science Programs

IT-related MS programs typically are designed either for working professionals or to prepare students for study at the doctoral level. **MS programs address a range of IT professionals' needs. Some programs offer preparation for advancement to higher level jobs, such as those in IT organization management and IT business management, or for more technically complex jobs, such as advanced IT development work. Other IT-related MS programs are geared toward expanding IT professionals' portfolios of skills into new IT disciplines, such as telecommunications, or toward preparing them for work in a highly specialized IT application area, such as bioinformatics.** These programs can be completed in as little as a year or may take up to several years, depending on full- or part-time attendance. In 2000, there were 381 educational institutions offering master's degrees in computer and information sciences.⁷⁰

IT-related MS programs typically require students to have previous course work in IT, perhaps a computer science bachelor's degree or an undergraduate degree in a technical field, as well as courses in high-level mathematics. Tuition costs for completing an IT-related MS program range from a low of approximately \$6,000 for in-state students at a public university to more than \$30,000 at a private institution.

Traditionally, MS-level computer science programs delve more deeply into the science, with technically advanced and complex course work. Students who follow this path often are qualified to do significant development work in the IT industry or in an applications area. Typical core courses cover topics such as algorithms, programming languages, compilers, computer architecture, artificial intelligence, database systems, and operating systems, as well as more advanced versions of courses on these topics (although a wide range of course offerings can be found in the core curricula of traditional MS-level computer science programs). In addition, students choose electives from a wide range of IT-related courses in these programs.

Some MS programs encourage or require students to couple core course work with work in a specialization or concentration in a particular IT sub-field. For example, at **Georgia Tech**, students can specialize in computer architecture, database systems, graphics and visualization, human-computer interaction, intelligent systems, networking and communications, programming languages and compilers, software methodology and engineering, systems, or theoretical computer science. At the **New Jersey Institute of Technology**, areas of specialization include artificial intelligence; computer algorithms and theory of computing; computer systems and parallel and distributed processing, database and knowledge-based engineering;

⁷⁰ Digest of Educational Statistics, National Center for Education and Statistics, 2001.



Maryland Roundtable

image processing and computer graphics; numerical computation; and systems analysis, simulation, and modeling.⁷¹

At **North Carolina State University**, the MS program in computer science was designed primarily to meet the needs of working professionals in North Carolina's Research Triangle and surrounding areas. The program involves traditional computer science core course work, plus graduate-level courses from the school's College of Engineering and College of Physical and Mathematical Science. These two colleges offer courses in a wide range of technical fields. In addition, students must attend four hour-long public presentations offered several times each semester by researchers from within and outside the university.

Some MS programs in computer science offer option tracks—such as a pure course work track, a track that involves a hands-on research project, or a track that involves developing a thesis. For example, at **Georgia Tech**, students are offered three options: course option (36 hours of course work); project option (27 hours of course work and a 9-hour project); and thesis option (24 hours of course work and a 12-hour thesis). Other programs may involve group projects or consultation with an actual business enterprise.⁷² Some MS programs require an exam. For example, at **New York University**, MS students in computer science must pass a comprehensive core exam based on four core courses on fundamental algorithms, programming languages, compilers, and operating systems.⁷³

Another IT-related master's program area is information systems, which typically focuses on the use of IT in businesses and other organizations. For example, in a joint effort, **New York**

⁷¹ www.cc.gatech.edu/student.services/ms/curriculum.html, www.njit.edu/catalog/graduate/00spring/15.htm.

⁷² Peter Freeman and William Aspray, *The Supply of Information Technology Workers in the United States*, Computing Research Association, 1999.

⁷³ www.cs.nyu.edu/csweb/Academic/Graduate/overview.html.

University's Stern School of Business and Courant Institute of Mathematical Sciences established an MS in information systems to develop IT professionals with knowledge of business applications. Students must complete 12 courses and a project course. The 10 core courses—5 from Stern and 5 from Courant—are divided into three groups. From the general business core courses, students choose two from among Financial Accounting and Reporting, Understanding Firms and Markets, and Managing Organizations. From the information systems core courses, students choose three from among Information Technology Strategy and Management, Managing the Digital Firm, Designing and Developing Web-based Systems, Data Mining and Knowledge Systems, and Electronic Commerce. Students take five courses in the computer science core, including the four required courses on operating systems, data communications and networks, Internet and intranet protocols and applications, and fundamental algorithms or programming languages. An advanced lab in computer science is also part of the curriculum; it involves the analysis, design, and implementation of a software system in a business environment.⁷⁴ The remaining two courses can be taken at either school.

In addition to the traditional MS programs in computer science and information systems, other MS programs focus on a wide range of IT specialties. These programs appear to respond to employers' desire for IT workers with advanced skills in specialized industrial or technology applications and for IT workers who have a firm grasp of business issues. The latter can be particularly important with respect to advancement to managerial level jobs. Figure 15 describes some of these MS programs.

Figure 15. Master's Degree Programs Teach a Wide Range of Specialties

Techno Master in Management Information Systems, Temple University: This program is designed to prepare IT professionals to manage, develop, and evaluate organizational information systems. It prepares students for careers such as systems analyst, system architect, project manager, and CIO. Courses focus on new and traditional IT concepts and tools (such as management information systems, database analysis and design, client-server, and Internet and intranet design) and the integration of information systems and business concepts. The program also focuses on analytical and critical thinking skills as well as communication, interpersonal relationships, and team building. Areas of concentration include health care information systems, managing the virtual organization, human resource management systems, e-marketing, electronic supply chain management, manufacturing systems, construction and engineering management, and more. In a capstone course, students work in teams to develop a complete IT solution for an organization. Prerequisites include knowledge of programming, information systems, and organizations.

www.sbm.temple.edu/curricula/ms-mis.html

Master of Science in Knowledge Discovery and Data Mining, Carnegie-Mellon University: The school's Center for Automated Learning and Discovery established this multidisciplinary program to train students in the rapidly growing area of knowledge discovery and data mining. The program involves course work, hands-on applications, and research. Courses include machine learning, statistical approaches to learning and discovery, and multimedia databases and data mining. Electives may be chosen from a large number of graduate courses. In a laboratory course, students get hands-on experience with practical databases and real-world data mining problems. Students also have the opportunity to work on a focused project, carried out either at the school or at a sponsoring corporation. Students conduct research with an advisor throughout the year. To complete the program, students must write a paper suitable for sub-

⁷⁴ <http://is-2.stern.nyu.edu/~ms-is/overview.html>

Figure 15. Master's Degree Programs Teach a Wide Range of Specialties, continued

mission to a journal/refereed conference and make a presentation of that work.

www.cald.cs.cms.edu/masters/student_handbook.html

Master of Science in Software Engineering, Drexel University: The College of Arts and Science, the College of Engineering, and the College of Information Science and Technology sponsor this multidisciplinary degree. The program, drawing on existing Drexel programs in three disciplines—computer science, engineering, and information science and technology—includes a focus on the behavioral, managerial, and technical aspects of software engineering. Core courses drawn from all three disciplines include software design, dependable software systems, fundamentals of computer hardware, fundamentals of computer networks, requirements engineering and management, and software project management. Students continue in one of three specialized tracks: computer science (focused on the development of software systems such as databases, networks, operating systems, graphics and animation systems, expert systems, and scientific computing); electrical and computer engineering (focused on techniques to model engineering problems and software solutions in electrical, mechanical, environmental, and chemical engineering); or information science and technology (focused on applying software engineering to information systems problems in commercial organizations and other settings). To enter the program, students should possess knowledge of certain programming languages and have previous course work and/or experience related to software engineering.

www.cis.drexel.edu/grad/msse

Master of Science in Biomedical Informatics, New Jersey Institute of Technology: This program prepares students for the application of computer and information sciences to support and manage health care and hospital management systems, laboratory automation, quality assurance, resource allocation, biomedical research, clinical decision making, and biotechnology systems. Core courses include Introduction to Biomedical Informatics, Health Care Information Systems, Biomedical Modeling and Decision-making Systems, Visualization in Biomedical Sciences, Research Methods in Health Sciences, and Data Structures and Algorithms. A thesis and directed research or project are required. Students choose an area of emphasis from clinical decision support systems, health care management systems, health science education/multimedia systems, and bioinformatics/biotechnology systems. Additional electives are required. Students entering the program are expected to have basic proficiency in a procedural programming language, database concepts, elementary calculus, and differential equations.

www.njit.edu/catalog/graduate/00Spring/11.htm

Master of Science in E-Commerce, George Mason University: The MS in e-commerce is managed by the School of Information Technology and Engineering and is a joint degree with the School of Management, School of Public Policy, School of Law, College of Arts and Science, and College of Nursing and Health Science. The program focuses on management, public policy, and IT, integrating these disciplines in the context of e-commerce in a wide variety of specialized applications, such as e-government, e-banking, and tele-health. Core courses cover e-commerce basic IT infrastructure, e-commerce software services, managerial economics and decisions of the firm, financial reporting and decision making, law and public policy in e-commerce, and case studies in e-commerce. In addition to core courses, students select courses from one of four concentrations: information technology, business and economics, law and public policy, or health care and services industry. Students participate in a group project focused on developing, designing, and implementing e-commerce systems. Among the requirements for entry into the program is programming experience in at least one block-structured programming language (e.g., Java, C, C++, Visual Basic, Pascal) or a scripting language used in Web design (e.g., JavaScript), gained either through course work or work experience.

<http://ite.gme.edu/msecomm/index.html>

Professional Master in Telecommunications and Networking, University of Pennsylvania: This program for full- and part-time students draws faculty from the School of Engineering and Applied Science, and from the Wharton School. Courses cover a broad range of telecommunications and networking issues (such as hardware and software technologies), as well as societal and management issues. Required courses cover networking technology, protocols, and practice; networking theory and fundamentals; broadband networking; and introduction to probability and stochastic processes. Electives are chosen from a wide range of courses covering business issues, telecommunications and technology policy, product development, marketing, technology management, regulation, entrepreneurship, and telecommunications technologies. A thesis is required.

www.seas.upenn.edu/profprog/tcom/curriculum.html

Figure 15. Master's Degree Programs Teach a Wide Range of Specialties, continued

Master of Science in Scientific Computing, New York University: The Department of Mathematics and Computer Science at the school's Courant Institute of Mathematical Sciences established this program for full-time and part-time students. It focuses on the mathematics and computer science related to advanced computer modeling. It is designed to provide training related to scientific computing, including modern computing tools and methods, numerical and mathematical analysis, data visualization, graphical user interfaces, Unix tools, and applications. Students entering the program need significant knowledge in higher level mathematics, such as calculus and linear algebra, and experience in programming in a high-level language. Core courses focus on numerical methods, applied mathematics, programming languages, fundamental algorithms, Unix, and computer graphics. Two electives are drawn from additional mathematics and computer science courses.

<http://math.nyu.edu/degree/scicomp.html>

Master of Science in Information Security, Georgia Tech: This program is a cooperative effort between the College of Computing and the Sam Nunn School of International Affairs, focusing on key elements of information security. Core courses include introduction to information security, applied cryptology, secure computer systems, network security, information security strategies, and a hands-on project. Students may choose from two concentrations: secure computing technology or information security policies and strategies. The latter focuses on topics such as technology forecasting and assessment, cost-benefit analysis, business process analysis and design, and privacy.

www.cc.gatech.edu/student.services/ms/infosec/index.html

Master of Science in Computer Science With Specialization in Multimedia and Creative Technologies, University of Southern California: This program is designed for computer science students who want an added focus on multimedia and creative technologies. Students must complete the core course requirements for the MS in computer science, courses on advanced operating systems, artificial intelligence, compiler design, programming language design, software engineering, database systems, and computer systems architecture. A course on multimedia systems design is also required. Students choose electives from one of two specialization tracks: graphics and vision or networks and databases. Electives in the graphics and vision track include those on computer graphics, geometric modeling, computer vision, 3D graphics and rendering, and digital image processing. Prerequisites for this program are a bachelor's degree in computer science, mathematics, or engineering and substantial background in computing.

www.cs.usc.edu/ms/msbro.htm

Executive Master of Science in Information Technology, University of Maryland University College: This program for experienced professionals involves six seminars: IT and the Industry and Strategic Management; Human Resources, Leadership, and Project/Financial Management; Advanced Topics in IT and Systems Security and Risk Management; Computing and Software Technology; Data Communications and Internet Technologies; and Systems Engineering and Capstone. Instructional methods include lectures, case studies, discussions, guest speakers, videos, computer exercises, written papers, oral presentations, and Web-based instruction. The program culminates with a strategy project in which participants are teamed with sponsoring corporations to develop market-entry or market-enhancement strategies.

www.umuc.edu/grad/exec/xmit.html

Master of Science in Robotics, Carnegie-Mellon University: The program is designed for full-time students in the School of Computer Science. Core courses cover perception, cognition, action, and math foundations. Course choices include those in computer vision; advanced perception; sensing and sensors; advanced artificial intelligence concepts; machine learning; mechanics and manipulation; kinematics, dynamic systems, and control; and math fundamentals for robotics. Students participate in supervised research, working on a project in a faculty member's laboratory. The student is expected to prepare a written report and give an oral presentation regarding the research, demonstrating the ability to present technical material to a technical audience that does not have expertise in the research area.

www.ri.cmu.edu/education/masters_general.html

Techno-MBAs

A new class of MBA program has arisen in recent years, focused on the integration of management and technical knowledge. In contrast to an MBA with a technical concentration, these programs—often referred to as “techno-MBAs”—focus on understanding the business value of technology, technology’s contribution to the bottom line, and technology as a tool and not the end-all. Generally, these degrees are designed for those with technical backgrounds who want to advance into management positions. The programs seek to impart business knowledge and skills to enable the student to speak and understand the language of business; to effectively use technology to grow the business, improve operations, and boost the bottom line; and to manage the development of technology and speed its entry into the market.

There are a wide variety of techno-MBA programs, each with unique offerings and foci.

- Some programs aim to train students to become CEOs or entrepreneurs; others prepare students to become chief technology officers or chief information officers.
- Some are general in nature and do not require a specialization; others offer specialization in areas such as e-commerce, management information systems, technology management, innovation management, and managing people in a technological environment.
- Some programs are designed for full-time students, and others for full-time high-tech executives.
- Most programs take the equivalent of two full-time academic years to complete, although they may be taken in a variety of ways: full time, on campus during the day; full time or part time at night and/or on weekends; or online anywhere/anytime courses combined with resident phases. Some programs have summer internship or field capstone requirements, and some have an overseas study requirement.

According to *Computerworld* magazine,⁷⁵ among the 25 techno-MBA programs it ranks as the best, annual tuition for the 2001–2002 school year ranged from a low of \$3,776 at the University of Georgia (in-state rate) to a high of \$33,094 at the University of Pittsburgh (out-of-state rate). The annual median in-state tuition for these programs is approximately \$12,000; median out-of-state tuition is approximately \$21,000. As noted above, these programs generally require the equivalent of two academic years to complete.

⁷⁵ The Top Techno-MBA Programs, *Computerworld*, October 22, 2001, www.computerworld.com/careertopics/careers/story/0,10801,64908,00.html.

Techno-MBA Programs

MBA/Master in E-Business, Temple University, The Fox School of Business and Management: This full-time program is designed to develop skills for e-business enterprises, focusing on management strategy, information systems, and e-business concepts and practices. Foundation courses cover a range of business issues such as accounting, economic and statistical analysis, marketing, and financial management. Management issues covered include managing people and organizations, globalization, managing risk, valuation of firms, and entrepreneurial thinking and innovation. Students choose a concentration such as information systems or e-business. The e-business concentration covers topics such as e-commerce law and regulation, electronic supply chain management, marketing in the digital marketplace, and coordination and control in the virtual organization. A capstone project focuses on developing a business plan for an e-business environment. The Fox School also offers an MBA in e-business, MBA in Management Information Systems, and master of science degrees in e-business and management information systems. Total tuition cost for the program ranges from approximately \$27,000 (in-state, Pennsylvania) to \$29,000 (out-of-state).

www.sbm.temple.edu/curricula/mbams-ebusiness.html

High-Technology MBA Program, Northeastern University, College of Business Administration: Northeastern's high-tech MBA program is a comprehensive program for managers working full-time to provide them with the business and technical management knowledge needed for advancement in their careers. The program focuses on leading growth and innovation in technology-based industries. The program is directed at three primary segments of industry in the New England region: systems and software, financial services, and health care and biotechnology. Since this program is designed for full-time professionals, students in the program tend to be somewhat older (average age about 31) than in more traditional MBA programs. Total tuition costs for the program are about \$51,000.

<http://web.cba.neu.edu/htmba>

MBA in Technology and E-Commerce, Northwestern University/Kellogg School of Management: Kellogg's MBA in technology and e-commerce is focused on understanding the components of innovation—technology, marketing, organization, and entrepreneurship—and the relationships among them. The program stresses that e-business transcends functional areas and emphasizes the importance of spanning boundaries, building relationships, and teamwork. In addition to core business classes, the two-year program includes courses in research and development management, Internet business models, business intelligence, and customer relationship management technologies. In addition to course work, the program requires completion of a summer internship. Elective courses offered through this program support career paths in entrepreneurship, venture capital, management consulting, marketing and product management, and technology management. Total tuition for the two-year program is approximately \$57,500.

www.kellogg.nwu.edu/academic/tech/index.htm

Executive Master of Science in Management of Technology, Georgia Institute of Technology, DuPree College of Management: Georgia Tech's executive master of science in management of technology is designed to prepare working professionals for transition into upper management, new venture startup, and business leadership. During the 19-month program, students meet every other weekend (all day Friday and Saturday), attend two one-week sessions in residence (attending classes for five days from 8:00 am to 5:00 pm), and participate in a 10-day European residency, visiting with European companies and professional counterparts. The curriculum provides technical, business, analytical, strategic, and collaborative skills for technologically intensive and changing organizational environments. Describing itself as an "MBA for the Age of Technology," the program trains students to manage technology innovation and implementation strategies, educates students on issues arising from the electronically connected international marketplace, and teaches students how to exploit the business opportunities made possible by the latest technology applications. Total tuition for the program is approximately \$49,000, plus \$2,800 for the European residency.

www.dupree.gatech.edu/programs/executivemasters/ExecMasters_Program.shtml

Two-Year IT Degrees at Community Colleges

Community colleges offer a range of IT education and training opportunities. These IT programs are popular, in part, because they are convenient and economical, and offer opportunities for both full-time students and working adults seeking to upgrade their skills or prepare for a career change by attending training on a part-time basis. Community colleges primarily provide preparation for low- and intermediate-skilled IT jobs. Many community college IT offerings focus on more practical applications of IT as opposed to more theoretical studies. Some are responding to employer demands for soft skills by adding group projects and writing requirements to IT curricula.

Community colleges do a great deal of IT education and training, including providing education in computer science and computer information systems management, retraining for current IT workers, training for workers who are making a career change into IT, and training for those with a bachelor's degree in a nontechnical field who seek to acquire technical skills. Only a small number of those enrolled in community college IT associate degree programs actually obtain the degree. Many students enroll to gain specific knowledge and skills, with no intent of earning a degree. Some find jobs using skills they acquire before completing the full course curriculum required to earn an associate degree; some are there to upgrade or update their skills; and still others already have a bachelor's degree and are not concerned with an associate degree or certificate. According to a study at Bellevue Community College in Washington state, over a period of three years, only 13 percent of IT students obtained an associate degree, compared with 83 percent who left before obtaining a degree or certificate. For IT, it appears that community colleges are increasingly used primarily as a retraining vehicle for current IT workers, for those adding technical skills to their portfolio, and for career switchers.⁷⁶

Two types of IT degree tracks are offered at community colleges—terminal and transfer. These programs typically require students to complete approximately 60 semester hours or the equivalent (such as 90 quarter hours) of work at a cost of about \$2,000 to \$3,000 for in-state students. These programs offer a mix of general education, math and science, and IT-related courses, along with courses on writing and speech. In 2000, 912 educational institutions awarded associate degrees in computer and information sciences.

Transfer track programs, focused on computer science or computer information systems management, prepare students for transfer to an IT program at a four-year college or university, working toward a bachelor's degree in computer science, computer engineering, or management information systems. Credits earned while acquiring an associate degree may not transfer to a four-year school. Some community colleges have tried to make the transfer easier by developing articulation arrangements with four-year colleges and universities. Articulation arrangements can be an important option for people who are seeking a bachelor's

⁷⁶ Robert Lerman, *The Role of Community Colleges in Expanding the Supply of Information Technology Workers*, Urban Institute, May 2000.

degree but have financial or geographic constraints that keep them from attending a four-year college or university in their first years of postsecondary schooling.⁷⁷

Typical prerequisites for students entering a computer science transfer track include college-level skills in English, four years of college preparatory mathematics, and higher level sciences such as chemistry and physics. Some programs recommend that students have some knowledge of computer programming.

In transfer programs, students pursue a mix of general education and IT-specific courses, with the course mix tilted more heavily toward general education studies in the humanities, social sciences, and advanced math and science courses (such as physics and calculus). This course mix is similar to what students receive in the first two years at many four-year colleges and universities.⁷⁸ For example:

- At **Bellevue Community College**, students elect 15 credits of courses in the humanities and 15 in the social sciences. They also take two English courses, four math courses, and at least three physics courses. The students take two courses on the fundamentals of computer science.⁷⁹
- At **Springfield Technical Community College** in Massachusetts, in four semesters, students complete several English, humanities, and social science electives. Science and math instruction includes two courses in calculus and two in physics. In the first year, students study computer science subjects such as computer systems and their role in society, Web page design, Visual Basic, algorithms, object-oriented design, C++, and data structures. In their second year, students study computer organization and digital logic, programming in Java, machine and assembly language, data structures and algorithms, linear algebra, and probability and statistics. Students are eligible to participate in a joint admissions program with the University of Massachusetts, in which they are automatically accepted to any of the university's campuses as long as they complete their associate of science degree with a cumulative grade point average of 2.5 or higher. Students who achieve a grade point average of 3.0 or higher receive a tuition reduction.⁸⁰
- Both **Northern Virginia Community College** and **Montgomery College** (in Maryland) offer 60-credit two-year transfer computer science programs. In addition to the typical two-year computer science courses such as those described above, both colleges require students in the transfer program to take courses in writing and speaking. At Montgomery College, students may choose a writing course focused on writing academic and research papers or a course that focuses on the writing used in tech-

⁷⁷ The Supply of Information Technology Workers in the United States, 1999.

⁷⁸ Ibid.

⁷⁹ http://high-tech.bcc.ctc.edu/computerscience/cs_curriculum.htm.

⁸⁰ www.stcc.mass.edu/dept/EngrTransfer.

nology and business. At Northern Virginia Community College, computer science transfer students take an introduction to speech communication, which covers communications in personal, small group, and public situations.⁸¹

Community colleges also offer transfer tracks in information systems or information management. These programs are geared to students who will transfer to a four-year program to study the theory and management of computer-based information systems in business and other organizations. For example, at **Montgomery College**, in addition to the general courses of study in the humanities, social sciences, natural sciences, English, and math, students study computer concepts, systems analysis and design, and programming. They also study a range of business topics such as accounting, economics, and statistics.⁸²

Global Wireless Education Consortium

The deployment of wireless communications technologies has experienced significant growth over the past few years, with more growth expected in the years ahead. Yet, in the past few decades, education programs in radio frequency and wireless electronics declined. While growth in the technology created new demand for wireless professionals, schools were eliminating wireless-related courses in favor of computer science courses.

Launched in 1997 to address this challenge, the Global Wireless Education Consortium (GWEC) aims to increase the quality and quantity of technicians, engineers, and information technology specialists for the wireless industry. Wireless technicians and some wireless programmers are schooled at two-year technical or community colleges. Wireless engineers, computer programmers, and systems designers are graduates of four-year or master's-level electrical engineering, engineering technology, computer science, or computer engineering programs. GWEC works to establish undergraduate wireless programs in both two-year and four-year academic institutions. "Points of Knowledge" were developed by industry and education representatives, and schools establishing wireless programs are asked to address each Point of Knowledge in their curriculum. That curriculum is shared among the academic institutions that are GWEC members.

Industry members of GWEC must fulfill several requirements: provide paid internships for students participating in the education partners' wireless programs; license non-product-sensitive training materials to GWEC, which will then license the materials to the education partners; and support an annual faculty workshop. Education partners are required to establish a GWEC wireless curriculum that covers each of the Points of Knowledge and their learning requirements; incorporate practical lab exercises for each learning requirement; integrate communication, teamwork, and problem solving into the classroom and lab work; agree to cooperate with other education partners in the member's area; and send wireless faculty to the annual GWEC workshop.

GWEC industry members offer students in GWEC schools the opportunity to compete for paid practical work experiences.

GWEC industry members include AT&T Wireless, Award Solutions, Cingular, EDS PLM Solutions, Emona Instruments, Ericsson, Flextronics Network Services, the Institute of Electrical and Electronics Engineers, Motorola, Movilnet, Nokia, Sprint PCS, Telcordia Technologies, and Verizon Wireless. Approximately 50 U.S. educational institutions—including community colleges, four-year universities, technical colleges, and private for-profit technical schools—are academic partners.

www.gwec.org

⁸¹ www.mc.cc.md.us/iti, www.nvcc.edu/curcatalog/programs/comsci.htm.

⁸² www.mc.cc.md.us/iti.

Terminal tracks are designed for students who intend to move directly into the workforce after earning their two-year degree. These programs—which often focus on programming, network and database administration, and technical support—have a higher concentration of courses in the technical discipline. The curriculum typically places less emphasis on concepts and theory than do transfer programs, and greater emphasis on practical knowledge. These students are prepared to perform in the workplace what they have learned in school, but they may be less prepared to transfer to other types of IT work because they lack a strong theoretical foundation.⁸³ Some students who earn terminal two-year IT degrees choose to continue their studies. For example, the **Northern Virginia Community College** has formal articulation agreements with several universities that will allow students who have attained terminal associate degrees to transfer and work toward a bachelor’s degree in management, occupational and technical studies, computer information systems, or business education.⁸⁴ Basic requirements to enter these terminal degree programs can be less than those for entering computer science transfer programs; for example, requiring high school algebra and geometry rather than four years of college preparatory mathematics.

Terminal programs are offered in a wide range of IT specialties. For example:

- At **Northern Virginia Community College**, students working toward an associate in applied science degree in information systems technology take 67–68 course credits, including a few general education courses and several required IT-related courses: introduction to information systems, computer program design, introduction to micro-computer software, introduction to telecommunications, and programming. Also included are business-related courses such as introduction to business, principles of accounting, principles of management, and a writing course. In the second year, students choose a specialization—either network administration, network engineering, or software development—and are required to take several technical courses that prepare them for entry into these fields. For example, in the network administration specialization, courses cover operating systems, software utilities, local area networks, troubleshooting, network services, and TCP/IP. In some programs, students may have the option of a coordinated internship in which they participate in supervised training in a business, industrial, or service firm.⁸⁵
- **Bellevue Community College** offers terminal associate of arts (AA) degrees in programming, technical support, database administration, and network support. These 90-credit (quarter hour) degree programs are designed to prepare students for entry-level IT jobs. For example, to obtain an AA in programming, students must complete courses in database applications, introduction to IT, database theory, systems analysis, and operating systems, as well as a number of courses in business and writing. Students may then choose to pursue one of two tracks: client/server (with an emphasis

⁸³ The Supply of Information Technology Workers in the United States, 1999.

⁸⁴ www.nvcc.edu/curcatalog/programs/infsys.htm.

⁸⁵ Ibid.



Seattle Roundtable

on Visual Basic, SQL, and database development) or a C++ track (with an emphasis on C++ and Windows programming). AA programs in programming and technical support have an established set of learner outcomes, setting forth the technical, business, and soft skills that program graduates are expected to be able to demonstrate. For example, those completing the programming program are expected to demonstrate knowledge and skills in business communication, business organization and environment, client relations, problem solving, professional development/self-learning, professional environment, project management, proposal writing, task management, teamwork, client programming, computer applications, computer systems history and trends, database designs, math and science for programmers, network architectures and operating systems, C++, SQL, Visual Basic, quality assurance, server programming, systems analysis, systems design, technical documentation, testing and debugging, user validation, and user interface design. To obtain the AA in technical support, students are required to complete a two-quarter internship at the college's help desk, with an optional off-campus internship. These Bellevue Community College terminal AA programs are guided by Program Advisory Boards, composed of employer representatives from the state's high-tech community.⁸⁶

- **Cincinnati State Technical and Community College** offers terminal associate degrees in business computer programming technology, computer information systems technology, computer network engineering technology, database management systems technology, network administration, PC support, and software engineering. In these programs, the course mix is weighted toward technical topics. The software engineering program covers general education courses such as math, physics, and English. Courses in speech, professional practices, technical writing, and project management are required. Technical courses are weighted toward programming in Visual Basic, HTML, C++, VB Script, and Java. As one of the 10 largest co-op education programs in the Nation, the school has a strong experience component in the IT associate degree programs. For 5 of 10 terms, students participate in a full-time (minimum of 36 hours per week) paid field learning experience related to their academic discipline and career goals.⁸⁷

⁸⁶ <http://high-tech.bcc.ctc.edu>.

⁸⁷ Paul W. Youket, Best Practices for Programs in Information Technologies at Community Colleges, Maryland Applied Information Technology Initiative, Maryland Association of Community Colleges Project, August 25, 2000, www.cinstate.cc.oh.us/Academics-IT.htm.

While two-year associate degree transfer programs can prepare students to matriculate to a four-year computer science program, some four-year colleges impose barriers to acceptance of the credits earned in a community college transfer program. Students in community college transfer programs need to develop a good understanding of which credits will be accepted and which will not at the targeted four-year college or university.

Some two-year terminal degree programs, such as those described above, teach the combination of up-to-date technical skills and some of the business and soft skills that employers say they want. For example, at **Cincinnati State Technical and Community College, Bellevue Community College, and Springfield Technical Community College**, students must demonstrate competencies in areas such as public speaking, small group communications, or written English in order to graduate.⁸⁸ In the Cincinnati State Technical and Community College two-year terminal IT degree programs, cooperative education—paid work experience—adds the fourth dimension to the portfolio of education, technical skills, nontechnical skills, and work experience that employers say they want. These programs offer promise for developing workers for entry-level IT jobs, although such jobs appear to be significantly more scarce in the labor market than jobs for which employers seek candidates with several years of experience. Students who participate in IT education and training programs that do not have a work experience component face an additional barrier to IT employment. Moreover, terminal two-year IT degree programs—which may not provide some of the depth and underlying knowledge of more traditional computer science programs—may not prepare students adequately for adapting to new IT technologies or moving into new IT disciplines.

While many community colleges appear to provide training that would prepare students to assume entry-level IT jobs, employers are concerned that two-year colleges do not provide the necessary in-depth training, theoretical foundation, and critical thinking skills. Some studies have suggested that employers, especially large employers, show little interest in hiring students who have trained for IT jobs at community colleges.⁸⁹ This perceived inadequacy in a worker's education and technical skills training often can be overcome by proven competence demonstrated through work experience.

Strong relationships between community colleges and employers—such as the establishment of program advisory boards that guide the IT programs at Bellevue Community College—can provide a number of benefits to the school and its students. These relationships offer mechanisms to gain information on the changing needs of employers, so that curricula can be developed and modified to more closely match employer needs. Community colleges may be able to draw on employers' technical workers to teach technical classes. In addition, the college can work to enhance its reputation with employers, increasing the chance that the school can place its students into IT jobs after program completion. Close connections can also bring investment and other resources to IT programs. Bellevue Community College

⁸⁸ Ibid.

⁸⁹ The Role of Community Colleges in Expanding the Supply of Information Technology Workers, May 2000.

benefited from the investment of financial and other resources in its IT programs from area employers such as Microsoft and Boeing.⁹⁰ **Compared to universities, community colleges can often be more responsive to employer demands and technological change because of their focus on practical applications, training people for employment, and, in some cases, their relatively close relationships with employers in the area.**

Advanced Technological Education (ATE) Program

This National Science Foundation grant program promotes improvement in technological education at the undergraduate and secondary school levels. With an emphasis on two-year colleges, the program focuses on the education of technicians for high-technology fields. It supports curriculum and educational materials development; preparation and professional development of college faculty and secondary school teachers; internships and field experiences for faculty, teachers, and students; and other activities. The program especially encourages efforts that give students insight into real-world work environments. ATE also promotes articulation between programs at two-year colleges and four-year colleges and universities. Two-year colleges are expected to play a leadership role in all ATE projects. IT is one of the fields of technology supported by the ATE program. ATE provides grants in three areas: ATE Projects, ATE Centers, and Articulation Partnerships. About one in five current ATE awards involves IT education and training.

ATE Centers are comprehensive national or regional resources that provide models and leadership for other projects and act as clearinghouses for educational materials and methods. They are typically cooperative efforts involving two-year colleges, four-year colleges and universities, secondary schools, business, industry, and government. Grant awards range from \$1.5 million to \$5 million, spread over four years. Five ATE Centers of Excellence focus on IT:

Southeast Center for Networking and Information Technology Education, Daytona Beach Community College, Florida: The center is promoting the development of curricula, processes, and infrastructure to improve programs and create a statewide delivery system to educate and train technicians in computer networking and IT. Efforts include incorporating IT workforce curricula with current industry certification requirements; providing seamless K-16 articulation with multiple occupational exit points; inservice training and professional development for faculty; determining training requirements and creating and validating curricula; providing student and faculty internships; promoting IT career awareness; and recruiting students from groups underrepresented in IT.

Kentucky Information Technology Center, University of Kentucky Lexington Community College, and Kentucky Community and Technical College: This consortium is working to implement widely an industry-driven IT curriculum; to provide professional development for secondary and community college IT faculty; and to increase industry and government participation in IT education in the state. A physical center provides education for faculty, staff, and private sector and government workers. A virtual center provides information on the IT curriculum, offers IT courses, and supports workshops. Mobile centers provide workshops for instructors and workers at their locations. Training focuses on a wide range of specific IT-related technical skills. An IT industry advisory board guides the center.

Midwest Center for Information Technology, AIM Institute, Omaha, Nebraska: This is a consortium of 10 community colleges, four-year colleges, secondary school districts, and businesses in Nebraska, Iowa, and North and South Dakota. The center emphasizes networking, computer applications, systems integration, application development, telecommunications, and digital media. Efforts focus on faculty and teacher development, student articulation, education/training programs for incumbent workers and students at different levels, and dissemination of best practices. Goals include a 50 percent increase in the number of teachers and faculty who have IT certifications, a 50 percent increase in the number of students articulating to community college programs and completing them, and a 25 percent increase in the number of students articulating to four-year colleges. Among recent activities are disseminating curricula to train small business owners and rural residents in e-commerce, a survey to identify faculty needs for IT training, a survey of employer needs, reaching out to high school students through posters and IT guidebooks, and expanding an online career guidance program.

National Workforce Center for Emerging Technologies, Bellevue Community College, Washington: The E-Portal to Information Technology and Careers provides online dissemination of IT curricula and educational materials, best

⁹⁰ Best Practices for Programs in Information Technologies at Community Colleges, August 25, 2000.

Advanced Technological Education (ATE) Program, continued

practices, career and certification information, and professional advancement opportunities. In addition, the center is a leader in developing, testing, and implementing IT skill standards, curricula, and instructional materials.

Northeast Center for Telecommunications Technologies, Springfield Technical Community College, Massachusetts: The center has led the development of work-relevant, industry-validated curriculum and materials for use in grade 11 through community college, and in four-year college programs in telecommunications. It is designing a series of telecommunications textbooks and lab manuals, and providing opportunities for faculty development and career awareness. The center is working with numerous community colleges to establish telecommunications technologies programs.

In addition to these centers, ATE is supporting a variety of IT education- and training-related efforts. For example:

Applied Information Technology Education Project, Mississippi Gulf Coast Community College: The project involves faculty training and certification, curriculum adaptation, developing a career awareness and exploration model focusing on females and underrepresented groups, and communicating that model to high school and college faculty and students.

State College and University, West Virginia: Through this project, West Virginia is instituting, statewide, a new associate of applied science degree in technical studies, with a network communications track and a computer applications track. The degree is being offered at all 12 of the state's community and technical colleges, through on-campus and Web-based study. An industrial advisory board provides advice and assistance. Students participate in internships.

Austin Community College, Texas: The Austin Regional Industry Education Systems Alliance is putting in place a competency-based system for IT education at the high school and community college levels. This effort includes development of IT skill standards for Texas, alignment of existing IT curricula with the skill standards, design and implementation of new curricula based on the skill standards, professional development for teachers, and performance-based assessments and certifications.

Valencia Community College, Florida: In partnership with the University of Central Florida and Rollins College, Valencia Community College is establishing an associate in science (AS) to bachelor of science articulation agreement model; enhancing recruitment, academic support, retention, and developmental advisement strategies directed at AS computer programming students; and updating the computer programming curriculum to better meet industry and student needs, and better prepare students for upper division study.

Bellevue Community College, Washington: The Washington State Information Technology Workforce and Education Initiative is a statewide collaborative project to identify and catalog Washington state IT workforce demands and available IT education programs. A gap analysis will lead to the development of new IT programs and to strengthening existing ones.

Regional Tech Strategies, North Carolina: This project involves six community colleges, university experts, and industry leaders focused on developing L-SITE (Learning through a Simulated Information Technology Enterprise), a realistic but fictitious enterprise that operates under varied conditions in each of the community colleges and represents the complexities and uncertainties of the real business world. Students learn by "experiencing" various challenges and problems they may face in a real workplace.

Erie Community College, New York: This project focuses on developing a new certificate program to provide training in Web technologies, including network fundamentals, client-server architectures, interactive dynamic multimedia human-computer interfaces, and relevant development tools and languages. The program will cover the complete, end-to-end Web technology spectrum. Objectives include developing, implementing, and evaluating new courses and education materials, developing a program web site to be shared by industry and academia, and developing "train the trainer" workshops for faculty.

ATE projects in IT train for the entry level: help desk, programmer, network administration and support, database support, and Web design. Some ATE projects include vendor training, such as Cisco, Microsoft, and Novell, but these are often embedded in a broader two-year program. Some ATE-supported programs offer internships. Most students who participate in ATE-supported education and training programs earn an associate in science degree. In IT, they may leave the ATE-supported program with one or more certifications. Many ATE students move on to four-year schools. ATE-supported programs are tightly linked to jobs and employer needs, and students experience a high rate of success in obtaining jobs in the industry or occupation for which they have trained.

Private employers play many different roles in ATE projects, including serving as advisors and partners on grants, providing instructors or equipment, working on curriculum development, and offering internships. Both large and small employers are involved.

www.ehr.nsf.gov/EHR/DUE/programs/ate

IT Certificate Programs

IT certificate programs (not to be confused with vendor or vendor-neutral certifications) are offered at many universities and community colleges. These adult continuing education programs typically specialize in providing in-depth teaching in some particular IT specialty, such as networking, e-commerce, or IT security; in a specific technical skill area, such as Java or C++ programming; or in a particular vendor's technology, such as Oracle databases. These concentrated programs of study can add depth to an IT worker's knowledge and skill in a particular specialized IT discipline or help the worker expand his or her skills into new discipline areas. These programs are often less costly, faster, and more focused, with more links than advanced degree programs to jobs and careers. Many people who pursue certificate programs are working professionals and pursue their certificates on a part-time basis.

Individuals may enroll in these programs with the aim of entering the IT profession, entering a new industry, upgrading their IT skills or expanding the scope of their skill portfolio, advancing in their career, or learning how to use a specific kind of information technology. Some of these certificate programs offer skills that would be considered relatively high compared with many other occupations, but are typically at the lower end of the IT skill spectrum. Others provide higher level skills.⁹¹

In certificate programs, students learn the theories and basic concepts of the IT specialty, as well as state-of-the-art practices. Earning a certificate can require passing as many as 10 courses. Some certificate programs have a hands-on, practical capstone or case study project in which the learner demonstrates the skills learned in the certificate program courses, sometimes working on real-world problems drawn from industry. While these projects provide helpful hands-on experience, they may not rise to the level of working experience that employers seek.

Completion of some certificate programs entitles students to Continuing Education Units (CEUs)—this is a nationally recognized unit of measure and recognition of participation in a noncredit organized continuing education program taught by qualified instructors. To earn one CEU requires 10 contact hours (50-minute hours) of continuing education. Other certificate programs offer credit toward degrees.

Northeastern University's Adult and Continuing Education program offers a range of part-time introductory, intermediate, and advanced IT certificate programs, some of which qualify for credits toward an undergraduate degree.⁹² The university's State-of-the-Art (SOA) program—which offers more than 20 IT certificates—provides training in new, established, and vendor-specific technologies. Most courses in this program are taught in a lecture/laboratory format by practicing professionals who are experienced in real-world day-to-day IT applications. Course curricula are revised on an ongoing basis. The SOA program courses are noncredit but offer CEUs. If

⁹¹ The Supply of Information Technology Workers in the United States, 1999.

⁹² www.ace.neu.edu.

students achieve a certificate through the SOA program, they may be able to receive college credit through an assessment program. Another dozen certificates can be attained through completion of IT courses in the Management Information Systems (MIS) program, which is offered for college credit. While SOA programs take a practical hands-on approach, MIS courses are more theoretical. The following are examples of Northeastern University certificate programs:

Introductory-level Certificates include computer programming (MIS), computer applications (MIS), Microsoft Technologies/Windows 2000 (SOA), and a computer systems specialist program (MIS). These programs are designed for those who have little or no background in IT, career changers, or those seeking an IT certification. Prerequisites are minimal, such as interest in programming, moderate technical knowledge, or the ability to manage intensive learning. The number of courses required ranges from 6 to 15.

The longest of these introductory programs—15 courses—is the 31-weekend Computer Systems Specialist program (about 12 hours per weekend). It is designed with career changers in mind, developing the skills of those who want to become computer systems specialists but have little or no academic or work-related background in computer and information systems technology. The program first provides basic information on computer applications software and the basics of structuring and designing a computer program. Students learn programming languages such as C, Java, and Visual Basic. They work to develop the specifications for a computer system, then take on a project to solve a real-world problem with a computer solution. Databases and networks are covered, as well as working in teams in order to develop project planning, leadership, and presentation skills. The program costs \$8,700 and grants credits toward an undergraduate degree. It provides basic technical skills for the entry-level IT professional.

Intermediate-level Certificates include data communications and systems technology (SOA), database design and administration (MIS), local area networking (SOA), object-oriented programming with C++ (SOA), and Windows programming (SOA). The six-course SOA programs on data communications and local area networking are designed to develop a sound understanding of the tools and techniques of these technical areas, and are targeted at career changers and those wishing to enter these IT disciplines. Candidates need moderate technical backgrounds for these two programs. The other three intermediate-level programs are designed for more experienced IT professionals. For example, the two programming courses have C programming experience as a prerequisite.

To achieve the certificate in database design and administration, learners cover in eight courses topics and technologies such as Visual Basic, structured systems analysis, SQL, Cold Fusion, Active Server Pages, and database administration. This knowledge and these skills should allow students to design, implement, and manage databases in a desktop, distributed, or client/server environment. The certificate program costs approximately \$5,300, and 24 undergraduate credits are awarded for completion.

Advanced-level Certificates include information networks professional (MIS), telecommunications systems technology (SOA), Web design (MIS), advanced database technology (SOA), client-server technology (SOA), software engineering using C (SOA), and enterprise security (SOA). These programs are designed for IT professionals with several years of experience in the field, some experience in the particular course's subject matter—such as databases, programming, or network administration—or previous course work. These advanced-level programs are designed to upgrade current IT workers' skills or prepare them to enter a new industry or IT technology.

For example, the four-course Certificate of Professional Achievement in Enterprise Security provides experienced Web and network professionals with the knowledge to protect an organization's systems from internal and external harm through both business and technical tools. The program covers Internet/intranet security and firewalls, Windows 2000 security, systems forensics, and corporate security policy. The 20-week, hands-on Advanced Database Technology Certificate program offers two tracks—one for Microsoft and one for Oracle. Each track requires students to complete six database courses on either a Microsoft or Oracle track. These courses cover design, programming, database/Web integration, and administration for those vendors' database systems.

Northeastern also offers hands-on certificate programs (SOA) that prepare students for attaining vendor certifications from Cisco, Microsoft, Oracle, and Sun. For example, the Oracle Database Administration Certificate program is offered for IT professionals who seek a career as Oracle database administrators. Participants must be familiar with SQL and understand relational databases. Four modules cover Oracle database architecture and administration, fine-tuning applications running on an Oracle database server, backup and recovery, and connecting an Oracle database via Oracle networking. The course costs about \$4,000.

The **University of Maryland's** University College offers 19 undergraduate IT-related certificates.⁹³ Each of these certificates is earned after completion of six courses, and they represent a mix of introductory or entry-level certificates and certificates for the IT professional. Introductory certificates cover subjects such as basic computer applications, graphics and design, database management, Web design, and Internet management. A range of database, operating system, and programming certificates are available for the IT professional. Each certificate program costs about \$3,600 for residents and \$6,550 for nonresidents. Some credits for certificates and some prerequisites can be satisfied through examination or an assessment of a written portfolio describing the candidate's work and other experiences.

In addition to certificates focused primarily on technical skills development, the University of Maryland offers several certificate programs designed to provide IT professionals with knowledge and skills in the areas of business, business functions, and project management. For example, the certificate program E-Commerce for IT Professionals covers issues such as the technological and market forces affecting e-commerce, hardware and telecommunications infrastructure, data mining, consumer behavior, supply chain management, security, telecom-

⁹³ www.umuc.edu/prog/ugp/certificates/cert_list_alpha.shtml.

munications regulation, and ethical and societal issues. The certificate program Project Management for IT Professionals covers the role of information systems in organizations, techniques for improving organizational productivity, teamwork, formal problem-solving methods, human factors, multimedia, and project management techniques such as PERT and Gantt charts. These six-course certificate programs also cost about \$3,600 for residents and \$6,550 for nonresidents.

Similarly, the **University of California at Berkeley's** IT certificate offerings include technical skills development but go further to include business skills and preparation for entry into a new industry.⁹⁴ The university offers about 20 IT-related certificates, most of them focused on technical skills development—some for individuals with little or no IT training, some for those with previous course work, and some for individuals with technical experience. Certificate programs can require up to 10 courses and cost nearly \$8,000, although many are in the \$2,000–\$5,000 range. These courses are often taught by instructors from industry.

Imparting key business skills for today, UC Berkeley offers an intensive certificate program called E-Commerce Business and Technology, with six required courses and two electives in the concentration areas of business analysis, e-commerce application development, marketing, and telecommunications/networking. This certificate focuses on the business and technical fundamentals of e-commerce in its traditional and emerging forms of business-to-business, business-to-consumer, and wireless. Core courses focus on planning and executing an e-commerce project, e-commerce systems design and integration, Internet technologies, e-commerce and business processes, and e-commerce business models. This program is designed for people who are familiar with the Web, basic networking concepts and operating systems, programming concepts, and basic business and management processes.

Some certificate programs prepare workers for a new industry or an expanded role in their current industry. For example, UC Berkeley offers a certificate program in Telecommunications and Network Engineering, which provides a knowledge foundation in telecommunications. Required courses cover relevant terminology and concepts in telecommunications, including digital communications; the deployment and integration of data communications systems; and networking technologies. Electives focus on four areas of concentration: networking technologies and network management, wireless and mobile networks, telecommunications technologies, and Internet technologies. This program is designed for higher level IT workers such as electronic and software engineers, or network and communications analysts who are currently working on telecommunications or are just entering or wish to enter the industry. Participants in this program should have a bachelor's degree in a technical field or equivalent professional experience and some knowledge of electronics and computers.

In another certificate model, UC Berkeley's certificate program in Business Intelligence and Data Warehousing is developed and taught by the Base Consulting Group. Nine courses (225 hours of instruction) cover both business and technical issues, providing learners with

⁹⁴ www.unex.berkeley.edu/cert.

the knowledge to design, develop, implement, and operate a data warehouse. Instructors are consultants in large-scale data warehousing. For every hour of classroom instruction (typically 6 hours per week), 1.5 to 2 hours of outside study are required, for a potential weekly study load of 18 hours, a substantial commitment for a jobholder. The course costs \$7,800.

Community colleges offer a range of IT certificate programs. The development of specific technical skills—such as Java, Oracle, and Unix—is a large focus of community college certificate programs, which range from introductory courses for the novice to more advanced technical courses designed for the incumbent IT worker who needs to learn a new technical skill.

For example, **Northern Virginia Community College**⁹⁵ offers a certificate in C++ programming that involves one introductory and one intermediate course designed to prepare students for entry-level work as a C++ programmer at a cost of \$1,230. The community college has a similar two-course certificate program in C programming. In the same community college system, at a different campus, a more in-depth, advanced C/C++ certificate program is offered, involving five required courses and three elective courses, which can be completed for \$2,235. Certificate programs are offered on many popular technical skills—client/server computing, Java, networking security, Unix, and Oracle database. A short certificate program—three courses on Front Page 2000—runs a low \$525. Northern Virginia Community College also offers a certificate in electronic business and commerce that—in addition to technical subjects such as XML, Oracle, and Cold Fusion—covers a range of business and soft skills such as e-commerce business models, teamwork and e-business teams, project management, customer relations management, and interpersonal communications.

IT-related certificates are also offered at the graduate level. For example, the **University of Maryland's University College** offers graduate-level certificates in applied computer systems, database systems and security, database systems technologies, information resources management, software development management, telecommunications management, information technology, and software engineering.⁹⁶ These certificate programs are targeted at a range of learners: IT professionals, technical managers, and individuals who may not be IT professionals but need a foundation in an IT topic. Some of these graduate-level courses require previous course work. For example, for applied computer systems, one semester of undergraduate calculus and familiarity with a high-level programming language are recommended; for database systems and security, one semester of undergraduate statistics is required; and individuals who wish to pursue the certificate in software engineering must meet all the requirements for admission to the master of science in software engineering degree program. Each of the graduate certificate programs requires completion of five courses and costs \$4,650 for residents and \$7,710 for nonresidents. While these courses are generally technical, some of them touch on business skills such as risk analysis, the management of risk, human-machine interface, IT acquisitions management, and the structure of the telecommunications industry.

⁹⁵ www.nv.cc.va.us.

⁹⁶ www.umuc.edu/prog/gsmc/certificates/its.html.

Medical Information Systems Technology (MIST) Program

Launched in 1997, the Medical Information Systems Technology (MIST) Certificate program at the SUNY Health Science Center (also known as Downstate Medical Center) is designed to train personnel for IT occupations in health care institutions and health-care-related industries. The program targets working health care professionals who are interested in professional advancement or shifting the focus of their careers. Students gain knowledge and skills in common business computer applications, PC architecture, Windows 2000 and server systems, Internet protocols, local area networks, web site development and design, database management, and introductory-level programming. MIST has an additional focus on information systems designed specifically for the health care industry. The 11-month program has four modules 10–11 weeks long, with 12 hours per week of classroom and computer lab course work. Some of the courses MIST participants take are medical information systems, medical terminology, database development with Access/SQL, web site development with Cold Fusion, LAN fundamentals, and introduction to Visual Basic.

Admission requirements include a minimum of 60 college credits or an associate degree. In addition, applicants need a working knowledge of Windows, Microsoft Word, the Internet, and e-mail. They must own a PC, be connected to the Internet, and have an e-mail account. Applicants are also required to take an admissions examination, which tests language, math, and basic computer skills. Admission decisions are based on the applicant's admission test score, education, experience, and oral and written communication skills as demonstrated in a personal interview and essay. MIST program tuition is \$4,000.

A large proportion of MIST participants are women and minorities who hold low-skilled jobs or jobs with limited career advancement potential, such as nurse practitioners, technicians, and administrative and clerical personnel. Surveys of MIST graduates show that among respondents, postgraduate salary increases ranged between 15 percent and 25 percent. The majority of graduates who had been employed in the health care sector remained in it but moved on to better paid positions that require IT skills. Participants who had been employed outside health care moved into IT-related positions at a wide range of institutions and industries.

At **George Mason University** in Virginia, several advanced certificate programs are offered at the graduate level.⁹⁷ For example, to earn a certificate in computational modeling, students must complete six courses: operations research—deterministic models; discrete systems simulation; computational methods in engineering and statistics; case studies in data analysis; and two electives. Courses taken for this certificate program count toward an MS in operations research, an MS in statistical science, or a Ph.D. in computational science and informatics. To enter the program, students must meet the minimum entrance requirements for the MS or Ph.D. degrees described above, have taken advanced mathematics classes, and have knowledge of a scientific computer programming language. In the certificate program in communications and networking, students take two foundation courses: random processes in electrical and computer engineering, and either computer network architectures and protocols or computer communications and networking. Students then must complete three electives from one of five areas of concentration: communication networks, optical communications, mobile communication systems, communication theory, and digital communications. This program is open to persons who hold a bachelor's degree in any scientific or engineering discipline from an accredited university, and course work can be used for credit toward an MS in electrical engineering or computer engineering.

As the examples in this report illustrate, **IT certificate programs offer a wide range of opportunities for potential and current IT workers to acquire, upgrade, and expand their IT skills.**

⁹⁷ <http://ite.gmu.edu/graduateresearch/graduateresearch.htm>.

CIO Certificate Program

The Federal Chief Information Officers (CIO) Council's focus on IT education led to a specific initiative to address the needs of federal executives—the CIO University.⁹⁸ The CIO University is composed of graduate-degree-granting universities. These institutions—George Washington University, Carnegie Mellon University, George Mason University, University of Maryland University College, Syracuse University, and LaSalle University—tailor their respective academic offerings to the unique requirements of the federal IT sector and its leadership.

In 1996, Congress passed the Clinger-Cohen Act, which established the role of CIOs in the Federal Government and served as the basis for developing core IT competencies required of federal employees before they are eligible to become federal Chief Information Officers. To guide training programs that would develop these competencies, the Federal Government translated its requirements for its senior IT corps into a roadmap for universities to develop a special curriculum.

After the Federal CIO Council identified a set of high-level competencies that met the requirements of the Clinger-Cohen law, learning objectives and major content areas were developed through group processes that involved 100 senior government executives, as well as representatives from industry and academia. From this process emerged a complete CIO certificate program.

At Carnegie Mellon, the CIO certificate program is a modular course of study of eight 1-week-long courses—expected to be taken every other month for a total of 16 months to complete—that directly address the Clinger-Cohen competencies of leadership, process and performance management, information resources strategy and planning, IT acquisition and program management, IT management, information assurance, e-commerce and e-government, and key technical topics. The complete eight-course program costs \$20,000 for Federal Government employees; other learners pay \$23,600. For those who earn the certificate and complete an acceptable thesis, the program offers 60 graduate units (out of 180 required) toward a master of information systems management. The University of Maryland's CIO certificate program can be completed in 12 months, meeting 8:30am–5:00pm on 35 Saturdays. Those who complete the course are eligible for 24 credits (out of 35 or 39 needed for the certificate) toward a master's degree at the school. The program costs \$16,632. George Mason University's CIO certificate can be earned in 18 months meeting on Saturdays; completion qualifies the student for a master's degree in technology management. The program costs \$25,000. George Washington University's program is run in conjunction with the school's Integrated Master of Science program in Information Systems Technology and costs \$15,900.

These programs—designed at introductory, intermediate, and advanced skill levels—are offered at community colleges and universities at both the undergraduate and graduate levels, and include programs to enhance the skill portfolios of experienced IT workers by adding highly advanced skills. While IT certificate programs focus mainly on the provision of technical skills, some programs also address development of business and soft skills. Certificate programs can vary significantly in length and cost.

While IT certificate programs offer many choices for IT skill development, both IT workers and employers face a confusing maze of offerings and a credential—the certificate—that has no standard meaning of accomplishment across the academic enterprise. For example, as previously mentioned, Northern Virginia Community College offers separate certificates in C programming and C++ programming, each requiring the completion of two courses. The C programming certificate requires a total of 68 hours of instruction for \$1,200, and the C++ programming certificate requires a total of 70 hours of instruction for \$1,230. Both focus on the mechanics of programming in these languages. At another campus in the same community college system, a combined C/C++ certificate program requires five mandatory courses (on C, C++,

⁹⁸ www.gsa.gov/Portal/content/offering_content.jsp?contentOID+113942&contentType=1004.

and object-oriented programming, and Visual C++ programming for Windows) and three electives (chosen from a nine-course menu spanning a range of topics related to Java, C#, Visual C++, and V.B.NetII). This combined certificate can be completed at a theoretical minimum cost of \$2,235 for 93 hours of instruction. With these certificate offerings, an employer could be presented with two job candidates with similar credentials from the same community college system: one with certificates in C programming and C++ programming, and another with a combination certificate in C/C++ programming. However, the candidates' courses of study were different.

Similarly, IT workers seeking a certificate on a particular technical skill can face significant variability in cost and in other attributes of certificate programs. In the first example (Figure 16), three universities' continuing education programs offer certificates in object-oriented pro-

Figure 16. Certificate Comparisons

Certificates in Object-Oriented Programming Using C++			
University 1 ⁹⁹	University 2 ¹⁰⁰	University 3 ¹⁰¹	
4 required courses	2 required courses	5 required courses	
2 electives	2 electives	2 electives	
180 hours of instruction	120 hours of instruction	185 hours of instruction	
Cost: \$6,130	Cost: \$4,180	Cost: \$3,690	
Certificates in Database Management			
University 1 ¹⁰²	University 2 ¹⁰³	University 3 ¹⁰⁴	University 4 ¹⁰⁵
4 required courses	3 required courses	4 required courses	3 required courses
1 elective	1 elective	2 electives	No electives
104 hours of instruction	130 hours of instruction	225 hours of instruction	90 hours of instruction
Cost: \$5,075	Cost: \$4,380	Cost: \$3,708	Cost \$1,686

⁹⁹ Northeastern University. Required: C++ Programming, Object-Oriented Programming, Object-Oriented Design, Advanced C++ Programming. Electives on the current schedule: C Programming, C Programming: Advanced Topics.

¹⁰⁰ New York University. Required: Object-Oriented Programming Using C++ Part I, Object-Oriented Programming Using C++ Part II. Electives currently offered: Java I, Java II.

¹⁰¹ University of California. Required: Object-Oriented Analysis, Object-Oriented Design, C++ Programming Language, C++ Programming Language II, Object-Oriented Programming Using C++. Least-cost electives: Distributed Object Programming with CORBA: Overview, Object-Oriented Project Management.

¹⁰² Georgia Institute of Technology. Required: Database Concepts, Database Modeling, Relational Database Design, Performance Issues and Tuning in Relational Database Systems. Electives offered: Microsoft SQL Server, Using Oracle.

¹⁰³ New York University. Required (least time commitment): Database Management Systems; Oracle Database Administration; Back-up, Recovery, and Network Administration. Elective (least time commitment): Introduction to Data Warehousing Strategies and Concepts.

¹⁰⁴ University of Maryland University College. Required: Introductory Course (on programming), Database Concepts, SQL, Advanced Database Concepts. Electives offered: Ethics in the Information Age, Systems Analysis, Data Mining: Introduction and Application, PL/SQL.

¹⁰⁵ University of Washington. Required: Database Management Fundamentals, Database Design and Implementation, Database Administration.

gramming using C++. Hours of instruction in the certificate programs and costs vary significantly. The second example shows similar variability in certificates in database management.

Variability in program content, length, and cost—even when certificates have the same name—means that IT workers and employers face challenges in understanding and considering IT certificate training options. Moreover, employers considering the qualifications of job candidates face the prospect of trying to understand what a particular certificate represents in terms of knowledge and skill when there are no standards to guide them. The inability to easily assess the value of these IT certificates—which, in the absence of standardization, would require exploring the actual curriculum in which each job candidate participated—may contribute to employers’ strong reliance on a job candidate’s work experience.

Education and Training Program Focuses on IT Career Ladder

Clayton College and State University in Georgia established a rigorous three-level Information Technology Career Ladder (ITCL) program that allows students to move progressively through an IT certificate to an associate of applied science in information technology degree to a bachelor’s degree in information technology. The program is part of the school’s College for Economic and Community Development.

Students can earn a certificate in information technology in two semesters. Earning the certificate requires students to complete courses in English composition, mathematical modeling, critical thinking, foundations of information systems, presentational speaking, database applications, and systems analysis. In addition, they must complete four technical skills classes chosen from classes covering Visual Basic, Java, C++, webmaster, networking, Unix, database design, and others. Among the four technical skills classes that must be taken, students must complete both the foundation course and the intermediate course in one of the technical skill groups; for example, both the foundations of programming in Java and intermediate programming in Java. After earning their certificates, students may join the workforce or proceed to the associate level.

The associate program accepts all courses earned in the ITCL certificate program. Studies leading to the associate degree include additional courses in English composition and presentation (audio/visual), and courses in government and history, finite mathematics, computing with spreadsheets, operating systems, and project management. Students must take three technical skills classes, including any technical skills foundation courses that were not taken at the certificate level, and are expected to complete another technical skills group. Students are also required to complete an internship. After finishing the associate program, students may join the workforce or progress to the bachelor’s degree program.

The bachelor’s program accepts all courses completed in the ITCL certificate and associate-level programs. At the bachelor’s level, students must complete other general education courses in areas such as the humanities, science, sociology, psychology, and history. Students choose three electives, including one IT course, from writing for digital media; mathematical application for IT; principles of management; advanced systems, security, and process development; or testing and quality assurance in software development. Students must also take four courses in a major concentration area selected from general IT with an emphasis on e-commerce; database administration; network planning, design, and management; and software development. To complete the bachelor’s program, students must develop a portfolio that represents the skills they acquired and projects they completed, and must participate in an internship cooperative. In the internship, students work in teams to complete projects in cooperation with local industry, applying the knowledge they have gained in a real work environment. Credits for the internship depend on hours devoted to it.

The complete career ladder requires 120 semester hours and costs approximately \$12,000 in tuition for in-state students.

www.it.clayton.edu/programs.asp

Private, For-Profit Education and Training Institutes

Private, for-profit institutions offer a wide scope and varying levels of IT education and training to prospective and current IT workers. Some schools offer a broad range of programs, from certificates and diplomas to master's degrees, and are exclusively IT focused. Others offer a variety of technical programs but focus entirely on providing entry-level knowledge and skills. Some of the larger providers have many local campuses and operate nationally or regionally. These schools tend to be workplace focused, and their curricula are directed primarily at teaching business and technical skills that are in demand in the marketplace.

These organizations often provide very flexible access to their classes, offering courses during the day, in the evening, on weekends, and online.

DeVry University (www.devry.edu). DeVry University is a private, for-profit institution offering bachelor's and graduate degrees through applications-oriented technology and business education to more than 55,000 students annually on its 22 campuses in the United States and six DeVry University Centers, as well as through its online offerings. DeVry is accredited by the North Central Association, an accrediting association recognized by the U.S. Department of Education.

DeVry offers programs leading to associate, bachelor's, and master's degrees, as well as graduate-level certificate programs. These programs can be taken full time or part time; during the day, evenings, or weekends; or online. Students can mix-and-match from these options to fit their schedules. In addition, DeVry offers accelerated courses and a fast-track program to speed the degree completion process.

Not all programs are offered at each of the campuses or University Centers. The bachelor's degree in information technology is the only offering available at all six DeVry University Centers and all but one of the U.S. DeVry campuses.

Associate Degree. DeVry offers several associate degree programs, including two that are IT-specific: network systems administration (80 semester hours) and electronics and computer technology (86 semester hours). Tuition for these degrees is approximately \$23,000 to \$26,000.

Bachelor's Degree. DeVry offers IT-related bachelor's degrees in information technology, computer engineering technology, computer information systems, and business administration, with concentrations in business information systems, e-commerce, operations management, and project management. Operating on a three-semester-per-year basis, the bachelor's degree programs require eight or nine semesters to complete for full-time students. The program in information technology is an exception. Designed for those who already have a bachelor's degree, DeVry's information technology bachelor's degree program (48 semester hours) can be completed in as little as three full-time semesters.

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The cost for the programs varies by campus. The cost of acquiring the bachelor's in business administration (eight full-time semesters, 128 semester hours) is approximately \$38,000 to \$42,000; the bachelor's degrees in computer engineering technology and computer information systems (nine full-time semesters, 154/139 semester hours, respectively) is approximately \$42,000 to \$47,000; and the bachelor's degree in information technology is approximately \$19,000 at all campuses.

Graduate Degrees. Graduate programs—including master's degrees and graduate certificates—are offered through the Keller Graduate School of Management of DeVry University. The master's in business administration requires completion of 16 courses and offers concentrations in electronic commerce, information systems, and project management. Tuition for the MBA is approximately \$19,000 to \$24,000.

The master's in information systems management requires 60 quarter-credit hours consisting of 15 courses at 4 quarter-credit hours each, including 5 courses in management foundations, 4 in information systems (IS) applications, 2 in IS tools, 3 in project management, and an integrative capstone course. Students may pursue an area concentration in distributed systems management, electronic commerce, or large systems. Total cost for the master's degree is approximately \$18,000 to \$23,000. The length of the program varies depending on how many classes are taken each term. Terms generally last 10 weeks, although an accelerated 5-week schedule is available for some courses at selected centers.

The Keller Graduate School offers graduate certificates in electronic commerce management (eight courses), information systems management (seven courses), and project management (six courses). Cost per four quarter-hour course ranges from \$1,185 to \$1,515, depending on the campus, and \$1,620 for classes taken through distance learning.

Each DeVry campus has a program advisory board composed of area business leaders and employers of DeVry graduates. These boards meet at least once a year to provide feedback on the curricula and on the performance of DeVry graduates. Feedback from each local advisory board meeting is forwarded to DeVry headquarters for use in improving the curricula.

The Chubb Institute (www.chubbinstitute.com). The Chubb Institute is a technical career school offering diploma and certificate programs to help students acquire the technical skills needed to start or further a career in IT. Chubb has 11 campuses in Georgia, Illinois, New Jersey, New York, Pennsylvania, and Virginia, and graduates approximately 8,000 students each year. Programs are available for full- and part-time students, and classes are offered during the day and in the evening.

Every Chubb Institute is accredited by a U.S. Department of Education–recognized national accrediting body. Accrediting agencies include the Accrediting Commission of Career Schools and Colleges of Technology (ACCSC), the Accrediting Council for Independent Colleges and Schools (ACICS), and the Accrediting Council for Continuing Education and Training (ACCET).

Chubb offers diploma programs in Web design, Web development and business programming, advanced Web development and business programming, networking, and personal computer programs. Diploma programs range in duration from 5 to 15 months and cost from \$4,095 to \$16,000. Chubb continuing education programs are targeted at IT professionals who want to expand or transition their programming skills into popular e-business languages.

In 2000, the Chubb Institute established an articulation agreement with the University of Phoenix that offers Chubb graduates the opportunity to petition for academic credit through the university, so that credits earned at the Chubb Institute will apply toward elective and general education requirements of the university's undergraduate degree programs.

Strayer (www.strayer.edu). Strayer University is a private university specializing in IT and business-oriented education for working adults. Undergraduate and graduate programs are available online and at 20 campuses in Washington, D.C.; Maryland; North Carolina; and Virginia. Strayer offers classes seven days and nights a week.

Strayer IT offerings include:

- 12-month diploma programs in computer information systems (with a range of specialties in database, networking, and programming), internetworking, network security and Web development;
- an undergraduate certificate in computer information systems;
- associate and bachelor's degrees in computer information systems, computer networking, database technology, and internetworking technology, with minors in accounting information systems, computer information systems, e-business, internetworking, and networking;
- master's degrees in information systems and management information systems; and
- an executive graduate certificate in computer information systems.

Full-time students who are taking 13.5 or more quarter-hours per quarter pay \$220.50 per quarter-hour; those taking less than 13.5 quarter-hours pay \$231 per quarter-hour. The cost of a bachelor's degree (180 quarter-hours) is approximately \$40,000; an associate degree requiring 90 quarter-hours costs approximately \$20,000.

ITT Technical Institutes (ITT Tech) (www.itt-tech.edu). ITT Education Services, Inc., a for-profit private college system, operates 71 ITT Technical Institutes in 28 states, serving approximately 31,000 students annually. ITT Tech offers associate and bachelor's degrees in several IT-related areas. Associate degrees are offered in computer network systems, software applications and programming, multimedia, and Web development. Bachelor's degrees are offered in computerized visualization technology (at seven colleges), information systems security (beginning in June 2002 at one campus; to be offered at selected other campuses subse-

quently), and technical project management. A bachelor's degree program online in technical project management for electronic commerce is available in 24 states. In addition, ITT Tech offers an associate degree program in computer and electronics engineering technology and a bachelor's degree program in electronics engineering technology at selected colleges.

Associate degree programs are eight quarters in length, 12 hours per quarter, with attendance in class three days a week for 4–4.5 hours per day. Bachelor's degree programs are designed for those who have completed associate degrees or have the equivalent amount of college credits. Bachelor's programs range from six to eight quarters in length, 12 credit hours per quarter, with the student attending three days per week for approximately 4 hours. The online bachelor's program is eight quarters of 12 credit hours per quarter.

Tuition for the associate degree programs described above is \$330 per credit hour. Tuition for onsite bachelor's degree programs is \$260 per credit hour; for the online bachelor's degree program in technical project management for electronic commerce, tuition is \$314 per credit hour. All textbooks are included in the tuition costs. Enrollment fees, administrative fees, and tools (for electronics students) are not included in tuition costs.

Associate degree programs are offered at all 71 colleges. In general, classes are held in three shifts: morning, afternoon, and evening. Beginning classes for most associate degree programs are offered each quarter. However, if there is insufficient enrollment for a particular program at the beginning of the quarter, that program may not be offered until the following quarter. Bachelor's degree programs are offered at selected colleges.

Each ITT Technical Institute is authorized by the state in which it is located and is accredited by the ACICS.

Involvement of industry representatives occurs at several points. The first is during curriculum development, when industry representatives are consulted about desired skill sets, appropriate laboratory and software design, and general industry trends. In addition, each of the colleges works with advisory boards in its local market. The college forms an advisory board of local industry representatives for each of the programs offered at that college. The boards provide information on local industry needs and trends and also assist the college in periodically assessing and updating curricula, equipment, and laboratory design. Finally, each college has a career services department that is responsible for maintaining constant contact with local employers, to assess employer needs and desires and to help graduates search for employment.

NETg (www.netg.com). Acquired by Thompson Corporation in 2001, NETg is a for-profit company offering a variety of IT and related instruction delivered through e-learning, instructor-led training, books, and e-books. NETg trains 4 million learners annually. NETg operates globally, conducting its research and development and product development in Limerick, Ireland, at its

Global Development and Innovation Center, and delivering its content and learner interfaces in 12 languages.

NETg offers its products and services directly to individuals, as well as to corporations to educate and train their employees. NETg uses a “blended learning” approach, providing education and training through a variety of delivery mechanisms—including online offerings, books, instructor-led training, simulations, and mentoring—to address different learning and life styles.

Among its instructional material, NETg has more than 3,000 e-learning courses, hundreds of printed and online books, instructor and student manuals for classroom training, self-study guides, and accelerated “boot camps” for IT certification.

NETg claims the largest library of enterprise content in the world, including all popular topics in IT, IT certification, and business and professional skills. NETg offers training to prepare students for a variety of certification exams offered by Microsoft, Cisco, Oracle, Novell, Sun, Linux, Lotus, and others; training in computer and IT principles, and specific software packages; and Cardean University’s MBA program. Individual courses covering four to eight hours of material cost approximately \$75-\$150 each. Many courses are offered at a discount in packages. For example, one offering allows students to take as many Microsoft Certified Systems Engineer (MCSE) courses as they can over a period of 6 months (110 are offered) for approximately \$840, or over a 12-month period for approximately \$1,440.

NETg e-learning combines interactive learning scenarios and assessments to ensure skills transfer, relying on simulations to provide learn-by-doing opportunities. NETg’s e-learning content is based on its more than 82,500 learning objects. Each object contains all the information required to learn a specific skill: a learning objective, a learning activity, and an assessment. This approach allows learners to access as much or as little of the e-learning content as needed.

Companies can tailor learning programs using NETg software and content, as well as by incorporating their own material. Companies can also customize learning interfaces to match their corporate look and feel. In addition, NETg offers companies the ability to centralize administration of enterprise-wide training efforts in a single, open system.



Chicago Roundtable

Vendor and Vendor-Neutral IT Certification

During the past decade, a new form of credentialing—certification—has emerged in the IT profession and has grown increasingly popular. One example of the rapid growth in certification is the increase in the number of MCSE certifications over the past few years: 35,000 in fall of 1997, 280,000 by June 2000, and almost 463,000 by July 2002.¹⁰⁶

These competency-based credentials are typically earned by passing one or more examinations, not by passing courses. Examinations are updated periodically to reflect current technology, knowledge, and practice. For example, CompTIA's vendor-neutral I-Net+ certification exam, introduced in 1999, was updated in April 2002, with more than 50 percent of its certification objectives revised to reflect new technologies and job requirements in security, e-business, and wireless.¹⁰⁷ IT workers may therefore have to engage in additional education, training, and test-taking to maintain their certification.

Approximately 300 IT certifications are sponsored by IT vendors and professional and industry associations.¹⁰⁸ Several hundred more IT certifications can be earned by passing low-cost tests offered by Brainbench,¹⁰⁹ and through 42 professional certification programs offered by Learning Tree International. There are certifications in many areas of IT, including networking, database development and administration, IT support, wireless, operating systems, IT security, and programming. There are also certifications focused on particular vendors' products.

¹⁰⁶ Training for Techies, Fall 2002.

¹⁰⁷ CompTIA's I-Net+ Certification Receives Complete Update—New Exam Debuts April 12, press release, April 11, 2002.

¹⁰⁸ Clifford Adelman, A Parallel Postsecondary Universe, The Certification System in Information Technology, U.S. Department of Education, October 2000; <http://infocenter.cramsession.com/certifications/list.asp>; www.infosyssec.com/infosyssec/itcert.htm.

¹⁰⁹ www.brainbench.com.

These certifications provide independent verification that bearers have achieved a certain level of expertise in a particular IT discipline or a specific set of skills and knowledge that relates to a specific IT product or technology. The certifications do not represent a multidimensional assessment of knowledge, soft and business skills, or experience. They are indicators of mastery of some specialized knowledge—in this case, an IT specialization—and are supplemental to formal degrees and work experience. These certifications represent standards of achievement that are established by their sponsors. The credentials may help entry-level or inexperienced IT job seekers convince an employer to give them a try. The certifications also expand a current IT worker's portfolio of credentials and may help an experienced worker move into a new IT discipline. Certification may be more important in certain IT disciplines than in others. In a recent survey, 68 percent of network engineers believed that certification was important to their careers, as did 60 percent of network administrators. However, other IT professionals—help desk workers, Java developers, Web and e-commerce developers, and CIOs—did not believe that certification was important to their career success.¹¹⁰

Three testing companies play a major role in administering IT examinations—Prometric, Cat-Global, and VUE Testing Services—and reporting results to certification sponsors. These companies are global in their reach. For example, in 2001, Prometric administered more than 6 million exams through 4,800 testing centers in 136 countries.¹¹¹ VUE Testing Services operates 3,000 testing centers in 120 countries.¹¹² Exams administered by these companies are proctored, timed, and delivered in a secure manner; they cost between \$125 and \$250, although total fees may be higher because some certifications require passing several exams. For example, certification as an MCSE requires passing seven exams.

There are two primary kinds of certifications. The first, and largest, group is composed of certifications related to specific vendors of IT products, including Microsoft, Oracle, Cisco, Novell, IBM, Sun, and others. These certifications indicate that bearers have demonstrated certain levels of capability in working with the particular vendor's technologies.

The second group is composed of vendor-neutral certifications, which are typically sponsored by professional and industry associations. Among the most popular is the A+ certification developed for service technicians by the Computer Technology Industry Association (CompTIA). Vendor-neutral certifications signify some level of accomplishment in a particular discipline, such as computer support and networking. At Brainbench, certification tests in programming and development are the most popular, followed by systems and network administration, technical support, and Web development and administration. Those four fields also have the highest number of test takers.¹¹³

¹¹⁰ Nick Doty, Train and Certify. Does It End? Just When You Thought Your Cert Training Was Done for a While, Microsoft or a Peer Demands Another Upgrade: Should You Even Bother?, Techies.com, http://home.techies.com/Common/Content/2001/04/23tc_whyrecertify.html, April 23, 2001.

¹¹¹ www.prometric.com.

¹¹² www.vue.com.

¹¹³ Special data analysis provided to the Department of Commerce by Brainbench.

Training for Certification Exams. While formal course work is not always required, there are a number of ways to prepare for certification exams. These include self-study books, computer-based training, courses on the Internet, courses in academic settings such as community colleges and high schools, and courses offered by private trainers or training centers authorized by vendors who sponsor certifications. For example, Microsoft offers a range of options for those who wish to prepare for its certifications, including instructor-led classroom training at its Certified Technical Education Centers, online training available around the clock from Microsoft training partners, and a full range of books and CD-ROMs from Microsoft Press.¹¹⁴

In a recent Prometric survey, IT professionals from the Americas said that printed materials designed for self-study and instructor-led classroom training were the best ways to prepare for certification tests.¹¹⁵ In another survey, far more Microsoft certified professionals used self-study materials and on-the-job training to prepare for certification than used methods such as instructor-led training or classroom training.¹¹⁶

Examples of Popular Certifications

Cisco: Cisco Systems, a manufacturer of computer networking equipment, sponsors three levels of certification—associate, professional, and expert—and focused certifications in specialized IT disciplines. There are two general certification tracks: the Network Installation and Support Certification track and the Network Engineering and Design Certification track. In the Network Installation and Support track, a person certified as a Cisco Certified Network Associate (CCNA) can install, configure, and operate LAN, WAN, and dial access services for small networks. One exam—lasting 75 minutes, with 45–55 questions—must be passed to achieve this credential. Six months of experience and training is recommended before testing. Next, the Cisco Certified Network Professional (CCNP) is a mid-level certification, representing journeyman knowledge of networks. A CCNP would be able to do what a CCNA can do, but for larger networks, from 100 to 500 nodes. Four exams (75–90 minutes, 55–80 questions) or two longer exams (a 135-minute, 145–155 question foundation exam and a 90-minute, 55–65 question exam) must be passed to achieve this credential. At the expert level (Cisco Certified Internet Expert [CCIE]), an IT worker would be able to install, configure, and operate networks in highly complex environments with specific protocols. To achieve CCIE status, a person must pass a two-hour, 100-question multiple choice exam, as well as a practical lab exam lasting up to eight hours. Individuals need about two years of experience in troubleshooting and managing networks to successfully complete the lab exam. The CCIE is considered one of the most difficult certifications to earn. Cisco's associate- and professional-level certifications are valid for three years, although advancing from the associate level to a professional level, or recertifying at the professional level, renews the associate-level certification. Professional level certifications are renewed by exam. Cisco certifications at the expert level are valid for two years, renewable through additional training and a recertification exam. Cisco also sponsors specialized certifications in cable, IP telephony, SNA/IP, content networking, Internet solutions, and security. Earning a specialist credential can require passing from one to five exams.

Microsoft: Microsoft currently offers nine certifications, including the Microsoft Certified Systems Engineer (MCSE), the most popular certification in the IT field, held by more than 450,000 persons. (More than 1.2 million individuals have earned Microsoft Certified Professional status, which requires passing just one Microsoft certification test.) The MCSE is a certification for IT workers who design and implement IT systems based on the Microsoft Windows 2000

¹¹⁴ www.microsoft.com.

¹¹⁵ 2001 Training and Certification Study, Prometric, Inc., 2001.

¹¹⁶ www.mcpmag.com/salariesurveys.

Examples of Popular Certifications, continued

platform and Microsoft.NET enterprise servers, such as systems engineers, technical support engineers, systems analysts, and network analysts who work in a computing environment of medium-to-large organizations. To obtain the MCSE credential, candidates must pass five core exams (four core exams on operating systems and one on design, 45–55 questions each with a 110- to 140-minute time limit) as well as two elective exams (about 215 minutes each). MCSE candidates are expected also to have at least one year of experience implementing and administering a network operating system in a multisite environment with at least 200 users. Training to pass the MCSE certification can take 6 to 24 months.

Oracle: Oracle certifications focus on database development, administration, and operation. Most Oracle certifications have one level—Oracle Certified Professional. However, the new Oracle 9i has three certification tiers—associate, professional, and master. The associate level is an apprentice or entry skill level, certifying capabilities to work as a junior team member with database administrators or applications developers. To earn this credential, the person must pass two tests (on Introduction to Oracle 9i/SQL and Oracle 9i Database Fundamentals I). Passing two more tests (Oracle 9i Database Fundamentals II and Performing Tuning) will earn a candidate the Oracle Certified Professional credential. The Oracle Certified Master is the highest Oracle credential. Candidates must have earned their Oracle Certified Professional credential, taken two advanced database administration courses from Oracle University, and passed a two-day practicum that costs \$2,000. While the Oracle 9i program is relatively new, pass rates on the Oracle 8 and 8i certification tests ranged from 57 percent to 79 percent. More than 115,000 people have Oracle certifications.¹¹⁷

CompTIA: The Computer Technology Industry Association sponsors vendor-neutral certifications—A+, Certified Document Imaging Architect, I-Net+, Network+, Server+, Linux+, IT Project+, e-Biz+, CTT+, and Security+. A+ is a popular certification for entry-level computer service technicians with six months experience. Testing covers a broad range of hardware and software technologies but is not focused on any vendor-specific products. Candidates must pass two exams. The core hardware exam measures competency for a microcomputer hardware service technician, covering basic knowledge of installing, configuring, upgrading, troubleshooting, and repairing microcomputer systems. Candidates must also pass an operating systems technologies exam, demonstrating basic knowledge of command line prompt, Windows9X, and Windows 2000 for installing, configuring, upgrading, troubleshooting, and repairing microcomputer systems. Both tests are adaptive, and each presents 20–30 multiple choice questions to be answered in 30 minutes.

Institute for Certification of Computing Professionals (ICCP): The ICCP sponsors a vendor-neutral certification, the Certified Computing Professional (CCP). Nearly 55,000 IT professionals have passed ICCP exams. To earn the CCP credential, IT professionals must pass examinations with a minimum score of 70 percent and meet certain education and experience requirements. Exams involve one core IT skills and knowledge test that covers technical, management, and business concepts: human and organizational framework, systems concepts, data and information, systems development, financial management and analysis, management science, and statistics. The person must also pass two specialty exams (although some current vendor certifications are accepted in lieu of one specialty exam) selected from topics such as business information systems, electronic communications, data resource management, management, networking, programming, and systems security. The experience requirement calls for 48 months of full-time work in a professional-level IT job, although 24 months of credit is given for a bachelor's degree in a related field. The CCP credential is valid for three years. The person can get recertified by taking another exam, taking new specialty exams, or participating in professional development activities.

Certified Internet Webmaster (CIW): The CIW is a vendor-neutral set of certifications for those working in Internet-related jobs or pursuing mid-level IT careers. After achieving CIW associate status by passing a “foundations” exam or passing the CompTIA i-Net+ exam, the CIW is offered in three master tracks—designer, enterprise developer, and administrator—or a cross-functional web site manager track that combines the three disciplines. For example, the enterprise developer track covers Web languages, application development, Java programming, object-oriented analysis and design, databases, and more. The crosscutting web site manager track covers site design, server administration, and Web languages. More than 30,000 CIW certifications have been earned.

SOURCES: www.techies.com, www.cisco.com, www.microsoft.com, www.comptia.org, www.Oracle.com, www.mcpmag.com, www.certcities.com, www.iccp.org, www.ciwcertified.com

¹¹⁷ www.oracle.com/education/certification/content.html.

Preparing for certification can represent a large investment of time and money. For example, Microsoft certified professionals surveyed for the 2002 Microsoft Salary Survey indicated that they and their companies expected to spend an average of \$1,850 in 2002 on certification-related materials and training. Respondents expected to spend about 199 hours preparing for certification in 2002.¹¹⁸ A recent analysis offered a range of costs for the different forms of certification preparation for some of the most popular certifications. For example, costs for self-study for the MCSE (books and a practice exam) ranged from \$1,040 to \$1,820; computer-based or online training ranged from \$1,920 to \$3,360; and instructor-led classroom training ranged from \$7,040 to \$19,320. For Oracle Database Administration, costs for self-study ranged from \$1,140 to \$1,425; computer-based or online training, \$2,020–\$2,525; and classroom training, \$7,140–\$13,800. The cost for self-study for the Cisco Certified Network Associate was \$250; computer-based or online training cost was \$550; and classroom training was \$1,760–\$2,750.¹¹⁹

Certification Sponsors' Role in IT Training

A large number of training programs have been established across the nation to serve individuals who seek training in preparation for certification exams. IT vendors have encouraged a growing array of these training programs by operating as training providers themselves, authorizing other training providers, creating authorized curricula and courseware, developing examinations, and certifying instructors. Secondary and postsecondary schools that want to provide IT education and training have been attracted to these vendor offerings, which provide a rapid and economical way to establish a turnkey IT training program. Vendor-authorized training is widely and routinely available. For example, a search on the Cisco web site for certification-related courses available in the United States during a 90-day period (June–September) indicated that Cisco's learning partners around the country would offer 1,805 courses.

Microsoft is one of the most active vendors in authorizing technical education centers. Microsoft Certified Technical Education Centers (CTECs) are technical training companies authorized by Microsoft to deliver Microsoft training. To become a CTEC, training companies must meet a minimum computer hardware requirement, employ at least two exclusive Microsoft Certified Trainers per site (instructionally and technically certified by Microsoft to deliver Microsoft courses), deliver Microsoft training and certification courses, meet quarterly minimum Microsoft courseware purchase requirements, establish and publish quality-control and general customer-satisfaction policies, abide by the Microsoft CTEC standards relative to protecting Microsoft's intellectual property from piracy, conduct student roster audits, pay a CTEC fee (\$2,500 in the United States), agree to site inspections and audits, follow guidelines with respect to the use of Microsoft Official Curriculum, issue completion certificates, specify training venues for classes available to the public, accommodate students with disabilities in classes offered to the public, and more. There are more than 2,000 CTECs worldwide.¹²⁰

For academic institutions, Microsoft recently established the Microsoft IT Academy Program. Through this program, accredited academic institutions receive a number of services, including instructor-led or online courses for faculty training, seminars and toolkits for implementing a program at the school, free software licenses for training, discounts on Microsoft curriculum and certification exams, call center support, an online student community, early access to new Microsoft products, and more. Postsecondary schools can sign up for one of two levels of service, at \$1,500 or \$5,000. High schools are eligible only for the \$1,500 reduced-service level. A school may operate as both a Microsoft IT

¹¹⁸ www.mcpmag.com/salarysurveys.

¹¹⁹ Ed Tittel, The Cost of Certification, *Certification Magazine*, August 2001. www.certmag.com/issues/aug01/feature_tittel.cfm.

¹²⁰ Microsoft Certified Technical Education Center 2002 Program Guide, <http://mcspreferal.microsoft.com/aboutCTEC.asp>.

Certification Sponsors' Role in IT Training, continued

Academy and a CTEC but not within the same organization. For example, a university's continuing education department may operate a CTEC, while an academic credit-granting department operates an IT Academy.

To become a Microsoft IT Academy, a school must be an accredited academic institution, follow marketing guidelines when promoting classes, have instructors with Microsoft Certified Professional certification in the area of course delivery, deliver any Microsoft certification course no more than 12 hours per week, enroll a minimum number of attendees for training sessions, adhere to a licensing agreement, deliver Microsoft official courseware, retain and report on student and faculty records, meet hardware/classroom setup requirements, and agree to site inspections and audits by Microsoft.¹²¹ Microsoft IT Academies use Microsoft Official Curriculum to train both credit and noncredit students in a wide array of Microsoft products, aimed at preparing students for entry- to mid-level jobs as network administrators, technical support specialists, software/hardware developers, and design engineers. Microsoft's recommended curriculum for its academies is focused on building student skills in preparation for exams to obtain the Microsoft Certified Systems Engineer credential.

Microsoft Official Curriculum (MOC) offers a range of training courses that are available in instructor-led, self-paced, and online formats. MOC courses are taught by Microsoft certified trainers. MOC courses are developed in association with Microsoft product development teams.¹²²

Cisco Systems has taken an active role in training IT workers to use its products. Cisco Learning Partners are training providers authorized to deliver curriculum developed by Cisco. There are about 40 Cisco Learning Partners in the United States. These partners provide certified Cisco Systems Instructors to teach product-specific and certification-preparation courses.¹²³

Cisco is also very active in the IT academy arena through its Cisco Networking Academy Program, introduced in October 1997.¹²⁴ The networking academy, offered primarily in public and private high schools and colleges, focuses on teaching students to design, build, and maintain computer networks. Cisco Networking Academy students participate in a 560-hour, eight-semester, Web-based and hands-on curriculum developed by educational and networking experts. Topics covered include the Internet, technology literacy, and networking principles, building, and maintenance. In the first four semesters (280 hours), students prepare to take the Cisco Certified Network Associate (CCNA) exam. These four semesters are available at both secondary and postsecondary institutions, and focus on providing students with a basic foundation in networking. In the second four semesters (280 hours), available primarily at the postsecondary level, students prepare for the Cisco Certified Network Professional (CCNP) exams. In these semesters, students learn complex network configurations and how to diagnose and troubleshoot network problems. Students use Cisco equipment in lab exercises. The Academies also work to offer students internships and college scholarships. In mid-2002, there were 115,570 students enrolled in 4,757 Cisco Networking Academies in the United States. About 45 percent of these Academies were located in K-12 institutions and nearly 40 percent in postsecondary institutions. The others were in nonprofits and community technology centers.¹²⁵ Cisco has launched a Work-based Learning Initiative to place Networking Academy students in internships and job shadowing experiences to provide them with an opportunity to apply the skills they are learning.¹²⁶ Cisco is also piloting an effort in Networking Academies in three states to offer students the TECH CORPS Soft Skills Program.¹²⁷

Oracle has taken an active role in training IT professionals in the use of its popular database products. Oracle University provides courses in a variety of formats, such as instructor-led training held throughout the country at its education centers (either at Oracle facilities or those of Oracle authorized training partners); live, instructor-led online training; self-paced technology-based training online or through CD-ROM; and a subscription-based Oracle Learning Network that

¹²¹ Microsoft IT Academy Program, Program Guide, United States and Canada, www.microsoft.com/education/msitacademy.

¹²² www.microsoft.com/traincert/training/moc/moc/asp.

¹²³ www.cisco.com/warp/public/10/wwtraining/learning_part/about_lear_part.html.

¹²⁴ www.cisco.com/warp/public/779/edu/academy.

¹²⁵ E-mail from Julie Kaminkow, Cisco Systems, June 6, 2002.

¹²⁶ http://wpl.netacad.net/index_new.asp.

¹²⁷ http://wpl.netacad.net/whats_new.asp.

Certification Sponsors' Role in IT Training, continued

offers online classes, seminars, chats, and forums. Oracle University uses certified Oracle instructors with hands-on experience and curriculum developed by Oracle. Oracle authorized training partners use course materials developed by Oracle, and instructors certified and approved by Oracle University. Course costs are in the range of \$2,000–\$2,500 for a five-day instructor-led course; \$1,500–\$1,800 for a five-day instructor-led online course; approximately \$400 for self-study online; and \$450–\$1,800 for training on CD-ROM. Oracle University also offers intensive e-learning FastTrack programs that last 12 weeks. The first and last weeks of these programs consist of instructor-led classes meeting daily from 9:00 am to 5:00 pm. In between, students may participate in online classes, CD-ROM training, reading assignments, practice labs, a hands-on project, practice exams, and other interactions with instructors and fellow students. In these programs, participants with IT experience are estimated to devote 15–20 hours per week in self-paced training, while less experienced participants may need to devote 25 hours per week. Three of the four FastTrack programs require little or no previous experience; the other, focused on the use of the Java language with the Oracle Internet platform, targets experienced IT workers with programming knowledge. These FastTrack programs cost almost \$10,000.¹²⁸

Oracle's Workforce Development Program partners with accredited education institutions focused on adult education that offer diploma, degree, or certificate programs. These institutions offer Oracle training in full-time and part-time programs providing preparation for Oracle certification exams. The institutions must employ instructors who have passed Oracle exams, offer training to individual adult learners, offer class instruction no more than 12 hours per week, and meet hardware and operating systems requirements. The partners are authorized to use curricula developed by Oracle University. Partners are eligible for free Oracle software, technical support, discounts on instructor training, discounts on certification exams, and other benefits.¹²⁹

The Oracle Academic Initiative (OAI) provides software, curriculum, training, and certification resources to its members, who are degree-granting colleges and universities that offer Oracle training as part of a degree program. OAI members receive software licenses, product support, discounts on training for faculty, access to Oracle University courseware, discounts on certification exams, and more. Members must be accredited institutions. The offering department must grant degree credits and degrees, use Oracle resources only to train students enrolled in the institution, meet certain software and hardware requirements, and use OAI materials in no more than 70 percent of the particular curriculum in which it is being incorporated. Curriculum categories include database operations and management, systems analysis, Internet application development, data mining and data warehousing, and applications development, with a focus on using Oracle products. All U.S. states and the District of Columbia have colleges and universities that are OAI members.¹³⁰

Each year, approximately 250,000 students receive training through Oracle's university and college-based programs.

Sun Microsystems has authorized training centers with instructors certified by Sun. Training is offered through instructor-led classes, online classes, and self-paced CD-ROM training. Sun also offers fast-track programs, in which students are immersed in instructor-led training for 12 hours a day for five days. Sun also sponsors an academic initiative that focuses on encouraging accredited academic institutions of higher education to provide Sun courses to their students and prepare them for Sun certification. As part of its academic initiative, Sun develops instructor and student guides for each course, and the use of Sun curriculum is required. Typically, faculty members attend Sun's Academic Development Center for Java or Solaris courses and take the appropriate exam before teaching a class.¹³¹

Novell, sponsor of the popular Certified Novell Administration (CNA) and Certified Novell Engineer (CNE) certifications, has authorized training partner programs for K–12 schools, community colleges, technical institutes, and universities, as well as for-profit training companies. Novell develops courseware and provides instructor training and supporting services. Authorized partners must meet certain standards for facilities, hardware, and software; use certified Novell instructors or Novell authorized instructors to deliver authorized courses; and use only current Novell authorized courseware for all Novell courses. Partners are expected to offer a full range of Novell certification courses.

¹²⁸ www.oracle.com/global/us/education/about.html.
www.oracle.com/education/partners/partners.html.

¹²⁹ http://workforce.oracle.com/wdp_guide.html.

¹³⁰ <http://oai.oracle.com>.

¹³¹ <http://suned.sun.com>.

Certification Sponsors' Role in IT Training, continued

Individuals involved in the partners program are encouraged to attend and participate in a variety of Novell-sponsored events. Novell's postsecondary program allows colleges and universities to teach Novell-authorized courses as part of their regular degree or certificate programs, for a grade and for academic credit. The Novell Technical Institute program is a similar program for K-12 schools.¹³²

3Com's NetPrep is a school-to-career program for high school and community college students. High school students take four one-semester courses on networking fundamentals, LANs, WANs, and network architecture. Each course includes approximately 90 hours of instruction. Eight community college courses provide learning at a higher level of difficulty and can be incorporated into associate degree programs. Curriculum developed by NetPrep includes course materials such as CD-ROMs, online materials, and lab exercises. Students who complete NetPrep receive a platform-neutral certification through the National Association of Computer Systems Engineers. Students who complete the high school program may qualify for entry-level positions as technicians or for further study. Students who complete the community college program may qualify for entry-level management information systems programs or for additional study at a four-year university.¹³³

CompTIA works to ensure the quality of training for its A+ and other certifications by using third-party experts to evaluate training materials prepared by others—books, self-study guides, classroom training programs, videos, and computer-based training—to determine whether the material adequately maps to CompTIA exams. This includes covering exam objectives, using sound instructional design principles, and incorporating learner assessments. If materials meet CompTIA's standard of quality, providers receive logos to display on the training materials.¹³⁴

Certification Training at the Delivery Level. Among **Southern Methodist University's Advanced Computer Education Centers** (Houston, Plano, Richardson, and San Antonio, Texas) there are Microsoft Certified Technical Education Centers, a Sun Authorized Education Center, Oracle Academic Initiative members, and Novell Authorized Education Centers. At the four Southern Methodist University (SMU) campuses, students can study for a wide range of certifications, including the popular MCSE, A+, Net+, Oracle Database Administrator, and Cisco certifications (although SMU is not a Cisco Networking Academy). SMU also participates in a number of "package" programs that prepare for multiple certifications. For example, current IT workers can prepare for MCSE Windows 2000 certification through 248 hours of training at a cost of \$6,595. The intensive, two-week, 160-hour MCSE Windows 2000 boot camp costs \$7,995. This program is designed to provide a fast method to upgrade from an MSCE NT 4.0 certification to an MCSE Windows 2000 certification. Career changers can prepare for their MCSE, MCSA, A+, and Net+ certifications in 448 hours of training for \$9,775. Oracle certification course packages range from \$6,575 to more than \$9,000. Students can participate in an 80-hour curriculum to prepare for A+ certification for \$1,695. Students can participate in 112 hours of training to prepare for certification as a Sun Certified Programmer for the Java 2 Platform at a cost of \$3,275. These certification courses are offered both during day and evening/weekend hours.¹³⁵

¹³² www.novell.com/education/chaninfo/newpartner.html.

¹³³ www.3com.com/solutions/en_US/education/programs/netprep_faq.html.

¹³⁴ www.comptia.org/certification/caqc.

¹³⁵ <http://acec.seas.smu.edu>.

College Credit for Certification Training

Through the Industry Training Credit Approval Process (ITCAP), Pima Community College in Arizona grants college credits to students who complete course work leading toward vendor certification, including certifications from Cisco, Microsoft, Sun, Linux, Novell, CompTIA, Oracle, and others. Credits are granted only if courses were taken at training facilities that are Authorized ITCAP Centers, which must adhere to guidelines concerning the administration and quality of their training programs, and if students pass assessment exams developed and approved by Pima Community College. Credits range from 0.5 credits for a course on deploying Microsoft Windows XP Professional to 4 credits for completing one semester of the Cisco Networking Academy.¹³⁹

Similarly, **George Mason University's Train to Technology (TTT) Program** provides extensive training to prepare for certification exams for the MCSE 2000, Oracle Developer, Oracle Database Administration, CCNA, A+, Network+, and others. The TTT program prepares students for entry-level and junior-level positions in the programming environment. The Northern Virginia Regional Partnership (NVRP; now defunct, see page 149) helped develop this effort through funding for computer laboratories and startup costs, as well as through student and employer outreach. In addition, NVRP helped establish a low-interest loan program with Sallie Mae for individuals interesting in participating in the TTT program. Instructor-led courses offer accelerated learning and hands-on applications taught in a lab environment, with class size limited to 25. Classes are available during the day, on weeknights, and weekends. Courses range from 40 hours for A+ to 240 hours for MCSE 2000, Java, and Web development. Students report spending 8–12 hours a week studying for class. Costs range from \$799 for A+ and \$1,999 for CCNA to \$3,999 for Oracle courses and \$5,499 for the MCSE program. Students come from a wide variety of education backgrounds and work experiences. Many have four-year college degrees; many have several years of work experience, but not necessarily in IT; others are current IT workers, career changers, and individuals transitioning out of the U.S. armed forces. Career services—such as career consultation, resume critiquing, workshops, and industry networking events—are available to program participants.¹³⁶

Certification training is available at many community colleges. For example, **Springfield Technical Community College** in Massachusetts is a Microsoft IT Academy, a Novell Authorized Education partner, and an authorized Prometric Testing Center. Courses are available to prepare for a wide range of CompTIA, Cisco, Novell, and Microsoft certifications. For example, for \$1,195, students can participate in a 36-hour evening program to prepare for the CCNA certification exam. A comprehensive training program to prepare students for CompTIA's A+ certification exam runs 200 hours during evenings and weekends, and costs \$4,945. The school indicates it has an 85–95 percent pass rate on the A+ exam. A 12-day intensive boot camp to prepare for the Cisco Certified Network Professional certification costs about \$8,500.¹³⁷

¹³⁶ <http://ttd.gmu.edu>.

¹³⁷ <http://cbt.stcc.edu>.

At **Bellevue Community College** in Washington, students can participate in an intermediate level curriculum to prepare for the MCSE certification. Class runs four hours a day, five days a week, for six months. A+ certification or equivalent knowledge and experience working in a high-tech environment are prerequisites. The program costs \$6,225. Preparation for the CCNA involves four hours of class a day, five days a week, for seven months. Prerequisites include A+ certification or equivalent knowledge, experience working in a high-tech environment, and aptitude for mechanics, math, and basic electronics. The program costs \$5,750.¹³⁸

Certification training is reaching U.S. high schools. For example, three high school academies in Fairfax County, Virginia, incorporate in their curricula courses that prepare 11th and 12th grade students for IT certifications while earning high school credits. Among the three academies, students can take courses to prepare for A+, Oracle, Microsoft, Cisco, and Novell exams. For example, at the **Chantilly Academy**, students can earn two high school credits in a course designed for those interested in pursuing careers involving maintaining and serving computers, related equipment, and peripheral devices. Students completing this course are eligible to take the A+ certification exam. Also at Chantilly, students can learn skills in designing, installing, configuring, operating, and troubleshooting computer networks. Two of the four courses required for the CCNA certification exam are offered at Chantilly; the two remaining courses are available at **Northern Virginia Community College**. Students earning a B or better at a similar course at the Marshall Academy may articulate eight credits with Northern Virginia Community College. **The Edison Academy** and the **Marshall Academy** offer Oracle Internet Academy programs. In the Edison program, students first participate in a Level I Oracle course, studying data modeling, SQL, and relational databases. This course prepares students to take the Oracle SQL exam, the first of five exams required to be a certified Oracle Database Administrator. The Level II courses cover the Java programming language and prepare students to take the first of five exams required to be a Sun certified Java developer. Students who participate in the Academy courses are taking and passing certification exams. High school seniors in the Academy program may have the opportunity to participate in internships in government and private sector organizations.¹⁴⁰

Certification training is also offered in partnership-type programs. For example, the **Communications Workers of America (CWA) National Education and Training Trust**, in partnership with the U.S. Department of Labor, offers IT training to veterans, those on active duty in the U.S. armed forces, and others. Training for the Cisco CCNA and CompTIA A+ is delivered in classroom settings and through distance learning. A Cisco Networking Academy mini-lab has been set up in a Texas union hall. Some scholarships are available for tuition, books, and certification testing.¹⁴¹

¹³⁸ www.conted.bcc.ctc.edu/ft_programs.htm.

¹³⁹ www.itcap.com.

¹⁴⁰ www.fcps.edu/DIS/OPTS/academy.

¹⁴¹ www.cwanett.org/about.asp.

In Massachusetts, the **New Economy Technology Training (NETT) Consortium** is a partnership among government, nonprofit, and for-profit organizations established to train underemployed and unemployed adults. Three community-based training providers offer the 280-hour CCNA curriculum and 120 hours of soft skills training over a six- to eight-month period. Soft skills training includes verbal and written communication, negotiation, customer service, conflict resolution, problem solving, applied math, project management, teamwork, and multitasking. Three-month paid internships provide hands-on experience in the workplace. Participants must cover their \$5,000 training costs, but some loans and scholarships are available. As part of the admission process, candidates take assessment tests to evaluate computer and Internet proficiency, basic math skills, and English reading and writing ability. Strong Microsoft Office and Windows computer skills, as well as a home computer and Internet access, are required for admission to the program.¹⁴²

In addition to vendor-authorized and academic training providers, there is a wide range of private training providers, online training, CD-ROM programs, self-study guides, assessments, drills, practice exams, and tutorials to help prepare people for taking certification exams. For example, several Web sites—such as certifyexpress.com, selftrain.com, gocertify.com, cramsession.com, and netcraftonline.com—are dedicated to providing training information and support for those preparing for IT certifications. From **SmartPlanet**, those preparing for certification can purchase online self-study courses and instructor-led courses that include subscriptions to course libraries. For example, a one-year subscription to 60 online courses for preparing for the MCSE is available for \$799.¹⁴³

IBM is a large provider of classroom, online, and satellite IT training, including training for Cisco, Linux, and Microsoft certifications. To help people select IBM-provided training courses for IT certification, IBM has prepared course roadmaps that are available on the IBM Web site. Users answer a series of yes or no questions in a decision-tree format, and the roadmap suggests courses the user may wish to take. The user can click a node on the roadmap and gain access to a course description that includes information on course duration, delivery method, skill level, language, tuition, who should take the course, course topics, prerequisites, and certification.¹⁴⁴

Many IT workers who provided comments for this review of IT education and training programs said that vendor certification programs provided them with specific marketable skills and offered them a way to get up to speed quickly in a new technology. They also indicated that vendor-authorized programs were often current, in step with industry directions, and taught by instructors who were up-to-date. However, IT workers cited the high cost of certification preparation programs offered by private IT training providers as a barrier to acquiring such skills and certifications.

¹⁴² www.nettconsortium.org.

¹⁴³ www.zdnet.com/smartplanet/why.htm.

¹⁴⁴ www-3.ibm.com/software/info/education.

In a recent survey by Prometric, U.S. IT workers indicated that they pursue certification to assess their skills and knowledge and increase their credibility, productivity, and compensation. The survey also indicated that certification-related training was valuable in helping IT workers better understand a vendor's products. There is a strong inclination to seek the training even without attaining the certification. In the survey, 70 percent of the IT professionals responding said that they would have pursued the training whether or not they could receive a certification as a result.¹⁴⁵ On the other hand, some IT workers who participated in this Commerce Department study said that some certification trainers "train to the test," focusing almost exclusively on the information needed to pass the test rather than providing in-depth training in the vendor's technology.

IT professionals who participate in certification are likely to view that vendor's technologies positively. In a recent survey, 97 percent of IT professionals reported that they were more or just as likely to recommend a vendor's product as a result of being certified in that product.¹⁴⁶

While these programs typically do not prepare a worker with the foundation knowledge and skills needed to build a long-term career in IT, they can train quickly in specific skills related to specific products. Acquiring these skills can be valuable for an IT worker at the current employer. However, simply acquiring certain technical skills may not be enough to overcome a prospective employer's preference for a candidate with experience using those technical skills. Students who participate in school-based IT academies, especially those that offer no work-study or internship experiences, may also have difficulty finding jobs based on the skills they have acquired because they lack experience using them on the job.

If turnkey IT vendor-based programs represent the major portion of a school's IT education and training offerings, the school may not be prepared to respond quickly with new programs when skill demands in the labor market change.

Boot Camps and Seminars

A diverse array of short-term intensive training and education programs have arisen to meet the demand for entry-level IT skills, continuing technical skills development, and industry-specific IT skills and knowledge. These offerings go by a variety of names, including boot camps, seminars, deep dives, or fast-track programs, and generally last from a few hours to a few weeks. They are offered by a wide variety of providers: small training firms, larger firms with locations across the nation, firms that convene programs in places such as hotels in metropolitan areas, colleges, professional associations, and partnerships.

¹⁴⁵ 2001 Training and Certification Study, Prometric, Inc., 2001.

¹⁴⁶ Ibid.

Skill Standards for Information Technology Workers

The National Workforce Center for Emerging Technologies and the Regional Advanced Technology Education Consortium—with the cooperation of the business, education, and IT workforce communities—developed skill standards in eight IT career clusters: database development and administration, digital media, enterprise systems analysis and integration, network design and administration, programming/software engineering, technical support, technical writing, and Web development and administration.

The skill standards identify foundation skills and workplace competencies that cut across all eight IT career clusters, as well as the specific job function skills required in each cluster. Foundation skills include the basics, such as reading, writing, and arithmetic, as well as soft skills such as problem solving, decision making, and self-management. Workplace competencies include resource management (time, money, materials, and human resources), information and communication skills, interpersonal skills such as teamwork and negotiation, systems thinking, and technology literacy. Skill standards detail the technical skills required in each of the job clusters and the performance criteria that indicate when a task is performed well. For example, specific skill standards tasks for the software engineer career cluster focus on systems analysis, architecture development, systems design and development, testing and validation, product release and delivery, postdelivery maintenance and enhancements, project management, task management, problem solving, and troubleshooting.

Skill standards can be used in a variety of ways. For example, educators can use them to develop IT curricula and assess what students have learned. Skill standards can also help employers in areas such as human resources management, developing career paths and training for employees, job analysis, and workforce recruitment.

Shorter-Term Training at Community Colleges

Community colleges are a primary provider of shorter term technical courses for those interested in entering IT occupations or seeking to maintain or upgrade their IT skills. Increasingly, students are seeking knowledge and skills through community college course offerings without the intent to seek a formal credential such as an associate degree or certificate.

Recognizing this educational niche, community colleges have responded with a plethora of offerings. For example, the Northern Virginia Community College (NVCC) system alone offers more than 150 noncredit, noncertificate IT courses, in addition to its for-credit offerings. (www.nvcc.edu/depts/docs/ce/workforce_brochure_matrix_unprotected.doc)

NVCC courses cover the broad scope of IT skills and are offered at a variety of skill levels at each of the school's five campuses. For example, Java and Visual Basic programming are offered at the introductory, intermediate, and advanced levels; 11 classes are offered in Oracle at one campus alone; and networking classes range from Introduction to Local Area Networks to Microsoft Windows 2000 Advanced Server Administration. NVCC offers a number of short (six class hour) courses in IT as well, such as Introduction to Software Testing, Introduction to PC Troubleshooting, and Software Development/Lifecycle.

There is great flexibility in course times and delivery methods: days, nights, and weekends; classroom, video, tele-course (via cable television), and online. The cost for noncredit courses varies with respect to duration and other factors. In general, costs range from \$109 for a course with 6 hours of classroom instruction to \$739 for a class with 32 hours of instruction.

In addition, NVCC offers more than 60 for-credit courses in computer and information sciences, ranging in cost from approximately \$44 to \$176 for in-state students, and \$190 to \$760 for out-of-state students.

Learning Tree International

Learning Tree International provides short-duration, hands-on, vendor-independent training courses in information technology. Courses are offered at 26 Learning Tree Education Centers and other locations in eight metropolitan areas, as well as onsite at client facilities.

Learning Tree offers more than 150 courses in a wide range of IT subjects—such as Windows XP/2000/NT, .NET, Java, XML, Oracle9i and 8i, and Unix—as well as preparation courses for 42 professional certifications. Courses are offered at the introductory, intermediate, and advanced levels, and generally span four or five days.

Courses are designed to provide a fast, in-depth immersion in the subject to enable students to use the newly acquired skills immediately on the job. Brief lectures are followed by hands-on exercises. Learning Tree uses instructors who work full time in industry, where they use the technologies they teach, helping to ensure that the content of the courses is practical, relevant, and current.

A four-day course costs \$2,345 and a five-day course is \$2,645. Students who opt for an eight-course package can reduce their per-course cost to \$937.

In addition, Learning Tree offers 11-day FastTrack Camps in Windows 2000, Java, and Web Development that provide the equivalent of three four- or five-day courses. The cost for these camps is \$5,995.

Learning Tree also offers its courses in Canada, Japan, Hong Kong, the United Kingdom, France, and Sweden.
www.learningtree.com/index.htm

In general, boot camp programs are characterized by long classroom days—often running 10 or more hours—followed by homework assignments. Instruction is provided through a combination of lecture, lab, practice/real exams, homework, and reading assignments. The duration and intensity of the training, and the detail and complexity of the material can create a sense of information overload among students. Boot camps, especially those conducted outside the living area of the student, provide an environment that is free from distractions, which enables students to focus on the material being taught.

There is great variability in the quality of boot camps. Factors include access to class materials in advance of the camp; quality and accessibility of the trainer(s) before the camp, during class, and after class; information and knowledge provided beyond that required to pass a test; classroom facilities with ready access to IT equipment to enable hands-on training; thorough test preparation; class size; and course topics explained in the context of real-world situations.

Many boot camps are technically focused and provide in-depth training in a specific area. These programs provide training on almost every conceivable IT subject: programming languages (Java, Cobol, C/C++); operating systems (Windows, Linux, Unix, Mac OS X); applications (Microsoft Office, Filemaker Pro, ColdFusion, iMovie); networking; security; and so on. Some of these courses offer preparation for higher level technical certifications. For example:

- **SecureInfo Corporation** offers a five-day Network Security Course for network and system administrators, IT managers, and information security specialists. The course teaches the latest techniques and technologies in attack and defense on several net-

work platforms, including firewall architectures, intrusion detection systems, and penetration testing. The corporate rate for the course is \$1,850.¹⁴⁷

■ **NETg's Wave Boot Camps** offer

- The Java Certification Boot Camp, a five-day program for students with a working knowledge of basic Web development and familiarity with programming in an object-oriented language to prepare for the Sun Certified Programmer for the Java 2 Platform exam. The course costs \$2,795.¹⁴⁸
- The 10-day Linux Certified Administrator Boot Camp, designed for those with six months to a year of experience with Linux systems and a basic understanding of Unix, TCP/IP networking, security, and file operations and manipulations, to prepare for the Sair Linux and GNU Linux Certified Administrator exams. The course cost is \$5,990.¹⁴⁹
- The Cisco Certified Internet Expert (CCIE) Boot Camp, a five-day course to prepare students with Cisco CCNP or CCDP certifications for the written exam portion of the CCIE certification. The course cost is \$5,995.¹⁵⁰

Others offer more fundamental courses to open the door to entry-level IT jobs:

- One training firm offers a 12-day Career Blaster Boot Camp, designed to prepare a student for A+, Network+, and Microsoft Certified Professional certifications.¹⁵¹
- **Transformations**, a privately funded program operating in the Denver area, offers a 14-week technology boot camp targeted at preparing undereducated, underemployed women for careers in IT. The effort operates out of a converted military barracks on a closed Air Force base.¹⁵²

Others are focused on IT applications of interest to a particular occupation:

- The **Institute for Healthcare Informatics**, a joint venture of Drexel University's College of Information Science and Technology and MCP Hahnemann University, offers a Healthcare Informatics Boot Camp that provides an introduction to the conceptual and technical components of health care and medical informatics. The cost is \$1,350.¹⁵³
- **SEARCH, the National Consortium for Justice Information and Statistics**, offers one-, three-, and five-day and two-week courses in computer-related crime investigation,

¹⁴⁷ www.secureinfo.com/training/535.asp.

¹⁴⁸ www.wavetech.com/waveus/newcurriculum/Jcert/Java_BC.cfm.

¹⁴⁹ www.wavetech.com/waveus/newcurriculum/Linux/Linux_BC.cfm.

¹⁵⁰ www.wavetech.com/waveus/newcurriculum/CCIE/bc.cfm?pagecode=CCIE.

¹⁵¹ www.intenseschool.com/bootcamps/aplus.

¹⁵² abcnews.go.com/sections/tech/WiredWomen/wiredwomen990421.html.

¹⁵³ www.cis.drexel.edu/research/ihi.

The National Academy Foundation's Academy of Information Technology

Established in 2000, the Academy of Information Technology (AOIT) is one of three career-focused academies offered by the National Academy Foundation (NAF). AOIT operates in high schools as a "school within a school," introducing students to career opportunities in IT and helping to prepare them for those opportunities by providing education and training in interpersonal, analytical, technical, and communications skills.

Schools undergo a competitive selection process to become an AOIT site. They must have an advisory board of local business and industry representatives to help with planning and implementation and to provide mentors and summer internships for students. Sites are selected by NAF based on diversity of geography, race, gender, and student ability. Currently, 5,000 students participate in AOIT in 129 U.S. high schools.

AOIT employs a standards-based, 9th–12th grade curriculum covering IT knowledge and general workplace competencies. It was developed by NAF and COD, a nonprofit organization focused on innovative educational approaches to help students prepare for careers and higher education. The AOIT curriculum consists of four foundation and six advanced courses:

Foundation Courses

Strategies for Success/Computer Applications: Presentation, word processing, spreadsheet, e-mail, browser, and desktop publishing.

Introduction to Information Technology: Basic concepts of information technology; types of IT careers; impact of IT on the world, people, and industry.

Logic for Programming: Describing, analyzing, and solving programming problems. Focus on learning programming skills (logic) using the syntax of the Scheme programming language.

Web Page Design: Basics of Web page design, including understanding and programming in HTML, improving Web page performance, image formats and their effect on performance, and plug-ins.

Advanced Courses

Systems Support and Maintenance: Troubleshooting and repairing hardware, software, and configuration problems; installing basic computer components; installing and configuring software.

Digital Media: Digital media, including audio, video, graphics, text, and animation tools. Concepts such as color and presentation are also addressed.

Digital Networks (Telecommunications): Basic concepts of connecting multiple computing devices. Concepts covered include physical connections, logical connections, bandwidth, access time, data rate, error detection, and correction.

Programming II: Advanced programming concepts (such as object-oriented programming), complex data structures, and code reuse.

Databases: Basic concepts of relational database engines and tools. Concepts covered include tables, rows, indexes, constraints, triggers, SQL syntax, storage, and the importance of data relationships.

Advanced Web Tools: Advanced Web topics, including Java, webscripting, Web server administration, and multimedia tools and concepts.

www.naf.org/theacademies/infotech

including courses in Law Enforcement Information Technology Planning and Implementation, Seizure and Examination of Microcomputers, and Basic Local Area Network Investigation. Course costs range from approximately \$240 for a three-day class to \$1,400 for the two-week class.¹⁵⁴

- The Computer Forensic Boot Camp, offered by **LC Technology International**, is a 40-hour course to introduce the basic elements of computer forensics to cyber-crime investigators; it includes courses on digital evidence, digital imagery analysis, IT hardware and software tools for forensic examination, and digital evidence seizure and recovery. The cost is \$2,500 for corporate investigators and \$1,250 for law enforcement investigators.¹⁵⁵

¹⁵⁴ www.search.org/leit/default.asp.

¹⁵⁵ www.lc-tech.com/cfbc.htm.

And still others provide IT professionals with needed soft and business skills. The five-day Stanford University/Information Week Boot Camp focuses on teaching business skills to CIOs, IT directors, vice presidents, and managers to help “today’s IT professionals become tomorrow’s leaders in business transformation.” The program costs \$4,995.¹⁵⁶

Federal Government IT Workforce Education and Training Initiatives

Amid the strong IT occupational growth in the mid-1990s, employers argued that they often could not fill IT jobs because of a lack of qualified workers in the United States. This led to an effort by many IT employers to have the Federal Government increase the annual limit on the number of foreign temporary workers who could enter the United States on H-1B visas. Under the H-1B visa program, employers may hire and bring to the United States high-skilled professional workers for up to six years. Some IT workers and employee advocates, however, argued that there were adequate numbers of Americans with the fundamental skills to fill these jobs, perhaps with some additional training, such as scientists and engineers who had lost their jobs during the post-Cold War defense downsizing, and older unemployed scientists and engineers.

In a compromise, the H-1B visa cap was raised under the American Competitiveness and Workforce Improvement Act of 1998 (ACWIA 1998), and a special account (the H-1B Nonimmigrant Petitioner Account, funded by a \$500 fee paid by employers for each H-1B visa) was established to support efforts to educate and train American workers for the occupations H-1B visas were being used to fill. ACWIA 1998 increased the cap from its FY 1998 level of 65,000, to 115,000 in FY 1999 and FY 2000, to 107,500 in FY 2001, with a return to 65,000 thereafter.

The American Competitiveness in the Twenty-First Century Act of 2000 (ACWIA 2000) raised the cap to 195,000 for FY 2001, 2002, and 2003, returning to 65,000 in succeeding fiscal years. Public Law 106-311 concurrently raised the employer fee for an H-1B visa to \$1,000. The fees are deposited in the H-1B Nonimmigrant Petitioner Account and allocated, by law, to the Department of Labor, the National Science Foundation (NSF), and the Department of Justice for education, training, and administrative activities.

While many federal programs contribute in some measure to the education and training of IT workers, this section of the report focuses on the Department of Labor and NSF programs funded from H-1B fees. While not focused exclusively on IT education and training, these programs are Federal Government attempts to respond to employer demand in critical skill areas, most notably in IT. Much of the policy discussion during the establishment of the H-1B fees and the programs they fund centered on the need to train U.S. workers for the jobs that foreign workers were being recruited for, especially for IT occupations, which account for the lion’s share of H-1B visas. No other occupation or group of related occupations comes close. The most recent analysis of the characteristics of H-1B visa recipients by the Immigration and

¹⁵⁶ www.informationweek.com/events/iwkbootcamp.htm.

Naturalization Service (INS) indicates that 62.7 percent of H-1Bs were employed in IT occupations (58.0 percent in “Computer-related Occupations” and an additional 4.7 percent in “Electrical and Electronic Engineering”).¹⁵⁷

Department of Labor’s H-1B Technical Skills Training Grants Program

The Department of Labor’s H-1B Technical Skills Training Grants (www.doleta.gov/h-1b/) program was established by ACWIA 1998 to provide technical skills training for employed and unemployed workers.

Funding. This program is funded through the allocation of a portion of fees employers pay for each¹⁵⁸ foreign temporary professional worker entering the United States under the H-1B visa program. ACWIA 2000 allocates 55 percent of the H-1B fees to the Department of Labor’s H-1B Technical Skills Training Grants program.

The Labor Department’s two grant programs funded by these fees have a matching funds requirement for those seeking grants. The matching funds must come from non-federal sources, and at least half of the non-federal matching funds must come from the businesses or business-related nonprofit organizations involved. Additional details of the match requirements are provided below.

Grantees. ACWIA 2000 directs that 75 percent of the Labor Department’s allocation of H-1B fees support grants to local workforce investment boards (WIB) or consortia of such boards in a region, referred to here as the “WIB-focused program.” Each workforce investment board or consortia of boards receiving grant funds must represent a local or regional public-private partnership consisting of at least one WIB; one community-based organization, higher education institution, or labor union; and one business or business-related nonprofit organization.

In the Labor Department’s Solicitation for Grant Applications (SGA), applicants are encouraged to collaborate on training programs that reflect the skills shortages and employer needs of their local area and region, using all available local and state data to research and assess shortages. Applicants are also encouraged to develop strong partnerships that enhance the sustainability of their programs and increase the success of placement and promotion once an individual has completed training. Training may include academic instruction, workplace training, customized curricula, or combinations tailored to fit the needs of both individuals and employers.

¹⁵⁷ Report on Characteristics of Specialty Occupation Workers (H-1B): Fiscal Year 2001, U. S. Immigration and Naturalization Service, July 2002, www.ins.usdoj.gov/graphics/services/employerinfo/FY2001Charact.pdf.

¹⁵⁸ Some H-1B employers are exempt from the fee, including institutions of higher education and related or affiliated nonprofit organizations; nonprofit or governmental research organizations; any employer who is filing for a second extension of stay for an H-1B nonimmigrant; primary or secondary education institutions; and nonprofit entities engaged in “established curriculum-related clinical training of students.” www.ins.gov/graphics/publicaffairs/questsans/h1bCHANG.htm.

Grant applications are evaluated against a weighted rating criteria. In the SGA covering the fourth- and fifth-round competitions,¹⁵⁹ the criteria included statement of need (maximum of 15 points); service delivery strategy (25 points); target population (10 points, plus 5 bonus points for effective targeting of minorities, women, individuals with disabilities, older workers, and individuals in rural areas); sustainability (10 points); linkages with key partners (15 points); outcomes (15 points); and cost effectiveness (10 points).

Applicants receiving a rating of 80 or above are placed on an “eligible to be funded” list for up to nine months. Inclusion on this list is not a guarantee of funding. Final funding decisions are based on the rating of applications and on statutory requirements such as urban/rural balance, geographic balance, and occupational composition. Applications that receive a rating of 79 or below are eligible to receive technical assistance in areas such as grant writing, partnership building and linkages, administrative requirements, and service delivery strategies.

According to the Labor Department, grants for up to \$3 million for a period of two years are awarded to programs that work toward training individuals in skills critical to H-1B occupations.¹⁶⁰ To date, the WIB-focused program has completed five rounds of grant competitions,

WIB-focused H-1B Technical Skills Training Grants		
	Number of Grants	Amount of Grants
Round 1	9	\$12.4 million
Round 2	12	\$29.2 million
Round 3	22	\$54.0 million
Round 4	24	\$66.6 million
Round 5	7	\$15.6 million

awarding 74 grants totaling approximately \$177.8 million. The average grant size for all competitions is approximately \$2.4 million. The matching funds requirement (provided as cash or in-kind contributions) for the WIB-focused program is 50 percent.

ACWIA 2000 designates the remaining 25 percent of the Labor Department’s H-1B funds to demonstration projects or programs conducted by partnerships of at least two businesses or a business-related nonprofit organization that represents more than a single business. Referred

to as Business Partnership grants—or the “25 percent pot”—these funds are reserved for efforts that would not be eligible for a grant under the WIB-focused program because of barriers in meeting its partnership eligibility criteria, on a national, multi-state, regional, or rural area basis. Only one Business Partnership grant competition has been conducted, with the Labor Department awarding \$34.5 million to 14 projects. The matching funds requirement (provided as cash and/or in-kind contributions) for this program is 100 percent.

Program Assessment. ACWIA 2000 attempted to ensure that data were available to assess the training grant program by requiring the Labor Department to “establish a tracking system to

¹⁵⁹ <http://wdsc.doleta.gov/sga/sga/01-105sga.htm>.

¹⁶⁰ Response to the Department of Commerce’s public request for comments from Gerard F. Fiala, Administrator, Office of Policy and Research, Education and Training Administration, U.S. Department of Labor.

monitor the performance of programs receiving H-1B grant funding” and report to Congress “the number of individuals who have completed training and have entered the high-skill workforce through these programs.” The law also directs the Labor Department to give consideration in the awarding of grants to “applicants that provide a specific, measurable commitment upon successful completion of a training course, to—

- (i) hire or effectuate the hiring of unemployed trainees (where applicable);
- (ii) increase the wages or salary of incumbent workers (where applicable); and
- (iii) provide skill certifications to trainees or link the training to industry-accepted occupational skill standards, certificates, or licensing requirements.”¹⁶¹

Finally, ACWIA 2000 requires that grant applications “articulate the level of skills that workers will be trained for and the manner by which attainment of those skills will be measured.”¹⁶²

The Labor Department has required grantees to submit quarterly progress reports with reporting requirements that included occupational areas for which skill training is being provided; job placements in skill shortage occupations; wage increases in skill shortage occupations of both employed and unemployed workers; number of promotions by participants who have completed the skills training program; the number of individuals currently in training, the number who have successfully completed training, and the number who are unsuccessful or who have dropped out of training; and the number of skill certifications received or training completions to industry-accepted occupational skill standards, certifications, or licensing requirements.

In addition to the outcome data collected through these reporting requirements, other information may help to assess the program’s responsiveness to IT labor market demands:

- **education and skill levels of trainees or those targeted for training;**
- **skill level of occupations workers are being trained for;**
- **technical skills being provided through training;**
- **use of internships and/or work experience in conjunction with the training;**
- **approximate cost and length of training per trainee;**
- **role and support by employers;**
- **role of local labor market information; and**
- **outcomes related to placing workers in the high-skill, high-demand H-1B occupations in the IT field.**

¹⁶¹ www.doleta.gov/h-1b/enabling/acwia_a00.pdf.

¹⁶² Ibid.

At the time of this report, limited data were available to assess the H-1B Technical Skills Training Grants Program’s effectiveness in providing training to prepare workers for H-1B occupations and its effectiveness in meeting its stated objectives. The conclusions reached in this report reflect the Department of Commerce’s analysis of publicly available information on these grants, including one-page program descriptions of each grant, and two Labor Department–contracted reviews of the program. Each of these reviews examined six grantees, chosen according to nonrandom criteria.

The first review, “An Early Review of the H-1B Skills Training Grant Program,” covered two grants focused on providing skills to health care workers and four grants targeted at IT workers.¹⁶³ The report did not address the extent to which H-1B grantee training produces graduates who could substitute for workers brought in on H-1B visas, stating, “This issue should be addressed in the large-scale evaluation recently awarded by DOL.”

However, the report did state that “if one standard is taken to be the bachelor’s degree level possessed as a minimum by most visa holders working in information technology (IT), the closest approximation of the three projects visited is the Houston-Galveston software development training.” Yet, the report states that the entry requirements for the Houston-Galveston Area Council program are “for 10th grade English skills, but only 8th grade math skills.”

These requirements are in contrast to the math requirements of higher education. For example, three years of college preparatory math (including algebra 1, geometry, and algebra 2) is a typical prerequisite for entry into bachelor’s programs at universities; for science and engineering degree programs (including computer science), the prerequisites often include calculus. For entry into a two-year transfer track associate degree program in computer science (designed for matriculation into a four-year program), the prerequisites include four years of college preparatory math. Even a terminal two-year associate degree program in IT (designed for immediate entry into the workforce) typically requires algebra and geometry. Each of these degree programs then requires additional mathematics courses. It seems unlikely that a worker beginning with 8th grade math skills and given nine months of training could compete for H-1B-level jobs.

The second report, “Exemplary Practices in High Skill Department of Labor H-1B Training Programs,”¹⁶⁴ studied six projects chosen from the first three competitions. The review does not purport to provide insights into the broader portfolio of grants but rather identifies “exemplary practices.” The authors’ primary selection criteria was how close a project was to meeting its enrollment target.

¹⁶³ Stephen E. Baldwin, KRA Corporation, An Early Review of the H-1B Skills Training Grant Program, review conducted for the Employment and Training Administration, U.S. Department of Labor, August 2001.

¹⁶⁴ Exemplary Practices in High-Skill U.S. Department of Labor H-1B Training Programs, Coffey Communications, LLC, for the U.S. Department of Labor, March 2002.

The review states that the program's two-year period of performance places constraints on moving participants to higher skill levels because of the time needed to start up programs and recruit participants, the length of associate degree programs (two years) and bachelor's programs (four years), and the time needed for intensive placement services after graduation.

Three of the six programs described provided significant training to prepare workers for IT occupations.

The **Municipality of Anchorage** project provides basic skills training for those with no technical experience, as well as modified vendor-specific training leading to certifications for computer technicians, network technicians, network administrators, Web design technicians, Web programmers, and database specialists. The report characterizes the project's training efforts as career-ladder training, adding that the grantee "would have provided training in systems analysis and programming, but the time constraints of the grant made this impossible, as these two occupations normally require a BA degree."

As initially conceived, the **New York City Workforce Alliance** project was focused on providing higher level IT skills through curricula developed and delivered by the City University of New York (CUNY). The project restricted enrollment to individuals "with a two-year degree, preferably in math and science with some calculus (to serve as a filter)" or "to individuals who possess a combination of high academic achievement in other disciplines and relevant work experience." In the first six months of the program, participants would have attended class two nights a week, three hours a night, receiving the equivalent of 15 credit hours of instruction. This training was to be followed by testing, then by an additional 10–12 weeks of training in one of four areas of concentration: Web development, Unix system administration, Java programming, or database systems administration. In the final phase, students were to participate in an internship, spending three-fourths of their time on the job and one-fourth in classroom training. Project officials and the Department of Labor subsequently decided that this approach was too costly on a per-trainee basis and that the prerequisites would exclude too many from training.

To reduce the per-trainee cost and to open access, this approach was abandoned in favor of a two-prong approach to training: one focused on unemployed/underemployed workers, the other using an employer-driven approach to training. Both of these approaches use a significantly shorter training horizon and are focused on providing lower level IT skills than the original plan envisioned. With respect to the unemployed/underemployed component, there are four components of training, ranging from the A-level introductory course (which provides basic instruction for entry into Web-related occupations) to the C-level course on Web administration. Level B1 includes courses in Web design, Microsoft Access, and Excel, and level B2 is focused on advanced Web design. The report states that 116 of the 158 people enrolled in the program had completed a minimum of one of the three-week/60+ hour training components. However, only six program participants had found jobs.



Maryland Roundtable

In the employer-driven project, courses range from 2 to 12 days. Course content ranged from “a simple introduction to Microsoft PowerPoint and Excel to more complicated Web page development.” According to the report, employers are reluctant to participate because of concerns about government paperwork and potential intrusion into company affairs.

The report concluded, “A problem faced by the program is providing IT-related job opportunities for those who have completed Component One [training for unemployed/underemployed] and following up with employers to determine if Component Two [employer-specific training] employees are actually being upgraded and provided with opportunities to use new skills.”

The initial plan proposed by the New York City Workforce Alliance project appears to have been more appropriate for preparing workers for H-1B-level IT occupations than the project as implemented.

The **Regional Employment Board of Hampden County (Massachusetts), Inc.** project has two components: (1) employer-based training incentives for incumbent workers, and (2) individual training accounts (ITAs) for unemployed and underemployed individuals to upgrade their IT or telecommunications skills by attaining industry certifications or college degrees.

The incumbent worker-focused program is customized to the needs of participating firms. Accordingly, the training provided varies greatly. Workers involved in the JDS Uniphase training program are working toward an associate degree in applied science or certification in telecommunications technology with a photonics option, taking one or two courses per term. At Coughlin Electrical Contractors, Inc., some employees are pursuing associate or bachelor’s

degrees in IT and telecom, while others attend short-term training for certifications, AutoCAD, or specific products. Systems Software Support, Inc., provides short-term (approximately one week) training programs to upgrade skills and obtain certifications.

The ITA component of the project provides unemployed/underemployed workers with a voucher to pursue training to enable them to advance in an IT career or in the telecommunications field. Candidates must have a high school diploma and experience working in the IT or telecommunications industry. No cap is placed on the amount of funds available through the ITA (the average ITA has been about \$10,000). Through this program, trainees have pursued certifications, classes in computer programming, and courses leading to degrees in microcomputer applications and information system processing. Approximately half of all participants have a high school degree and half have a college degree.

The report cites several factors negatively affecting project implementation, including the following:

- **The two-year grant period (even with the option of a “no-cost” additional year) impeded the ability of the projects to offer degree programs, even associate degree programs, because of the time required on the front end to recruit and assess candidates and on the back end to assist in job placement.**
- **The nature of training for incumbent workers requires significant flexibility on the part of training providers, and some providers were not able to adapt. Small institutions and community colleges seem to be most flexible.**
- **The economic downturn adversely affected some employers’ willingness to participate in the training efforts.**

Conflicting Directions on Targeted Occupations. In meeting expectations for use of H-1B fees, the program has suffered from conflicting statements of the program’s objective as reflected in the law (ACWIA 2000), expectations of legislators and executive branch officials,¹⁶⁵ and the language in the Department of Labor’s SGAs about occupations and skill levels targeted for training under the program. In addition, while ACWIA 2000 specified only that the target population for the program was employed and unemployed workers, the Department of Labor added another objective to the program by giving additional points to grant proposals that included strong outreach to minorities, women, individuals with disabilities, older workers, and individuals in rural areas.

While much of the discussion on establishing the H-1B fee focused on preparing American workers for jobs, especially IT jobs, being filled by H-1B visa holders, neither ACWIA 1998 nor ACWIA 2000 explicitly directs that the funds be used to train workers for high-demand H-1B occupations. ACWIA 1998 indicated only that the funds were to be used to provide technical

¹⁶⁵ Statement by the President, Office of the Press Secretary, The White House, October 17, 2000.

skills training for employed and unemployed workers. The provisions in ACWIA 2000 were more prescriptive about the specific skills on which the program’s training efforts should focus:

“At least 80 percent of the grants shall be awarded to programs and projects that train employed and unemployed workers in skills in high technology, information technology, and biotechnology, including skills needed for software and communications services, telecommunications, systems installation and integration, computers and communications hardware, advanced manufacturing, health care technology, biotechnology and biomedical research and manufacturing, and innovation services.”

“No more than 20 percent of the grants shall be available to programs and projects that train employed and unemployed workers for skills related to any single specialty occupation, as defined in section 214(i) of the Immigration and Nationality Act.”¹⁶⁶

Three grant competitions were conducted under ACWIA 1998, and two competitions under ACWIA 2000. For each round, the Labor Department issued an SGA that provided guidance, instructions, and evaluation criteria for potential applicants.¹⁶⁷ While each SGA referred to the need for applicants to look to H-1B occupations to determine “skill shortage areas,” they also included other language that was more ambiguous in terms of occupational targets and skill levels. In particular, the language used in the SGA for the fourth competition—together with the more prescriptive language of ACWIA 2000—was ambiguous. For example:

Skill Shortages in H-1B Occupations vs. General Skill Shortages. One area of ambiguity is in the characterization of the types of occupations on which training should focus. According to the SGA for the fourth and fifth WIB-focused (the “75 percent pot”) competitions,¹⁶⁸ “Training investments should be targeted in occupational areas that have been identified *on the basis of H-1B occupations as skills shortage areas.*” In addition, the SGA states: “The aim of the skills training is to place employed and unemployed workers in *highly skilled H-1B related occupations.*” However, elsewhere the SGA says: “Training must focus on *occupations that are experiencing skills shortage in the domestic job market.*” [emphasis added]

This latter, more expansive view could include occupations such as nurses and other health care professionals who generally do not require a four-year degree and thus would not be considered H-1B occupations.¹⁶⁹ This broader interpretation may have resulted in the awarding of a high percentage of grants to projects focused on nursing

¹⁶⁶ 214(i) defines a specialty occupation as one that requires “theoretical and practical application of a body of highly specialized knowledge” and “attainment of a bachelor’s or higher degree in the specific specialty (or its equivalent) as a minimum for entry into the occupation in the United States.”

¹⁶⁷ SGA/DFA 01-105 governed both the fourth- and fifth-round competitions.

¹⁶⁸ H-1B Technical Skills Training Grants, SGA/DFA 01-105, April 2001, <http://wdsc.doleta.gov/sga/sga/01-105sga.htm>.

and other health care occupations not likely to qualify as H-1B occupations. In the most recent analysis of H-1B visa use by the INS, only 3.4 percent of these visas were issued for “Occupations in Medicine and Health” and 2.0 percent for “Occupations in Life Sciences.” It should be noted that roughly 60 percent of the visas in these latter categories are for physicians, surgeons, and life scientists.¹⁷⁰

However, in the Labor Department’s fourth-round competition, half of the grants (12 of 24) included a focus on preparing workers for nursing and other health care occupations, even though nursing is not an H-1B occupation. Fewer than half of the grants (11 of 24) included a focus on preparing workers for IT jobs. Of the seven grants announced in the fifth round, three are focused exclusively on nursing and other health care occupations (accounting for 46.7 percent of the grant money), and four focus exclusively on IT.

It does not appear that the grants issued by the Labor Department in either the fourth- or fifth-round competitions meet the ACWIA 2000 provision requiring that 80 percent of grants be awarded to programs that provide skills in “high technology, information technology, and biotechnology,” and that no more than 20 percent of grants go to a single specialty occupation.¹⁷¹

Training for Direct Placement vs. Career Ladder. The second area of ambiguity is in the skill level to be achieved through the training. The SGA covering the fourth- and fifth-round competitions states that training should be “geared toward employed and unemployed workers who can be trained and placed *directly* in highly skilled H-1B occupations.” However, elsewhere the SGA reiterates the direction of ACWIA 2000, stating that “training is not limited to skills commensurate with a four-year degree,” as is generally required for an H-1B visa, but rather that training “should prepare workers for a broad range of positions along a career ladder...that *eventually lead* to a high skills level job.” [emphasis added]

One of the concerns expressed by employers is the effectiveness of this program in developing workers with the knowledge and skills necessary for positions that H-1B workers are filling today in IT occupations. The National Journal reports complaints from the high-tech industry that training programs supported through H-1B fees were too focused on entry-level positions and therefore were not helping employers find American workers to fill the jobs now taken by H-1B holders.¹⁷² In a letter to the

¹⁶⁹ Nurses are not covered under the H-1B provision of the Immigration and Nationality Act; registered nurses may be admitted to the United States under the provisions of an H-1C visa.

¹⁷⁰ Report on Characteristics of Specialty Occupation Workers (H-1B): Fiscal Year 2001, U.S. Immigration and Naturalization Service, July 2002, <http://www.ins.usdoj.gov/graphics/services/employerinfo/FY2001Charact.pdf>.

¹⁷¹ The ACWIA 2000 legislation specifically refers to “specialty occupations.” Defined in terms of the Immigration and Nationality Act, nurses are not a specialty occupation. The intent of Congress, however, seems to be that the program not be overly focused on any single occupation.

Department of Commerce recommending improvements to the program, the Information Technology Association of America states that the program should “Raise the skill bar requirement on the kinds of training programs that are supported through the grants. [Department of Labor] funding should not just focus on entry-level IT jobs; it should also address training for higher-end IT positions.”¹⁷³

With few exceptions, grantees that have an IT focus in their program appear to have taken the career-ladder approach to training workers for IT occupations. Grant recipients’ IT-focused training efforts appear to be aimed primarily at providing skills for IT jobs that do not generally require a four-year degree, in contrast to the professional-level IT jobs held by H-1B visa holders. Labor Department synopses of the winners of the fifth-round competition indicate that some of the new grantees may be exceptions. For example, the description of the Hillsborough County (Florida) Workforce Board’s \$3 million grant indicates that 92 percent of its training funds will be used for “workers currently employed in high skills IT careers who, with additional training and experience, will be able to fill positions currently held by H-1B workers.” In addition, the City of Phoenix’s grant project proposes to “identify, recruit, assess, train, and place successful trainees in information technology (IT) and software development occupations. Successful H-1B project participants will replace H-1B visa holders.”

H-1B workers are required by law to have the equivalent of a four-year degree in the field or equivalent experience.¹⁷⁴ In practice, nearly all those granted an H-1B visa hold a bachelor’s or higher level degree. According to a July 2002 study by the INS, 56.8 percent of approved H-1B petitions in fiscal year 2001 held a bachelor’s degree and an additional 41.5 percent held a master’s degree or higher.¹⁷⁵

Nevertheless, the Labor Department placed no emphasis in its SGAs on attracting degree holders to its IT training programs. Candidates with such preparation would be more likely to acquire a job in an H-1B-level IT occupation. In addition, employers show a strong preference for IT workers with paid, hands-on experience in the specific technology required by the job. **Employees trained through the H-1B Technical Skills Grant Program who have little or no IT work experience are likely to face difficulties finding employment.**

Perspective of IT Workers Responding to Commerce Online Request for Comments. More than 90 percent of the 145 IT workers responding to the Department of Commerce online survey said that they were unaware of any Department of Labor–sponsored or –supported IT workforce training programs. The sentiment expressed most frequently by those few who expressed familiarity with the Labor Department’s IT training efforts was that they were too focused on entry-level, low-end skills.

¹⁷² Bara Vaida, Labor Secretary Taps High Tech to Discuss Workforce Issues, *National Journal, Tech Daily*, April 2, 2001.

¹⁷³ ITAA Statement on H1-B Training Program, sent by email to the Department of Commerce, July 17, 2002.

Program Changes for the Sixth Competition. From the data available, it appears that few grants from the first five competitions would produce workers capable of filling IT jobs held by H-1B workers. In addition, these grants have been insufficiently focused on the occupational areas of greatest demand, as indicated by the occupational portfolio of those granted H-1B visas, especially with respect to training workers for IT occupations.

The Commerce Department is encouraged, however, by improvements to the program as reflected in the Labor Department's SGA for the sixth competition. The new SGA identifies the target audience for training as those who can be trained and placed directly in highly skilled H-1B occupations, while allowing for training to prepare workers for positions on a career ladder leading to an H-1B occupation. In particular, the SGA spells out "DoL's strong interest in achieving a higher level of training than has occurred in some H-1B grants, to a level that clearly prepares individuals to meet the H-1B visa definition of 'theoretical and practical application of a body of specialized knowledge,'" and requires that for all career ladder training, grantees demonstrate that "it is likely that the majority of individuals on the ladder will complete the highest rungs of H-1B level training." In addition, the new SGA requires grantees to provide additional information in their mandatory quarterly reports that will be useful in assessing the program's effectiveness.

National Science Foundation's Computer Science, Engineering, and Mathematics Scholarships Program

The National Science Foundation's Computer Science, Engineering, and Mathematics Scholarships (CSEMS) (www.ehr.nsf.gov/ehr/duel/programs/csems/) program provides grants to postsecondary academic institutions to fund scholarships for academically talented, financially needy students, enabling them to enter the high-technology workforce after attaining an associate, baccalaureate, or graduate degree in computer science, computer technology, engineering, engineering technology, or mathematics.

Among CSEMS's stated objectives are increasing the number of well-educated and skilled employees in technical areas of national need; improving educational opportunities in computer science, engineering, and mathematics; and increasing retention of students through degree attainment.

NSF established the CSEMS program in accord with ACWIA 1998. CSEMS is funded from a \$1,000 fee that employers pay for each temporary foreign professional employee who enters the United States through the H-1B visa program. The 1998 Act allocated 28.2 percent of the H-1B fees to the CSEMS program. ACWIA 2000 modified the formula for allocating H-1B funds; NSF now receives 23.5 percent of these fees. Of the 23.5 percent, the U.S. General Accounting Office (GAO) reports that NSF uses about 22 percent for scholarships and the balance (approximately 1.5 percent) for nontraining activities.¹⁷⁶

¹⁷⁴ Immigration and Nationality Act, Section 214.

¹⁷⁵ Report on Characteristics of Specialty Occupation Workers (H-1B), July 2002.

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CSEMS funds are granted to academic institutions on a competitive basis to support scholarship activities. The number and size of the grants vary, depending on the scope of projects and availability of funds. Institutions may apply for a grant of up to \$100,000 per year for up to four years for scholarships, administrative costs, and student support.¹⁷⁷ Up to 5 percent of the grant may be used for administrative costs, and an additional 5 percent may be used for student support activities (described below).

As of November 2002, CSEMS had made 466 awards to institutions in 44 states, the District of Columbia, Puerto Rico, and the Virgin Islands, totaling about \$128.9 million and providing 42,900 scholarships (figure 17). CSEMS anticipates making approximately 90 awards totaling \$30 million in FY 2003.¹⁷⁸

Figure 17. CSEMS Funding History

Fiscal Year	Number of Awards	Number of Scholarships	Amount Awarded
1999	114	9,000	\$ 22.6 million
2000	110	7,700	\$ 24.0 million
2001	150	16,200	\$ 50.6 million
2002	92	10,000	\$ 31.7 million
Total	466	42,900	\$ 128.9 million

SOURCE: National Science Foundation

Data collected on CSEMS scholarship recipients from the first three competitions show that 38 percent were majoring in computer science, 37 percent in engineering, and 20 percent in mathematics. NSF had no information on the academic majors of 12 percent of the scholarship students; the remainder of the students were in programs that spanned two of the three CSEMS disciplines (e.g., computer science and engineering). Almost all of the scholarships provided through CSEMS grants have been awarded to undergraduate students working toward an associate degree (21 percent) or a bachelor's degree (72 percent). A small number of graduate students working toward a master's degree (6 percent) or a doctoral degree (1 percent) have received CSEMS scholarships.¹⁷⁹

¹⁷⁶ High Skill Training: Grants from H-1B Visa Fees Meet Specific Workforce Needs, But at Varying Skill Levels, GAO-02-881, U.S. General Accounting Office, September 2002.

¹⁷⁷ The current program announcement (NSF 03-501) states: "Awards are normally not expected to exceed \$100,000 per year for up to four years." According to CSEMS program manager Duncan McBride, in the first few rounds, a few exceptions were made to the normal maximum where there was a compelling case; however, changes in the program make it unlikely that future awards will exceed the normal maximum.

¹⁷⁸ Information provided to the Department of Commerce by the National Science Foundation in November 2002.

The grantee institutions are responsible for selecting scholarship recipients. Institutions may elect to support individual student scholars for four years or may elect to support several cohorts of students for a shorter duration within the award period. As originally established, the CSEMS program provided scholarships of up to \$2,500 per academic year for up to two years. ACWIA 2000 increased the maximum annual amount and duration of CSEMS scholarships to \$3,125 per year for up to four years.

To be eligible for a scholarship, students must be U.S. citizens, nationals, refugee aliens, or permanent resident aliens at the time of application; be enrolled full time in a computer science, computer technology, engineering, engineering technology, or mathematics degree program at the associate, baccalaureate, or graduate level; demonstrate academic potential or ability; and demonstrate financial need as defined for undergraduate students by the U.S. Department of Education rules for federal financial aid or, for graduate students, defined as eligibility for Graduate Assistance in Areas of National Need (GANN).

According to the GAO review of the H-1B education and training programs,¹⁸⁰ NSF believes that CSEMS scholarship funds are “not restricted to tuition, [but] can be used for any expenses related to school, such as housing, transportation, or childcare.” The GAO report states that school officials said that since many of the CSEMS students work part-time jobs, the flexibility to use these funds for these non tuition expenses enables them to “use the time that they would be working at a job to focus on schoolwork.”

NSF expects academic institutions that receive CSEMS grants to provide scholarship recipients with the student-support infrastructure necessary for graduation (institutions can spend up to 5 percent of their grant on these support activities), including

- recruiting of students to higher education programs and careers in the CSEMS disciplines;
- mentoring of students by faculty and industry representatives;
- academic support, such as tutoring, study groups, or supplemental instruction;
- industry experiences or internship opportunities;
- community building and support among CSEMS scholars in the institution;
- participation in local or regional professional, industrial, or scientific meetings and conferences; and
- career counseling and job placement services for CSEMS scholars.

CSEMS scholarship recipients who have graduated report career interests in a range of occupations, including several in IT: computer science, computer programming, information systems,

network technician (Internet security), semiconductor technician, electrical engineering, aerospace engineering, mathematics, mining engineering technology, and manufacturing design engineering. Companies employing CSEMS graduates include the National Security Agency, Lucent, IBM, Sandia National Laboratory, 3M, Wal-Mart (computer programming), Texas Instruments, Intelligent Epitaxy, ST Microelectronics, and Hallmark Cards (computer technician).

The CSEMS program is largely focused on providing education at the level of those who enter the workforce under H-1B visas. Among the issues that should be examined as more data become available are the following:

- **Do CSEMS scholarships attract students to IT who would otherwise not pursue IT as a course of study?**
- **With the recent rapid growth in computer science enrollments that may have resulted in some institutions reaching a saturation point in their IT programs,¹⁸¹ where they can no longer add new seats because of limitations in teaching resources, do the CSEMS scholarships actually increase the number of students who receive IT degrees?**
- **Of those who leave the CSEMS program, how many leave school altogether? How many opt to pursue a non-CSEMS academic major?**
- **Given the focus on increasing educational opportunities for students in financial need, is the financial support provided through CSEMS scholarships sufficient to enable these students to complete their degrees?**
- **Does the use of CSEMS funds for nontuition-related costs (e.g., housing, transportation, and child care) contribute to the program's goals?**
- **How effective are the nonfinancial support mechanisms (e.g., mentoring, tutoring, and internships) in enabling CSEMS students to excel in academics, obtain meaningful experience with employers prior to graduation, and find appropriate job opportunities upon graduation?**
- **Do CSEMS students who graduate pursue and receive jobs in IT? How long do these students remain in IT occupations?**
- **How does the size limitation of the grants to academic institutions (maximum of \$100,000 for four years) affect the interest of community colleges and four-year colleges and universities in competing for these grants?**

¹⁷⁹ Information provided to the Department of Commerce by the National Science Foundation in February 2002.

¹⁸⁰ High Skill Training, September 2002.

Veterans' Benefits Support IT Education and Training

The Montgomery GI Bill offers those recently released from active military service and members of select military reserve units (Army Reserve, Navy Reserve, Air Force Reserve, Marine Corps Reserve, Coast Guard Reserve, Army National Guard, and Air National Guard) support for undergraduate or graduate degree programs, as well as business, technical, and vocational programs that lead to a certificate or diploma. For example, the GI Bill provides up to 36 months of education benefits, payable for 10 years following release from active duty.

The Department of Veterans Affairs (VA) has also established an accelerated payment program (i.e., an accelerated payment of GI Bill benefits), which will provide a lump sum payment of 60 percent of tuition and fees for certain high-cost, high-technology programs. To qualify, those eligible for GI Bill benefits must be enrolled in a high-technology program and must certify that they intend to seek employment in a high-tech industry as defined by VA. Both degree and non-degree programs qualify. Education and training programs that cover a wide range of IT knowledge and skills qualify for accelerated payment, including those focused on computer and information sciences, artificial intelligence and robotics, computer programming, data processing, computer systems analysis, computer software and media application, computer system networking and telecommunications, and computer/information technology administration and management. Participants certify that they intend to seek employment in one of the following industries: biotechnology, life science technologies, optoelectronics, computers and telecommunications, electronics, computer-integrated manufacturing, material design, aerospace, weapons, or nuclear technology.

VA also reimburses for certification tests that are approved under the GI Bill. Currently, these tests include Microsoft, Oracle, Cisco, and CompTIA IT certifications. Those eligible for benefits under the GI Bill can receive up to \$2,000 per test, but no more than the actual cost of the test. There is no limit to the number of tests that can be taken.

www.gibill.va.gov/education

State, Local, and Regional IT Education and Training Partnerships

Responding to the high demand for IT workers, state and local governments have undertaken a variety of initiatives—often in partnership with the Federal Government, industry, academia, and nonprofit organizations—to provide IT education, training, and retraining to current and prospective IT workers, including both students and those seeking to change jobs or careers.

These initiatives have taken a variety of forms in the types of education and training offered, the types of institutions through which the education and training are delivered, and the ways in which these efforts are supported financially.

The following initiatives demonstrate the diversity of efforts undertaken nationwide by state and local governments, often with support from the Federal Government. **With the downturn in IT-related industries resulting in greater availability of IT workers, some of those initiatives have been disbanded. Nevertheless, they offer models that may be put to work in the future, if or when the demand for IT workers strengthens significantly.**

MetroTech

MetroTech (www.metrotechitjobs.com) is a regional workforce development initiative designed to meet the need for highly trained technology workers in the metropolitan Washington, D.C., area. MetroTech provides recently laid off/dislocated workers and military personnel leaving

active duty with individualized training designed to round out the skill sets needed to move them quickly into specific job openings with area employers. The inclusion of certain exiting and retiring military personnel is designed to enroll individuals who have security clearances, for which there is large post-September 11th employer demand.

Funded by a \$20.2 million Department of Labor grant, MetroTech is a regional consortium created by the State of Maryland, the District of Columbia, and the Commonwealth of Virginia in partnership with the Greater Washington Board of Trade, Washington D.C. Technology Council, High Technology Council of Maryland, and Northern Virginia Technology Council. MetroTech program staff qualified to develop projects and recruit potential employees are located in more than a dozen cities and counties in the District of Columbia, Maryland, and Virginia. To date, MetroTech has partnered with approximately 240 employers.

MetroTech helps employers located within a 50-mile radius of the District of Columbia with specific job vacancies requiring high-technology skills. Focused primarily on providing training in information technology (with a smaller effort focused on biotechnology, including bioinformatics), MetroTech takes a unique employer-driven approach. A management team composed primarily of private-sector employers and some workforce professionals governs the program.

MetroTech provides customized training for job candidates whom employers agree to hire upon completion of the training. MetroTech provides training for both portable and company-specific technical skills, as well as soft skills. MetroTech may also retrain incumbent workers (preferably those with salaries of \$45,000 or less) who have demonstrated that they are valuable employees and possess the capacity to move into a technical position.

A MetroTech representative meets with a prospective employer, gathers information—such as training needs, number of participants, job description(s)—and completes a short project proposal. There is no limit to the size of proposals in terms of the number of vacancies to be addressed. Employers may specify the training providers to be used. The length of training depends on the gap between a particular candidate's skills and those required by the employer.

Identification of prospective job candidates is flexible: MetroTech can refer candidates who meet employer hiring criteria (after screening that may include tests and personal interviews), or employers may recruit eligible job candidates on their own. The employer determines which

Arizona's Business Tax Credit for IT Training

The Arizona Information Technology Tax Credit is available to businesses as a 50-50 match for IT training (for up to 20 employees in 2002). The set-aside is capped at \$5,000,000, with half the funds available for corporations and half for sole proprietorships and partnerships. The per-employee tax credit may not exceed \$1,500. If the number of qualifying applications exceeds the capped amount, the per-employee credit is reduced proportionately. To be eligible for the tax credit, training courses must be offered by an accredited college, university, private career school, or other postsecondary institution.
www.commerce.state.az.us/workforce/IT%20Training%20Tax%20Credit.html

individuals will enter the training. Employers can be as active in the selection process as they choose to be, including interviewing, screening, and testing at any time throughout the process. The employer then submits a one-page letter expressing a nonbinding commitment to hire or upgrade the trainee(s) upon satisfactory completion of the training or during the training period.

The MetroTech management team reviews and acts on the project proposal within one week. The management team decides whether the project is appropriate, taking into consideration the types and costs of training for the specific positions and the salaries the candidates will receive once they enter employment. MetroTech funds 100 percent of all approved training and skill certification costs. MetroTech is tax-free and offered at no cost to prospective employees and employers but operates with the understanding that individuals who successfully complete employers' specifications for training and/or certifications will be hired into positions with the organization. The average training cost per participant is approximately \$7,000. In some cases, however, employers may prefer a candidate to receive on-the-job-training, which MetroTech will support on a 50-50 cost-share basis with the employer.

MetroTech does not have a list of approved training vendors. Employers may bring training providers to the project, or training providers may bring employers to the project. Accordingly, trainers and/or providers of information/high-technology materials are encouraged to establish or build upon existing relationships with employers.

MetroTech expects to train approximately 3,000 workers over the course of its grant, which runs through 2004. As of June 2002, approximately 960 workers had completed training under the program and had been placed in jobs at wages that are, on average, 92 percent of the individuals' predislocation wage. Another 335 individuals were employed while completing their training. Others were receiving services such as career counseling and remedial training to prepare them for training for a specific job. Altogether, 2,600 individuals had been served.

During the peak of demand for IT workers, MetroTech's focus was on training workers for entry-level IT jobs with starting salaries of approximately \$27,000. MetroTech often used community colleges for training, although the semester/term system used by these institutions was inflexible and made it difficult to quickly respond to employers' needs. MetroTech found private providers (such as Chubb and DeVry) to be more flexible in both the content and timing of their training, especially for candidates who required more advanced training.

With the economic downturn, pressure on employers to find IT workers has eased and, with more IT workers available, many employers have increased their skill requirements, seeking more experienced and knowledgeable job candidates. MetroTech has responded with a focus on job candidates who are well educated and highly skilled and have a track record of consistent employment, but are lacking one or more technical skills needed to meet an employer's specific job requirements.

Some MetroTech-trained candidates have been hired for jobs that pay as much as \$80,000, although the overall average wage for individuals entering employment after MetroTech training is \$45,760. MetroTech also reports greater success in placing job candidates contacted soon after their dislocation, reaching them through mechanisms such as “pink slip parties” and social gatherings for recently unemployed IT workers where they meet prospective employers and share leads with others in their position.

Among the challenges reported by MetroTech in this employer-focused model:

- Overcoming employers’ reluctance to believe that a publicly funded program could be so employer focused and come with no strings attached except for the promise of hiring a trainee;
- Overcoming employers’ past bad experiences in working with government programs, especially the bureaucratic processes; and
- Getting the time and attention of busy employers for whom this type of program is outside their regular experience.

MetroTech reports that the path to overcoming these challenges is to work through organizations that enjoy employers’ trust, such as local/regional technology councils and chambers of commerce.

MetroTech attributes its success fundamentally to its employer-driven model, which includes:

- Developing a relationship of trust with employers;
- Providing training customized to employer needs;
- Timely response to employer proposals;
- Some control ceded to employers (selection of candidates; development of training requirements; selection of training provider, subject to MetroTech Management Team approval); and
- Careful screening of candidates.

These positive attributes also make MetroTech a labor-intensive model that requires a dedicated staff.

MetroTech says it has been successful in its “green-to-gray” military transitioning effort, in part because the candidates arrive with good basic skills and a strong work ethic, often have a security clearance (which is important to many Washington-area companies providing services to the Federal Government), and are eligible for assistance under the Job Training Partnership Act/Title III program.

Michigan Virtual University

Recognizing the importance of a highly educated workforce to its technology-based economic development strategy, the State of Michigan has undertaken a range of innovative efforts to attract, develop, and retain technology-savvy workers. One such effort is Michigan Virtual University (MVU) (www.mivu.org), a cooperative effort of the state government, the Michigan Economic Development Corporation, universities, and industry. MVU was established to provide high-quality, convenient, and cost-effective education and training to Michigan's current and future workforce in order to preserve existing jobs, draw new companies and jobs to Michigan, and improve the competitiveness of Michigan companies.

MVU is a private, not-for-profit company that contracts for the online delivery of its programs and services through colleges and universities in Michigan and private training providers. MVU was seeded through the Michigan Strategic Fund (the agency responsible for overseeing the state's economic development strategies) and generates revenues through course fees, contract services, sponsorships, and grants. MVU's primary focus is workforce development and continuing education, bringing together academic and business partners to develop and distribute course content.

MVU's Professional Development Center is the gateway to free IT education and training through two state-supported initiatives.

Information Technology Training Initiative. Under the State of Michigan's Information Technology Training Initiative, all students, teachers, faculty, and staff in Michigan's K-12 schools (public, parochial, and charter), community colleges, public four-year universities, and accredited nonprofit independent colleges and universities may take, free of charge, more than 700 self-paced mini-courses in IT and soft skills. These courses have been licensed by MVU from NETg, a division of Thompson Learning, for use through 2003.

Business e-education Freeway. Through MVU, small businesses (25 or fewer full-time employees) can access IT education and training free of charge through Michigan's Business e-education Freeway (BeeFreeway). The BeeFreeway offers more than 1,300 self-paced employee training modules in IT, management, and office skills, prepaid by the Michigan Department of Career Development through May 2004. Since the modules are self-paced, advanced students can move through them quickly, while beginners can take the time they need to master the material. Instruction is offered in small segments to accommodate busy workers. Companies with more than 25 full-time employees may pay to obtain access to these courses for their employees.

There is significant commonality between the Information Technology Training Initiative and BeeFreeway course offerings. Both offer courses in e-commerce, programming languages (e.g., C++, Visual Basic, Java, Perl, HTML); Internet and Web development (e.g., Macromedia Dreamweaver and Flash, Microsoft Frontpage and Visual InterDev); networking and operating systems (e.g., Novell, Cisco, Unix, Linux, Windows); database fundamentals; systems analysis;

project management; business skills; and soft skills, as well as courses to prepare students for Cisco, CompTIA, CIW, IBM, Microsoft, and Oracle certification exams.

Northern Virginia Regional Partnership

The Northern Virginia Regional Partnership, Inc. (NVRP) (www.nvrp.org) was one of 19 regional partnerships supported by the Commonwealth of Virginia since 1997 through its State Regional Competitiveness Program. Virginia was forced to cut and eliminate many programs because of revenue shortfalls resulting from the economic downturn; as a result of these cuts, funding for NVRP was eliminated, and the partnership closed its doors in June 2002. Nevertheless, NVRP offers a useful model for other regions and states.

The NVRP was a public-private coalition of leaders from industry, local governments, education, and civic associations formed to develop strong relationships with the region's technology industry and with educators, with the goal of creating a world-class workforce that would attract businesses to locate in Northern Virginia.

The partnership was guided by a 17-member executive committee and an 80-member board of directors, composed of Northern Virginia leaders in business, government, education, and civic organizations. From 1997 through its demise, NVRP received more than \$12.4 million in funding from the Commonwealth of Virginia's Regional Competitiveness Program, which it used to support a variety of activities.

NVRP's Regional Workforce Development Coordinating Center was a one-stop information clearinghouse for individuals seeking technology jobs as well as for companies seeking workers to fill job openings. The Career Center helped individuals identify job opportunities, training programs, and the resources and financing to get the training.

To help workers interested in transitioning into IT jobs and to help upgrade the skills of lower-skilled IT workers, NVRP established partnerships with area community colleges and universities to sponsor a range of intensive IT training programs that could be completed within six months. NVRP provided more than \$6 million to educational institutions for these programs through one-year grants of \$50,000–\$350,000. These funds were used for program development and to encourage stronger links between the institutions and employers in developing curricula. Since most of these training programs offered noncredit courses, they did not enjoy the benefit of state subsidization. To make these noncredit courses more affordable, a portion of the NVRP grant money was used to support the development of the courses, lowering the costs to participants by approximately 20 to 30 percent. Also, NVRP effectively leveraged its \$6.8 million investments in IT training programs by generating more than \$22.6 million in direct, indirect, and industry contributions. In the absence of NVRP support, the viability of these programs remains an unanswered question. Participating institutions will have to assess whether they can replace NVRP funding through tuition increases or by securing corporate or foundation funding.

NVRP-established programs include the following:

George Mason University

- **Train to Technology (TTT) Program:** Initially designed to train students in software and Internet technologies and prepare them to enter the IT workforce as productive development and support team members, TTT now offers a slate of advanced courses for more experienced students, typically those who have completed a first TTT course. TTT offers students extensive hands-on IT training in courses focused on MCSE Windows 2000, Oracle Developer, Oracle Database Administrator, Sun Java, Web Development, ASP.Net, ColdFusion, CCNA, A+, Network+, and Certification for Information System Security Professional (CISSP). Courses range significantly in duration and cost. For example, CompTIA's A+ and Network+ training programs require 40 hours of classroom instruction and cost \$799 each; MCSE Windows 2000, Java, and Web Development require 240 hours and cost \$5,499. Classes are offered during the day, on weeknights, and on weekends. Many TTT students have four-year college degrees and/or several years of work experience, though not necessarily in information technology. All must have demonstrated technical aptitude.

<http://ttt.gmu.edu>

George Washington University

- **Most Valuable Partners (MVP) Program:** The program offers training to earn certificates in Internet networking, advanced Internet networking, network security, and Web design.

www.gwvirginia.gwu.edu

Virginia Polytechnic Institute and State University

- The university offers online courses in programming and Web development that count toward Virginia Tech's Java Certificate, offered through its Continuing Education division.

Northern Virginia Community College

- **Technology Retraining Internship Program (TRIP) (Annandale Campus):** This is a six-month, full-time intensive training program to equip college graduates with non-technical four-year degrees with basic technical skills and some advanced computer competencies. The goal is to produce IT employees prepared for entry-level employment through a unique combination of classroom and on-the-job training. The first three months of the program are devoted solely to computer training, while the second three months are divided between advanced training and part-time corporate internships (both paid and unpaid). The program is offered three times a year with 25 students per class, graduating approximately 75 students a year. TRIP participants are selected based on their performance on a differential aptitude test (DAT), an application, and an interview. The DAT is designed to measure verbal, analytical, mathematical, and technical abilities.

- **Fast-Track Technology Program (Loudoun Campus):** The program retrains adults with two- or four-year nontechnical degrees, providing high-level software skills through an intensive part-time training curriculum. Program candidates undergo a rigorous selection process that includes a DAT (free) and a content-specific course (offered at a cost of \$100). A candidate who is successful on the DAT may then take a content-specific course. Acceptance into the program is based on a final test at the end of the course. Candidates with two-year or four-year degrees are preferred, although consideration is given to nondegreed individuals who demonstrate aptitude and interest. Training is offered at night and on weekends. Each specialized track (such as Java, C++, Webmaster, Oracle) takes approximately five months to complete and includes approximately 160 hours of classroom instruction and an additional 10 hours per week of supervised lab time. NVCC-Loudoun offers three tracks per year, basing its decision on which track to offer at a particular time on current market demand. The program costs \$4,000 per track.
www.nv.cc.va.us/loudoun/continuing/asp/fasttrack.asp
- **Technology Workforce Development Center (Alexandria Campus):** The program offers hands-on training, practice tests, and unlimited lab time to prepare participants for IT certification exams.
- **Manassas Advancement Center (MAC) (Manassas Campus):** The center offers career changers and IT industry professionals seeking to upgrade their skills a wide variety of programming, networking, and database administration programs, many preparing students for CCNA and MCSE certification exams.

As of March 2002, 10,566 adult students had completed NVRP-funded IT training programs. Of these, 2,441 reported upgrading their technology skills with their current employer and/or successfully transitioning into the region's IT workforce. The actual number may be significantly higher, as students were not required to complete surveys. Currently, there are 8,543 students in NVRP training.

NVRP/Sallie Mae IT Career Assistance Loan Program: Helping to overcome the cost barrier to career transition. Recognizing the cost barriers facing people who want to transition into IT jobs—including the cost of training, lost income, and lack of access to flexible financing (particularly for short-term, noncredit training programs, which generally do not qualify for federal student loans or grants)—NVRP established an innovative low-interest loan program in partnership with Sallie Mae, the nation's leading source of funding and servicing support for education loans. NVRP was able to reduce Sallie Mae's risk and secure low-interest loans (prime plus 1.75 percent) for individuals interested in participating in NVRP-sponsored training programs by using public funds to establish a loan loss reserve—a 20 percent loan guarantee that helps protect Sallie Mae against losses from default.

Unlike other educational loans, loans made under the IT Career Assistance Loan Program can be used to cover living expenses as well as traditional educational expenses such as tuition



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and books. Other benefits of this loan program include online loan application, with a decision within 30 seconds; no loan application fee or other up-front fee; repayment over a period of up to five years; and interest-only payments during training. Through May 2002, the program had approved 401 loans, totaling nearly \$2 million, with an 88 percent loan approval rate. The program offers flexible repayment terms to accommodate students' ability to pay. Remarkably, the program boasts a zero percent default rate to date. Data from approximately 100 loan recipients who completed NVRP-sponsored training programs show an average salary increase of 19 percent, rising from \$36,360 to \$43,243.

As a result of the success of the IT Career Assistance Loan Program, Virginia plans to use it as a model to establish a statewide program.

Preparing Future IT Workers. In addition to its focus on adults, NVRP also worked with middle school and high school students to prepare them for careers in IT. NVRP supported 11 Cisco Networking Academies in high schools in six Northern Virginia school districts, providing initial funding for teacher training and some equipment. These academies have graduated 479 students, and another 460 are in the pipeline. The success of the Cisco Academies led NVRP in 2002 to increase its financial support to enable five of Virginia's regional school districts to expand their offerings to include Sun Java and CompTIA A+ courses.

Since 1998, NVRP's Summer Technology Program has provided middle school students with basic and advanced IT training at the state's higher education institutions. In 2001, 927 stu-

dents participated in the program. Each participating institution has a unique offering. At the NVCC campuses, students studied a range of scientific and technological subjects—including software, robotics, advanced Internet, boat building and environmental science, biotechnology, and chemistry—using multimedia software, Web page design applications, and digital cameras and equipment. At George Mason University, the program focused on integrating IT skills and academics. Virginia Tech’s program focused on Web page design and HTML programming. Marymount University focused on the use of IT in textile and fabric design, interactive Web design, digital photography, and Java programming. And the Columbia Lighthouse for the Blind instructed visually impaired children on Web page development, learning and applying portable assistive devices, and building PowerPoint presentations.

Software Council Fellowship Program

The Software Council Fellowship Program (SCFP) was a private nonprofit corporation with the mission of providing highly skilled workers to the software industry through retraining and education. Initiated in 1993 by the Massachusetts Software Council and several agencies of the Commonwealth of Massachusetts, SCFP provided a bridge for professionals transitioning from other industries to find careers in the software industry. Originally run out of the Council, SCFP was separately incorporated in 1996. Initially funded by federal dislocated worker monies, SCFP moved toward the goal of being self-sustaining, operating primarily on financial support from industry. Company interest and support for the program was very high during the late 1990s and in 2000; however, the economic downturn in 2001–2002 reduced companies’ interest in and ability to participate in the program, resulting in the termination of the program in 2002.

Candidate recruiting was done through periodic newspaper advertising and distribution of information to government one-stop employment centers and outplacement centers. Most SCFP candidates were older (average age 47), had previous annual salaries in the \$35,000–\$80,000 range, and were highly educated professionals (65 percent with advanced degrees) who had been laid off. In the early 1990s, candidates came to the program as a result of defense downsizing and a decline in the Massachusetts computer hardware industry. In the latter years of the program, candidates came from such sectors as banking, teaching, and government.

SCFP focused its efforts on retraining professionals with marketable business skills in one industry for mid-level, mostly nontechnical jobs in software and Internet companies. To be eligible for the program, candidates had to have had basic personal computer user skills and at least 10 years of business experience. Candidates were screened through their resumes and personal interviews.

SCFP did not provide formal IT technical skills training; that was never the goal of the program. The 21-week training program taught how-to-learn skills, team-building skills, problem-solving skills, and the knowledge of how to use job-hunting resources, while the companies provided on-the-job practical training.

IT Training for Dislocated and Disadvantaged Adults

Training programs have been established at the local and regional levels to provide dislocated and disadvantaged adults with occupational skills that could lead to an entry-level IT job. While many of these programs receive some support from the Federal Government, such as the U.S. Department of Labor, support comes from a variety of sources, including state and city government, foundations, and private companies. These training initiatives are often connected to community-based organizations, community technology centers, and community colleges.

These programs are diverse in the populations they serve. However, because of the types of funding streams available from government, the job placement goals associated with some funding streams, and rigorous candidate screening, these programs tend to target dislocated, underemployed, disabled, or older workers rather than the least advantaged or welfare-to-work population.

Typically, these programs offer free or low-cost tuition. However, since many of the programs require full-time participation as well as homework, participants must find ways to cover their living expenses while in training. It can be difficult for those working part time or full time to participate.

A number of program elements frequently characterize these training programs:

Candidate Screening: While many of the programs do not require previous computer experience, many employ rigorous candidate screening, and some require minimum levels of reading and math competency, for example, ranging from 6th to 10th grade reading level. Factors that may be assessed during screening include basic literacy, motivation, basic computer skills, employability, communications and team skills, and the likelihood of completing an intensive IT training program. A high school diploma or GED, interviews, orientation programs, and a drug test are sometimes required. To gain entry to the Byte Back internship program, candidates must pass tests at the intermediate level in Microsoft Windows, Word, and Excel. To qualify for the Milwaukee-based Homeboyz Interactive Digital Training program, candidates are required to obtain employment in a low-skilled job for up to a nine-month probationary period.

Intensive, Longer Term Training for Small Groups: Training in these programs can be lengthy, as long as 800 hours, and can cost several thousand dollars or more per participant. Small groups of individuals participate; for example, 20 per year or 10–20 per training site.

Entry-Level Technical Skills Training: The training provided in these programs focuses on low-end or entry-level IT skills for occupations in computer support and help desk, Web design, networking, and multimedia. This includes training to prepare program participants for the A+, Network+, I-Net+, and entry-level Novell (CNA) and Cisco (CCNA) certifications. HTML and Web site design tools are also popular in these programs. For example, the San Francisco-based OPNET, which trains low-income young adults for the new media and Internet industry, offers eight weeks of training in Web-related technical skills such as HTML, XML, Photoshop, JavaScript, and Flash. The Washington, D.C.-based Byte Back established a Cisco Networking Academy. A few of these programs offer higher level training in programming, such as Visual Basic or preparation for the MCSE certification. The Chicago-based I.C. Stars program teaches C# and SQL. In San Francisco's Bay Area Video Coalition, participants can take a 16-week certificate training program in programming, which covers database design, implementation using Microsoft SQL server, Web programming with Active Server Pages, Visual Basic for Applications, and Microsoft Access.

Soft Skills Training: Some soft skills training is typically provided, usually involving resume development, job search, and interviewing skills. Some programs also focus on teamwork and collaboration, communications, and problem solving. For example, in the Milwaukee-based Homeboyz Interactive program, participants focus on soft skills such as job readiness, teamwork, self-motivation, speaking, writing, listening, leadership, and self-directed learning. In I.C. Stars, participants learn project management skills, develop business networking skills, and explore market trends and forces. However, the soft skills employers say they want in IT workers are often beyond the scope of these programs.

Internships: Some of the programs use internships to provide participants with on-the-job experience. For example, after completing their training in Web development, OPNET participants can work at a two- to four-month paid internship in a company with an IT department or Web programming presence. In exchange for 10 hours of classes per week, Byte Back participants intern 10 hours per week in the Byte Back program office or maintaining computers in its partner institutions. Other programs have nonprofit or commercial, for-profit IT service arms where program graduates can intern. New York City's Per Scholas program operates a nonprofit computer reconditioning operation in which graduates of its computer support training program can work part time while searching for full-time

IT Training for Dislocated and Disadvantaged Adults, continued

employment. Homeboyz Interactive's HBI Consulting business provides an internship option for program participants, as well as on-the-job training while graduates search for full-time jobs.

Support Services: Many programs provide trainees with a range of support services. For example, OPNET's Support Net provides training stipends of \$200 per week, job counseling, job placement assistance, tutoring, mentoring, and peer group support. I.C. Stars offers a stipend to help cover a portion of living expenses while participants are in full-time training. I.C. Stars also offers three-hour evening workshops in which trainees can work with coaches and alumni on computer programming exercises.

Follow-on Training: Several programs have established higher level training opportunities and other support services for their program graduates. OPNET established an AdvanceNet initiative, which provides training to its program graduates so they can upgrade their skills with Java, Perl, Unix, and advanced systems administration.

These programs have varying levels of success in placing their graduates in IT-related jobs. Graduates who are placed in jobs often see a significant gain in their earnings. Most of the training provided focuses on skills at the low end of the IT skill spectrum. Graduates of these programs compete with many other job candidates who have acquired the same or similar skills through traditional academic and commercial training providers, and all of them compete for the lower-end jobs that appear to constitute about a quarter of IT job openings. These program graduates would require additional education and training to move on to more advanced work in IT.

These training programs face similar challenges in their development and operation. It can be a challenge to cobble together funding from government and nongovernment sources to develop the program and keep it running. Sometimes, requirements for government funding are not in line with the length and cost of the training required. Requirements for funding may target some groups for training but exclude others who would benefit from the training. Many of the programs operate with donated equipment and struggle to keep equipment up to date and relevant for job training. Programs also have difficulty recruiting and retaining qualified instructors. The programs must work to build relationships with firms to gain information about their skill needs, to secure internships for their trainees, and to get commitments to hire their graduates for entry-level jobs.

SOURCES: *From Promising Practices to Promising Futures: Job Training in Information Technology for Disadvantaged Adults*, by Karen Chapple, et al., the Ford Foundation and Bay Area Video Coalition, October 2000. www.byteback.org, www.homeboyz.com, www.opnetwork.org, www.icstars.org, www.bavc.org, www.perscholas.org

Fellows who had exhausted their unemployment benefits were eligible for a stipend of \$270 per week from fees paid to SCFP by participating companies. Fellows paid tuition of \$1,200 (approximately \$50–\$60 each week of the training program). SCFP believed that the tuition fellows paid was important; it gave them a sense of “ownership” and produced a higher level of commitment to the program.

In the first week of the program, fellows participated in a preparation and orientation session composed of a three-day retreat that included “recharging” (to bolster their self-confidence); exercises to teach team-building, creativity, and problem-solving skills; and an overview of current trends in the software and information technology industry. Fellows then spent four days a week at a company, working on a well-defined project with mentor support and supervision. A fifth day of the week was spent with other fellows in seminars and continuing workshops, usually featuring leaders in the technology industry. During the final eight weeks of the program, this fifth day was used for developing job-seeking skills, such as resume preparation and interviewing skills. Given the job churn in the economy generally and in IT occupations in

particular, SCFP considered job-seeking skills an important lifelong skill. SCFP did not offer placement assistance, instead placing the responsibility on the fellow. SCFP hosted fellows' resumes on its Web site.

According to SCFP, the program had a high completion rate (98 percent); in general, fellows' salaries equaled or exceeded the average previous salary (approximately \$50,000) of the candidates. Six hundred fellows completed the program. Approximately half of the SCFP fellows were hired by the companies in which they trained, while the overall placement rate was approximately 97 percent.

In addition to the primary fellows program, SCFP piloted, over the course of three years, an internship program for college seniors. SCFP's 13-week Software Industry Internship Program was conducted in partnership with the University of Massachusetts-Lowell's College of Management. It offered software career development for college seniors or those with less than 10 years of work experience. The internship program consisted of a thorough orientation to the software industry, a paid internship at a software company in a team project, and ongoing learning about the software industry and training in contemporary business skills. Thirty-five interns graduated from the program.

Online Learning

Online learning is a rapidly growing method used by a wide range of workers, especially IT workers, to access knowledge and credentials. Many institutions—such as NETg, IBM, DeVry, and SmartPlanet—offer online learning as a channel for delivering their curricula; for some institutions, it is their primary or exclusive courseware delivery mechanism. The following are examples of institutions that offer online learning opportunities and/or are involved with the development of the medium:

Asynchronous Learning Networks (ALNs). Asynchronous learning is a means for students to take courses and access knowledge on demand. Systems designed for this purpose provide remote access to resources—people (professors, peers, practitioners), libraries, laboratories, databases, reports, and so on. Unlike some distance learning/broadcast approaches that emphasize time- and place-dependent television delivery in a lecture format with limited interactions, ALNs seek to de-emphasize lectures and emphasize interaction by using the tools of information and communications technology to link people and to provide a framework.

ALNs offer the potential for self-paced learning that would enable motivated students to move through a course quickly, while enabling other students to take the time to master a subject. These attributes could lead to decreased time-to-degree, higher student retention, and lower cost of education.

In addition, the on-demand nature of ALNs opens up learning opportunities for those who wish to continue their education but whose work and family life place significant demands on their time, demands that are often inflexible. This characteristic is particularly valuable to IT workers who often face long work hours and are buffeted by technological change that mandates intense, continuous learning. And it is, of course, especially beneficial to middle-aged and older IT workers who are more likely to have time-intensive family responsibilities.

Sloan Foundation Program in Learning Outside the Classroom: Anytime, Anyplace, Online (The Sloan Foundation, www.sloan.org; Asynchronous Learning Networks, www.aln.org; The Sloan Consortium, www.sloan-c.org). The Alfred P. Sloan Foundation Program in Learning Outside the Classroom: Anytime, Anyplace, Online¹⁸² was established in 1993 to foster development and deployment of asynchronous learning. Since the program’s inception, the Sloan Foundation has made 160 grants and committed approximately \$40 million to the effort, including 122 grants directly supporting projects at colleges and universities; 20 grants in support of planning activities, mainly preceding a project grant; and 26 grants in support of knowledge dissemination activities.

The Sloan Foundation estimates that through the 2000–2001 academic year, more than 400,000 students enrolled for ALN courses offered by Sloan Consortium members (grantees and other institutions that teach full degree or certificate programs online in the ALN style). In addition, approximately 15,000 faculty have taught these courses. Today, members of the Sloan Consortium offer more than 300 full degree and certificate programs online. Most of the degrees and certificate are in IT disciplines; the balance are primarily in engineering and telecommunications disciplines, with a few in other areas such as business, communications, and nursing. Figure 18 provides information on some of the consortium members with large ALNs.

Figure 18. Selected Sloan Consortium Members with Large ALNs¹⁸³

Institution	Enrollment	Course Titles	Degrees and Certificates
University of Maryland University Campus	65,000	320	24
SUNY System (SUNY Learning Network)	27,000	1,400	40
St. Leo University	20,000	60	5
University of Illinois System (Uillinois OnLine)	8,300	378	28
Penn State (World Campus)	6,000	95	
Northern Virginia Community College	10,000	100	8

¹⁸¹ The 2000–2001 Taulbee Survey of the Computer Research Association reports that “some programs may be operating in ‘saturation’ mode, where they simply cannot accept more undergraduate majors

Here is a sampling of some of the Sloan Consortium members' ALN-style offerings in IT:

- **Jamestown Community College in New York** offers an associate of science degree in computer science designed for students who plan to transfer to a four-year college or university to major in computer science.
- The **University of Illinois at Urbana-Champaign** offers a master of computer science through the Internet. Lectures are recorded and made available on demand through the Internet within an hour of the live lecture. Each course uses threaded discussion boards, videoconferencing, and e-mail to communicate.
- The **University of Maryland University College** offers asynchronous courses leading to:
 - a wide range of *certificates*, including Database Management, E-Commerce Management, Internet Technology, Object-Oriented Design and Programming, Visual Basic, Software Engineering, and Technology and Management;
 - *bachelor's degrees* in computer and information science and information systems management; and
 - *master of science degrees* in computer systems management, electronic commerce, information technology, telecommunications management, and software engineering.
- The **Virtual College of New York University's School of Continuing and Professional Studies** employs both asynchronous and synchronous learning, offering real-time lectures and seminars (which are also recorded for those who cannot "attend"); threaded discussion forums; text-chat; e-mail; file sharing; and tools to enable collaboration and team activities. Virtual College offers a wide range of IT certificate programs, as well as a master's program in management and systems.
- The **University of Washington** offers 13 IT-related certificate programs via asynchronous learning, accessing information through the Internet, textbooks, and audio, as well as communicating with instructors and classmates via teleconferences, the Internet, and voice mail.

Sloan Foundation priorities for its 2002 grants include support for unrepresented disciplines, education and training within and for specific industries (such as the telecommunications and electric power industries), in well-defined niches (such as its work with Pricewaterhouse-Coopers and the U.S. Army in connection with eArmyU), and to highlight applications of ALN in New York City. A second set of grants will aim to strengthen the online learning industry.

In terms of the effectiveness of ALNs, Sloan finds "[no] significant variation in learning effectiveness between classroom and online courses taught in the interactive mode."

Online Educational Institutions

While some institutions of higher learning use ALN to supplement traditional classroom education, others offer education and training online as their primary or exclusive delivery channel. Some institutions focus exclusively on undergraduate- and graduate- level degrees, some focus on technical skills and certifications, while still other institutions offer a combination of both. Here are a few examples:

The University of Phoenix (www.phoenix.edu). The University of Phoenix is a for-profit university offering bachelor's, master's, and doctoral degree programs online and at more than 100 U.S. campuses and learning centers in 22 states and Puerto Rico. With a focus on working adults, the average age of Phoenix students is 35. The university offers degrees in a wide range of fields—IT, business management, education, nursing, and technology—making it the largest private institution of higher learning in the United States.

In 1989, the University of Phoenix became one of the first to offer college degree programs online via the Internet. Today, the University of Phoenix Online has approximately 37,600 students. Using software provided by the university, degrees can be completed entirely online through the university's asynchronous format, which offers students the ability to pursue their degrees whenever and from wherever they choose. Administration, registration, and textbook purchases can be performed online as well. Students must have a computer and Internet connection. Lectures, questions, and assignments are downloaded for review offline. Courses are offered one at a time and last approximately five or six weeks. All faculty hold a master's or doctoral degree and work in the fields they teach, enabling them to provide a fusion of theory and real-world practical experience.

The University of Phoenix developed its programs in consultation with the private sector and continues to seek industry feedback to update its courses and to use the most current proven concepts, methods, and practices to provide students with the skills and experience that are in high demand.

Prospective candidates must have a high school diploma or equivalent and be at least 23 years old (with some exceptions granted) to gain admission to an undergraduate program. In addition, because the university emphasizes the importance of immediate application of skills, students must be employed or have access to an organizational environment that allows them to apply the concepts they learn in courses.

Tuition costs are \$410 per credit for undergraduate courses and \$505 for graduate courses.

The University of Phoenix Online offers two IT-related BS degrees, one in e-business and the other in information technology; a master of science in computer information systems; and an MBA in e-business.

- Each of the IT-related bachelor's degrees requires a minimum of 120 credits. The 60-credit core of upper division courses for each degree costs approximately \$24,600.
- The MS in computer information systems includes 12 three-credit courses and 1 one-credit course. Total tuition cost for the required 37 credits is approximately \$18,685.
- The MBA in e-business includes 15 three-credit courses and 1 one-credit course. Total tuition cost for the required 46 credits is approximately \$23,230.

SkillSoft/SmartForce (www.smartforce.com). In September 2002, SkillSoft and SmartForce merged, bringing together SkillSoft's extensive business course offerings with SmartForce's extensive IT course offerings. The combined company, which operates under the name SkillSoft, now has an IT skills and certification library of more than 2,800 course titles, encompassing software development, operating systems and server technologies, Internet and network technologies, enterprise database systems, Web design, and desktop computer skills, as well as courses supporting more than 40 certification programs. The company's business library has more than 1,600 courseware and simulation titles. In addition, the company has more than 2,500 unabridged IT and business books and reports, including content in over 15 languages, that are available to online subscribers through SkillSoft's subsidiary, Books24x7. The company has more than 2,800 corporate customers worldwide and more than 4.5 million licensed users.

SkillSoft is currently working to ensure interoperability across the newly combined product line. The company plans to integrate the SmartForce and SkillSoft learning platforms and provide legacy support for SmartForce legacy systems, e3 course architectures (explained later in more detail), and online mentoring for IT certification. What follows is a description of SmartForce's offerings before the merger.

SmartForce offers preparation for more than 40 professional certifications for IT professionals in application development, database technologies, enterprise resource planning, groupware technologies, Internet technologies, internetworking, IT core concepts, mainframe technologies, and operating systems. These offerings cover preparation for certification from vendors such as Microsoft, Cisco, CompTIA, IBM, Oracle, Novell, Sybase, Lotus, Java, Avaya, Lucent, and the European Computer Driving License Foundation.

In addition to the company's certification training, SmartForce offers IT courses in information technology core concepts, NetObjects, technical support, Internet security, e-business, e-commerce, Java, C/C++, INFORMIX, Internet and intranet skills, internetworking, and Unix, as well as courses covering products offered by Netscape, Novell, Oracle, Intel, Cisco, SAP, IBM, Sybase, Lotus, Linux, Microsoft, Macromedia, and Sun Microsystems.

Instruction is offered through the teaching of concepts, demonstrations, workshops, seminars, white papers, and Weblinks. Collaboration is achieved through around-the-clock mentoring, expert-led chat, peer-to-peer chat, seminars, discussion boards, mentored exercises, workshops,

and group study and meetings. SmartForce enables students to practice newly learned skills and test knowledge through software simulations, interactive exercises, role-playing simulation, quantitative simulation, Web projects, and online labs. Finally, assessment is accomplished through performance tests, proficiency assessments, certification prep tests, and customized assessment and certification tools.

SmartForce e3, the company's Internet-based application architecture, is scalable to support a single user or thousands, in one location or worldwide. Through its Web-based interface, students are able to get instruction, collaborate, practice, and test any time and anywhere they can access the Internet. SmartForce also enables its customers to offer their own customized programs and develop and publish their own learning objectives.

SmartForce enables companies to improve and assess employee competencies. Since the training is customizable for a specific company yet uniform in its content and delivery, the company is able to inventory its skills portfolio, compare that to company needs, and fill in the gaps with targeted learning. In addition, this system enables the industry to identify what it refers to as "self-selecting hi-pots"—employees who seek out learning opportunities and excel, demonstrating self-motivation and high potential to their employers.

Capella University (www.capellauniversity.com/gateway.aspx). Capella University is a privately held, for-profit company owned and operated by Capella Education that operates exclusively as an e-learning institution. Capella University offers more than 500 online courses, accredited undergraduate and graduate degree programs in 40 areas of specialization, certificates, and continuing education to adult learners pursuing advanced study while working. Capella has five schools, including a School of Technology and a School of Business.

Capella's School of Technology offers certificates in graphics and multimedia, information system quality assurance, network technology, Web application development, Web application project management, and Web application security. Each certificate requires completion of 30 quarter credits, taught as five courses (six quarter-hours each). The cost for each course is \$1,425, for a total cost of approximately \$8,550.

In addition, 10 courses (two quarter-hours each) are offered in selected IT areas such as network security, enterprise security, legal issues for IT professionals, and programming languages. The cost for each course is \$1,425.

The School of Technology offers a BS in information technology that emphasizes theoretical and applied uses of information technology, with specialty concentrations in Web application development, graphics and multimedia, project management, and network technology. In addition to technical instruction, the curriculum includes mandatory courses in communications and ethics.

The curriculum requires 16 courses (six quarter-hours each) at a cost per course of \$1,425, for a total cost of approximately \$22,800. Admission to the bachelor's program requires an associate degree or a minimum of 60 quarter-hours (40 semester-hours) of course work earned at the lower division undergraduate level.

The School of Technology offers an MS in information technology designed for those with IT-related degrees who want to increase their technical and management knowledge as well as for those with non-IT degrees seeking to move into IT. Course work includes network technology, Web application development, wireless and mobile development, project management, system design methodologies, quality assurance and testing, Web security, and graphics and multimedia. Master's candidates may specialize in system design and programming, network architecture and design, or project management and leadership.

The master's curriculum requires 12 courses (four quarter-hours each) at a cost of \$1,550 per course, for a total cost of approximately \$18,600.

Capella offers tuition discounts to members of the U.S. armed services, and partners with corporations and government agencies to provide educational opportunities to their employees. Capella also has partnerships with 67 community colleges in 23 states, enabling graduates of associate programs to continue their education.

MindLeaders. MindLeaders offers online courses directly to students as well as through businesses, government agencies, and nonprofit organizations. The company offers more than 780 technical and business courses over the Internet, through organizations' intranets, and by CD-ROM. Courses include preparation for certification exams (such as A+, CNE, MSCE); a broad range of IT topics (data warehousing, networking, database management, programming languages, operating systems); and vendor-specific hardware and software from companies such as Microsoft, Cisco, Lotus, Novell, Oracle, Sybase, SAS, and Adobe.

Students have round-the-clock access to content experts through the company's Instant Mentoring service. In addition, MindLeaders offers its students access to extensive technical and end-user libraries. MindLeaders creates custom packages with varying course content for end users and organizations. Cost varies depending on the courseware selected. On the low end, MindLeaders offers a one-year license to federal agencies that provides access to 285 courses at a cost of approximately \$120 per user, though more extensive offerings can cost up to \$500 per user.

Books, CD-ROMs, Other

Many IT workers participate in self-study using computer-related books and manuals. One IT worker who participated in a Commerce Department roundtable commented, “Two years ago I needed to step up to a new skill if I was going to keep my job. The formula was as follows: I took the initiative in the month of December when I had all my vacation holidays to study Java at home with great books that are out there, that gave great sample code. After a month of studying Java—brand new to me—I walked in and passed Sun Microsystems’ certification exam.”

A plethora of technical books are available from dozens of publishers and booksellers, including large ones such as John Wiley & Sons, McGraw-Hill, Addison Wesley, Prentice-Hall, Barnes & Noble, and Thompson. IT companies also offer a range of training materials in printed form, and Microsoft Press is one of the most popular providers. Typically, these books teach specific IT skills and can be purchased for under \$100.

IT training is also available in CD-ROM format. These programs are self-paced, can be used at a time and place of the learner’s choosing, and may include testing, tutorials, and practice sessions. Costs for IT training on CD-ROM vary significantly, from as low as \$100 to several thousand dollars.

Other resources available to IT workers for learning skills include user groups, Web sites with technical tips, free tutorials, and other Internet-based technical resources.

Churn in the IT Labor Market

Another way IT workers expand their portfolio of skills and experiences is moving from one job to another. This enables them to apply their skills on new projects and in new business settings and industries, and to gain new work experiences, which prospective employers may value. Moving to a new job may also offer the opportunity to acquire new technical skills based on the technologies a new employer uses. One employer representative at a Commerce Department roundtable commented, “And that’s why they go to the outsource providers, because they can go from company to company and learn technology every six months to a year.” Another participant followed up that comment with, “They’ll do a six-month stint, a nine-month stint at this place and then that place, and build their portfolio.”

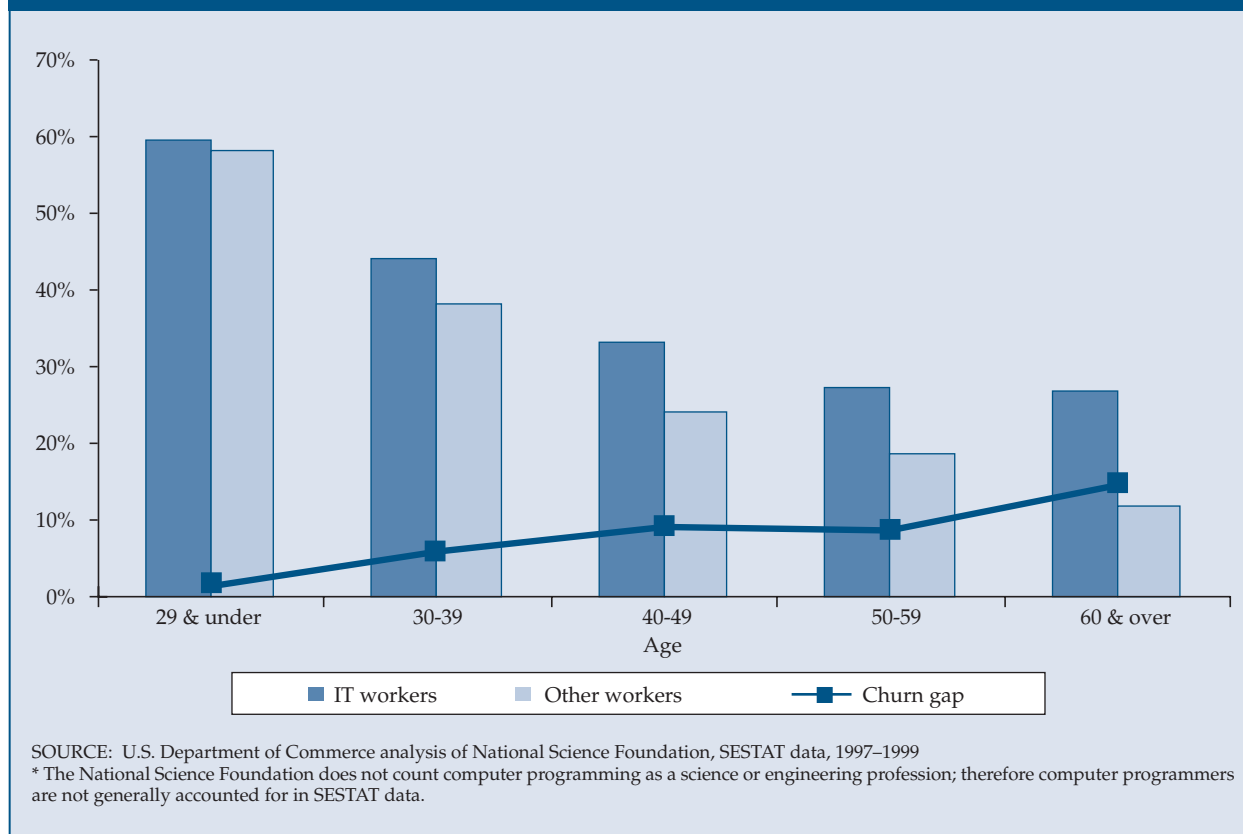
The Virginia Governor’s Commission on Information Technology found that “The most favored tactic for addressing the experience shortfall is to hire the experience away from someone else. To a certain extent, this approach is supported by IT workers themselves because, by moving to another firm, they can often get to work on the type of system or project that will upgrade their skills and keep them at the leading edge of technology.”¹⁸⁴

given their teaching resources.” www.cra.org/statistics/survey/01/01.pdf

Analysis of data from the National Science Foundation’s Scientists and Engineers Statistical (SESTAT) Data System shows a higher overall churn rate for IT workers. Of those holding IT jobs in 1997, 36.7 percent—more than a third—had changed employers or jobs with the same employer by 1999. By comparison, only 26.1 percent of non-IT workers in the SESTAT database changed employers or jobs during that period.¹⁸⁵

While the churn declined with age for both IT and non-IT workers, the discrepancy in churn between IT and non-IT workers grew with the age of the workers (figure 19). For workers under the age of 30, the churn for IT workers over the two-year period was 59.5 percent; for non-IT workers, it was 58.3 percent. For those between the ages of 50 and 59, the churn for IT workers was 27.3 percent, compared with 18.7 percent for non-IT workers. For those age 60 and older, the churn for IT workers was 26.7 percent, compared with 12.0 percent for non-IT workers.

Figure 19. Churn in IT* and Other S&E Occupations
Percent of Workers Changing Jobs and/or Employers from
1997 through 1999, by Age



¹⁸² www.sloan.org/programs/edu_careers.shtml#careers.

Keeping Pace with Technology and Business Needs

One challenge IT training providers must meet is keeping pace with technological change in a field of technology characterized by short life cycles. For example, some IT workers who participated in this review said that universities and colleges—particularly public institutions—often have technical curricula, equipment, and software that are out of date. The Virginia Governor’s Commission on Information Technology found that “There are elaborate approval processes that educational institutions must follow in order to create, revise, and/or declare obsolete credit courses and programs. While these processes are intended to ensure effective curricular standards and to meet accreditation requirements, they are the very reason why effecting change in credit offerings is often considered slow by business and industry.”¹⁸⁶

IT education and training providers who participated in this review identified a number of methods they use to keep their programs up to date. These include ongoing faculty training and revision of training materials, employing practicing professionals as faculty, and requiring teachers to have strong ties to current practices. Some training programs use advisory boards or committees; survey, poll, or otherwise communicate regularly with employers; or contract out to external vendors. One provider indicated that, since it creates noncredit courses, it does not have to wait for faculty committee approval, which can be time-consuming. Another school offers a base set of courses, with technical electives that can be quickly changed to meet changing needs. The Virginia Governor’s Commission on Information Technology found that “There are few, if any, academic restrictions placed on noncredit training and courses, and programs to meet the needs of business and industry can be highly responsive in terms of timeliness and specific objectives.”¹⁸⁷

A problem for IT education and training providers is getting and keeping instructors skilled in the latest or “hot” technologies who can teach these skills to students. Schools have had difficulty competing for these instructors against private companies that can pay higher wages.

Helping Graduates Get Jobs

Some IT education and training providers offer placement services for their graduates. These services include resume development, developing interviewing skills, workshops on leadership and lifetime learning skills, employment expos, and hosting job recruiters.

¹⁸³ www.sloan.org/programs/historystatus.shtml.

¹⁸⁴ Investing in the Future, September 1999.

Summary

Overall, the IT education and training landscape is rich and diverse, with a wide range of offerings for those who wish to:

- train to enter the IT field as new workers or career changers;
- update, expand, or deepen their skill sets;
- move into a new IT discipline; or
- prepare for career advancement.

Many of these programs could prepare workers who have good academic skills for entry-level IT positions. However, higher level, more advanced IT jobs are not typically accessible to workers who do not possess at least a four-year degree, often a technical degree, which can require many years of education and training. For example, in a study of Virginia's Information Technology Workforce, participants saw short-term certification programs as an effective training vehicle for some lower level IT positions. For mid- to high-level positions, however, such training was not considered to be sufficient for developing the combination of knowledge, skills, and abilities needed to perform the job duties.¹⁸⁸ **Programs that help current IT workers acquire new skills are vital not only for keeping IT workers viable in the labor market but also for enabling them to expand the scope of their skills and qualify for a broader range of job openings.**

For all its great richness and diversity, the IT education and training landscape is confusing and hard to navigate, and little guidance is available. There is wide variability in training program purposes, and wide variability in cost, even among programs that purport to have the same purpose. Given the wide variety of IT training options, students or potential career changers may not have adequate knowledge to choose an appropriate education and training program.

Despite the availability of good training, employers place a higher priority on actual experience in the application of technical skills. Therefore, no matter how good the training a worker has received may be, a worker without practical, hands-on, often paid work experience may not be considered for a job. This underscores the need for training program elements such as work-study and internships, and for **providing training in a hands-on format that teaches technical skills as they would be used on the job.**

Unfortunately, some participants in the Commerce Department roundtables who had worked to develop internship-type programs said they had a hard time convincing employers to participate. Employers often believe that taking on interns takes up too much time

¹⁸⁵ Non-IT workers in the SESTAT database include those employed in non-IT occupations who hold science or engineering degrees and/or science or engineering jobs.

and that they will not receive an adequate return on the training they provide to interns; that is, interns will not seek regular employment with the company after the training and internship are completed. A report from the Washington Software Alliance commented on the challenge of expanding internship programs: “Expansion of these opportunities may be a challenge because younger and small companies often feel that they cannot spare the resource to mentor interns.”¹⁸⁹ Similarly, Northern Virginia Community College launched a fast-track IT program to train career changers for positions in computer programming and networking administration, hoping to be able to place these mid-career employees into internships at local IT firms. The internships the college needed for these mid-career changers either did not materialize or were offered for entry-level positions at about \$10 per hour, and often for jobs that did not apply the software and networking skills program participants had studied.¹⁹⁰

On the other hand, some employers who participate in cooperative work-study programs or develop long-term work relationships with students (i.e., repeated summer jobs) find that these efforts develop student loyalty, help tie the students’ academic work to the company’s needs, and often pay off with the company retaining the students in regular employment after they graduate from college.

IT education and training providers may need to undertake strong efforts to expose employers to their programs to increase employers’ comfort with hiring program graduates who have acquired IT skills through training but do not have job experience in their application. Employer success stories and testimonials could help gain other employers’ attention and raise their confidence and participation in such approaches.

Outside of traditional college degree programs, the bulk of IT education and training offerings appears to be focused in two areas: providing entry-level IT skills and providing current IT workers with specific up-to-date technical skills. With respect to the emphasis on the entry level, it is important to note that the majority of IT job openings today and those projected for the decade ahead are for experienced IT workers or workers who have knowledge and skill levels typically associated with a bachelor’s degree. In fact, the percentage of professional IT workers with at least a bachelor’s degree is high and rising. The Virginia Governor’s Commission on Information Technology noted, “While the education and training providers within the Commonwealth offer many opportunities for existing IT workers to upgrade their skills, and some institutions have targeted the bulk of their efforts at postbaccalaureate retraining programs for existing workers for other fields, the fact remains that the bulk of education and training efforts are directed at potential new entrants to the IT field. This, however, is the category of worker that was reported acceptable for only 20–25 percent of the vacant jobs.”¹⁹¹

¹⁸⁶ Investing in the Future, 1999.

¹⁸⁷ Ibid.



Seattle Roundtable

There are fewer IT training programs designed to train professionals in other fields for transitioning into **the IT profession**. **This is a promising pool of seasoned workers; many already possess at least a bachelor's degree, have job experience, and possess a range of soft and critical thinking skills. However, for these working adults, long and expensive academic IT programs are impractical.** On a cautionary note, career changers need accurate perceptions of what to expect when switching into an IT profession from another occupation. They would likely start their new profession at a lower rung on the career ladder than from whence they came, and they may have to take a pay cut. The experience of Northern Virginia Community College's fast-track program for career changers, described above, is illustrative. Also, career changers, too, face employers' preference for workers with actual job experience in applying technical skills.

For those contemplating entering the IT field or developing training initiatives designed to increase the pool of IT workers in a region, it is important to note that the IT field is demanding in terms of knowledge and skill. A high level of basic knowledge and skill is required, along with a range of soft skills, thinking skills, and technical skills. In addition, regardless of their training, some people appear to have a greater aptitude for IT than others, and some enjoy it more. For example, one high-tech company recruiting for openings in an internship program received approximately 300 applications. After initial screening and testing in mathematics aptitude, reasoning, and spatial-relations skills, only 30 applicants passed; half of those were admitted into the 10-week training program.¹⁹² **Applicant screening and assessment, such as that carried out in the MIST and NETT Consortium programs, can help identify candidates who have not only the knowledge and skill needed to participate in IT training but the aptitude to thrive in the field as well.**

Among IT workers who participated in this review, there was a strong belief that completing a four-year college degree program—especially a technical degree program—and vendor certification programs offered skills that were immediately marketable for obtaining an IT job.

In terms of long-term success in the IT field, many IT workers strongly believed that a four-year degree—especially a technical degree—was important. The IT workers also cited on-the-job training and experience as important, although as a group they pointed to a wide range of education and training models that contributed to long-term career success, including graduate programs, vendor certification programs, short courses, self-study, and private IT training schools. A number of IT workers specifically cited learning soft skills and business skills as being important to career advancement, a view shared by many employers.

Having participated in various models of IT education and training and assessed their usefulness in practice, IT workers participating in this review offered their observations:

- **They commented that traditional four-year technical degree programs produce well-rounded IT workers and that the rigor and duration of these programs ensure lasting knowledge. On the other hand, traditional four-year technical degree programs offer less in terms of hands-on practical experience and do not typically provide business-related skills or link the learning to solving specific business problems. In addition, some programs at universities may be out of date or unable to match the speed of change in IT.** One IT worker commented on a master's program he was attending and later dropped because of the lack of contribution he felt it would make to his career: "This was a very well-known university. The people who were teaching the course were tenured and teaching computer courses based on programming languages from eight years ago." IT workers also commented that faculty don't typically work outside the education institution and, as a result, are disconnected from the real-world IT environment.

Some employer representatives made similar observations. One commented, "Kids [who] get into college today, they've already been on the computer five to seven years and know more about programming than any of us did after five years in the industry. So by the time they get out of college, one would hope that they have a better, broader skill set, but they don't because the colleges...don't focus on teaching the young people the type of skills for information systems, enterprise activity, and so forth. It's more still to the basics of application design and base programming..." Another employer representative said, "My point is that there's even a disconnect at the schools like the University of X, where you may have a mathematician teaching an engineering course, but now you're dealing with information technology, change management, or supply chain. They don't even know what it is." **In addition, the highly specialized and fragmented nature of IT labor demand makes it more difficult to link IT education and training programs to employer needs than would be the case if the demand for skills was more homogenous in nature.**

The ability to keep IT programs in higher education institutions up to date and responsive to employer needs is a concern. One participant in the review commented, “We have tried extensively at the Workforce Committee at the council to develop working relationships with our higher learning institutions across the region, and we have been very unsuccessful in making them understand the business model of ‘get it done now and not 18 months from now,’ and they can’t seem to get it. We tried to develop partnerships, relationships, dialogues, education summits...and they just don’t move at the speed that these folks need to move.”

- **Programs at community colleges are viewed by many IT workers as having good value, offering practical knowledge and skills, and offering easy access. Some IT workers said, however, that some programs at community colleges were too simple, did not deal adequately with soft skills, and teachers may not be up to date on the newest technologies.**
- **IT workers commented that programs at private IT schools often used the latest technologies and had industry instructors with current experience, but the programs were very expensive.**
- **Vendor training, boot camps, and seminars were said to be intensive, current, in step with industry directions, and time-effective. Some IT workers said that vendor certification programs were often too focused on test preparation and spend inadequate time on teaching how to use the technology to address real-world scenarios, such as integrating the vendor’s technologies with other IT products. Teachers in these programs were typically up to date and had often worked in the industrial setting, but sometimes lacked pedagogical skills. These programs were said to be very expensive.**
- **The absence of soft skills instruction—in areas such as communications, teamwork, and interpersonal relations—is viewed by many employers and IT workers as a weakness of many IT education and training programs.**
- **Most IT workers said they were not familiar with federally supported IT training programs or that they were not eligible to participate in them.** Some workers expressed frustration about being ineligible for federal training support, even if they were currently dislocated. **In addition, some desirable IT training does not qualify for federal support because of its cost or length.** Also cited was a bias in favor of training people for alternate occupations for which there is immediate demand, rather than supporting high-tech training during a downturn in the industry so that workers will be prepared when the industry turns around. As one IT worker put it, “So sometimes, unfortunately, it’s easier for a laid-off American worker to get funding to go to truck-driving school than it is for highly trained, experienced workers to get money to keep their IT skills up.”
- **IT workers who responded to our request for comments showed a strong preference for on-the-job training, often under the tutelage of an experienced mentor, and**

self-study. Employers see value in this too, as one commented at a roundtable on the most efficient way that people learn: “It’s hands-on. It’s apprenticeship. You know, it’s internship. It’s relationship. It’s getting the conglomerate of skills through experience so you’re using the technical skill while you’re learning the team skill, while you’re learning, viewing somebody exhibiting leadership skills.”

While IT workers show strong preference for on-the-job training, they named a number of characteristics they desire in formal IT education and training:

- **not cramming too much knowledge in too little time;**
- **programs that are hands on;**
- **trainers who are up to date, with real-world experience—those who have applied what they are teaching in an industrial setting.** As an IT worker who participated in one of the Commerce Department roundtables commented, “ What I see as far as training is, when I went to Chubb, I went at night, working full time, and teachers at night were better because they were practitioners.”
- **a focus on teaching in the context of a project or solving a business problem, rather than teaching in the context of the IT tool itself (figure 20); and**
- **being able to put skills to work soon after they are learned. If they don’t use the skills, they forget them.**

Figure 20. Focusing on the Business Problem Instead of the Tool

“They focus on how to use a given tool, not on how to solve a business problem. Too many times, I’ve been in meetings where somebody says, ‘We have a problem.’ Immediately, the DB [database] guy says, ‘I can solve that with a database’; the programmer says, ‘Nah, we need a program’; the Windows guy says, ‘No, a simple Word for Windows macro will do the job.’ So then they start in with whatever solution method is picked, but they haven’t taken the time to understand the requirements or how this thing fits into the broader picture. A lot of sysadmin (systems administrator) tasks actually overlap with security, facilities, finance, operations, marketing, sales; yet sysadmins haven’t a clue about how these functions work. Ever see a marketing guy and a sysadmin sit down to lunch together? Neither have I. Well, actually, I did once, but it wasn’t pretty. Anyway, most sysadmins won’t talk to the marketing people and vice versa. Which is too bad. I went to school in the late 1970s, and on the way to getting my BS in physics, Harvey Mudd College required that I take an economics class. It’s funny: If you don’t sell something, then you’ll starve. It doesn’t matter how wonderful your something is, if it doesn’t sell, you have nothing! This lesson is not found in ANY technical training I am aware of.”

“The course I took in C++ Programming was like teaching someone to copy a book word for word and call it a masterpiece. I didn’t really learn anything deep about programming and can’t call myself a programmer because it didn’t teach a ‘cycle of creation’ as I call it. But with the programming course, it was literally ‘Type this, type that—see!—you made a program!’ Copying something isn’t the same thing as learning how to do it yourself. I could copy *War and Peace*, but it won’t make me Leo Tolstoy. I think it would have been more valuable to teach to a project. In other words, formulate a project and have the people work as a team to solve the various challenges and teach the problem solving process. Learning C++ would be secondary to learning how to program.”

SOURCE: Department of Commerce online survey responses

IV. ROLE OF EMPLOYERS AND WORKERS IN MEETING THE DEMAND FOR IT SKILLS

The rapid rate of technical change in information technology and the continual introduction of new information technology products create shifts in the IT skill mix in demand. Old IT skills become obsolete, demand for certain IT skills can spread widely and rapidly, and new skill demands routinely hit IT labor markets. As a result of this rapidly changing environment, IT workers must frequently update their technical skills. In addition, IT workers often seek training to broaden their portfolio of technical skills to support moves into other IT disciplines or to advance in their careers.

Both employers and IT workers play a role in meeting these demands. Many employers offer assistance to IT workers who wish to expand their education or technical skills. Some employers also make large investments in national and community technical education and training initiatives. Nevertheless, IT workers take substantial responsibility for their own education and technical skills training.

Employer Role in IT Education and Training

Making or Buying Skills. Employers can obtain the skilled IT workers they need by either hiring workers who already have the needed skills or training workers in those skills. However, as time has become an increasingly important competitive factor for many employers of IT workers, the time available to retrain existing employees or train new employees in the skills needed for new projects or job openings has diminished. In this environment, many companies have concluded that they cannot afford the time, risk, and uncertainty associated with “making” the employees they need through training or retraining. Instead, companies often seek employees who already possess the needed skills and can “hit the ground running.”¹⁸³ A Computing Research Association study highlights this practice: “The high level of competition and the short product life and product development time often make it difficult for companies to hire new employees who require a lengthy period of break-in training before they can become productive. It also makes it difficult to retrain an existing employee for a significantly different job. Thus, competitive pressures sometimes force companies to lay off workers of one type and hire workers of another type. Or they may refuse to hire anyone who does not already possess all the needed skills.”¹⁹⁴

¹⁸⁸ A Study of Virginia’s Information Technology Workforce, prepared by Caliber Associates for the Center for Innovative Technology, August 23, 1999.

¹⁸⁹ Findings of the 2000–2001 Workforce Study, WSA.

These pressures can be especially challenging for smaller firms. The Virginia Governor's Commission on Information Technology found that "The risk mitigation factor especially shows up in smaller companies or smaller divisions or satellite offices of larger companies. In these smaller venues, hiring managers perceive that there is greater risk associated with an individual not being able to hit the ground running and successfully perform his or her duties, because there are far fewer people available to pick up the slack....They would rather procure the specific expertise they need as they need it, and many are convinced that they cannot afford to do otherwise."¹⁹⁵ A Computing Research Association study adds, "Some companies, especially small ones, have trouble affording the costs of carrying a less-than-fully productive employee for six months or a year, much less having the responsibility as well for providing the basic occupational skill training."¹⁹⁶ Small firms may even lack the capacity to provide training. One Commerce Department roundtable participant characterized the dilemma faced by small firms: "There are almost 3,300 software and Internet companies in Massachusetts, and 70 percent of them have 25 or fewer employees. So in terms of training programs, most of these companies don't have an HR person, let alone someone who can just do training."

A West Coast employer spoke about the experiences of start-up companies, "I mean most of the start-ups I've ever been exposed to don't have the money and really don't have the resources to draw from [for training]." Another roundtable participant reinforced this point, "And then the start-ups...are cash-constrained because the VCs [venture capitalists] are funding them or their investors are asking how fast the product's going to get out and the time to market. Is somebody else going to leap ahead of us? It [training] is all the employee's burden, frankly." This commenter reported that the large, more prominent high-tech companies are better able to make investments in developing the skills of their IT workers.

Many employers of IT workers are pursuing a "buy" strategy, seeking the exact skills and experience they need for a particular project or job opening. While buying skills on the open market can require paying a premium for them, companies are often able to access the most current skills and get a fully trained worker, while reducing or even eliminating the cost of training.

Buying skills can also increase staff flexibility and reduce risks associated with uncertainty about future skill needs. As one employer representative explained, "An IS worker will come in. We have this new system we need to have upgrades done on. You're going to come in, you're going to do this job whether it takes you a month, three months, six months, whatever the case may be. You come in, you do the job. The job is done. You're done with your duty here at Company A."

A study of Virginia's technology workforce found that government contractors are more likely than commercial businesses to procure employees as needed to meet the education and experi-

¹⁹⁰ Peter Behr, NOVA Tech Trainees' Job Hopes Fade, *Washington Post*, July 16, 1999.

¹⁹¹ Investing in the Future, September 1, 1999.

ence requirements of particular contracts. Contractors are also more likely to follow a “buy” strategy, because they are unable to bill clients for trainees that do not meet these requirements.¹⁹⁷ At one of the Commerce Department roundtables, an employer representative spoke to this issue: “...we had the luxury at that time of having 20 individuals or so who were completely underutilized and, you know, not billing on an engagement, and could do some of that training. And we’d shift those individuals into the billable seats and the others out and do some of that training to get at it in that regard. Well, you know, as a result of the way the economy has gone, we’ve seen a dramatic shift in that, and what we’re facing is we don’t have those 20 people on the bench any longer.”

There is some evidence to suggest that, when faced with difficulties in finding workers with needed skills, training is not a high priority as a coping strategy. In a survey of companies in Washington state, employers showed greater preference for employing local contractors, increasing staff hours or productivity, employing out-of-state contractors, subcontracting tasks to other firms, and bringing in foreign workers on visas than for training their employees. Only outsourcing offshore and employing contractors offshore were less popular coping strategies than “customized training.”¹⁹⁸ Similarly, in a survey of IT hiring managers, those surveyed showed greater preference for outsourcing, using existing employees, hiring temporary employees, and running an ad than they did for hiring without the needed skill and providing training. Only reviewing applications on file was less popular than training as a skills-gap coping strategy.¹⁹⁹ However, survey data are mixed in some areas. A survey of CIOs by CompTIA showed that 65 percent of respondents had resorted to training their own staff to fill open IT positions, the second most preferred strategy reported. Among the CIOs, working with government programs as a specific strategy to fill open IT positions was rated dead last, although human resource officials viewed government programs more favorably.²⁰⁰

There are risks associated with pursuing a “buy” strategy. It can take significant time to seek, recruit, and hire candidates with the exact skills and experiences needed. Moreover, compared to current employees who possibly could be trained, outside hires lack important company-specific knowledge and may be less committed and loyal to the employer.

The Decision to Invest in Incumbent IT Worker Training. As with other investments, companies invest in training because they expect returns in the form of improved performance or greater worker retention. However, tight labor markets can increase the risk of training investments and reduce the likelihood of capturing an acceptable return.

¹⁹² NOVA Tech Trainees’ Job Hopes Fade, July 16, 1999.

¹⁹³ The Digital Work Force: Building Infotech Skills at the Speed of Innovation, U.S. Department of Commerce, Office of Technology Policy, June 1999; A Study of Virginia’s Information Technology Workforce, August 23, 1999.

¹⁹⁴ The Supply of Information Technology Workers in the United States, 1999.

Investment in knowledge and skills—intangible assets—represents a higher level of risk than investment in tangible assets such as facilities and equipment, since these intangible assets can move easily. The tight IT labor market of recent years—a function of both growth in the demand for IT professionals and the need to fill specific niches—has created an environment in which many companies seek to hire the people they need by luring talented IT workers away from their current employers using a variety of mechanisms. These inducements (compensation, benefits, and better working life conditions) encourage job-hopping among IT workers, creating a disincentive for companies to train or retrain workers. Companies that invest in the training of employees to upgrade their IT skills may create attractive targets for poaching by other companies, putting at risk both the employees and the companies' training investment. In addition, some IT workers practice frequent job changing as a means for advancement and for broadening their skills.

Employers at Commerce Department roundtables described the problem: "...we would hire kids off the college campuses, or even from a high school environment. They'd come to work for us for nine months, and nine months later they'd be going down the street to the next better bidder, frankly." Another employer reported that "...a certain percentage of people, we train, and they go out and get other jobs, and that's really painful for small companies...."

Factors that may be considered in a company's willingness to invest in training an IT employee include company skill needs, the need to offer benefits to attract and retain employees, and employees' career goals and talent. In terms of paying for employee training, companies appear more willing to support training that dovetails with their short- to mid-term needs; for example, training for needed technical skills or teaching business skills to promising IT workers. While this creates opportunities for training and job progression that benefit the company, it may not constitute the career development sought by the employee.²⁰¹ Many companies require an IT worker's manager to approve the training before the employee will be supported in this endeavor.

Several employers reported that they look more favorably on making investments in training for "high-pots"—employees identified as having high potential. At one roundtable, an employer representative said that her publishing and media company has a program for high-potential IT workers that involves two years of rotation through the company's various business segments. This program is designed to give potential managers a broader perspective. An Internet-based financial services company that participated in a Commerce Department roundtable had a similar effort for recent college graduates: "So what we've provided for them is a training program that extends a little over three months that exposes them not only to more of the IT from our architecture, but to every single group within our organization: quality, network, operations, you know, software...train them with keeping a bigger-picture perspective of the organization and how their job fits in." High-pots can also be tapped when new opportunities arise within the organization. As one government employer representative reported, "If something new comes along, information assurance is such a big thing now. When

¹⁹⁵ Investing in the Future, September 1999.

Nurturing Potential IT Talent: Internships and Work-Study Programs

The reluctance to invest in training can extend to participation in internship programs. As one participant in a Commerce Department roundtable commented, with respect to smaller and mid-sized companies, “The responses I have gotten to intern programs...is they don’t have the time or the money for that. They must have experienced staff to come in to build that product.” A participant from a local technology and business center working to develop interest in technical careers for kids indicated that while the business community does provide short-term career experience opportunities—for example, participating in job shadowing day—technical students at the high school and community college level have a great deal of difficulty getting more in-depth exposure to the industry and to high-tech careers through summer jobs and internships. An employer representative commented, “It’s very hard to convince managers and employees to take on even an intern for a few weeks, because it really costs them time. And I have trouble answering, what’s in it for us? Yeah, corporate citizenship stuff, but in a market-driven world...it is a hard sell.” Other participants described similar difficulties in getting internship programs to work. For employers who do business with the Federal Government, another barrier to taking on interns or IT trainees was that they are not billable on a federal contract.

Nevertheless, some employers who participated in Commerce Department roundtables did hire interns and reported that keeping a continuing relationship going with a student, summer after summer, through high school and college raises the likelihood of contributing to the development of a skilled and experienced worker whom the sponsoring company has a good opportunity to hire once the student completes his or her formal education. One employer reported, “You find greater loyalty, definitely...not only [among] the long-term interns but [among students in the] co-op programs—because their academic studies are tied to the work they are doing. We have a tremendous 88 percent retention rate of those folks who have more than two internship rotations or two co-op rotations with us.” One roundtable participant suggested a model: “What we would like to see is a type of pipeline developed with companies in the area, and with the universities, so that students develop an internship, say, maybe in their senior year of high school, and some type of program where students know they are going to have an ongoing relationship with a company as they proceed through community college, as they build on their education, as well as their technical skills, and get the experience, so that they stay with that company for several years until they finish their bachelor’s degree.”

A representative from the U.S. Department of Defense [DOD] who participated in one of the Commerce Department roundtables described a program for nurturing future employees in information security—an Information Assurance (IA) scholarship program. “We’re picking up students in the second and third years in the schools. And we’re having them come into the Department of Defense on training programs in the summer...We’re monitoring their grades, we’re providing grants to the colleges saying we want you to build up the infrastructure in the IA areas. We want you to provide training to your faculty members. Then we go out and inspect these colleges...While we pay for [students’] college degrees, they have to sign [an agreement] with DOD stating that they will work one year for every year of college that we pay. So it’s a win-win situation. They’re getting their college paid for, they’re getting experience on the job during the summer, they’re coming in and getting a job starting at the GS-7 or GS-9 level...We’re getting people who can come in and run and deal with the things we need right now.” The Department of Agriculture has a similar effort with the Land Grant Universities and the Historically Black Colleges and Universities, involving both college tuition support and summer employment. The Agriculture Department’s representative commented, “You know, they’re part of the family right from the beginning.”

we were trying to create positions within our information technology over at [Federal Agency A], we looked at the people who were on board and who had showed potential in other areas or were a quick study or a good study and could probably take it on. So then you train them.”

Another employer representative explained that his company’s Leadership Development Program, aimed at high-potential employees, will support employees in getting a degree or certification, but employee participants must sign a contract or an agreement to stay with the organization for a certain length of time. Another employer required employees who left the company after being reimbursed for education and training to pay back the investment on a prorated basis.

In addition to considering the value of investments in training, employers also have to weigh these investments against other needs and opportunities. As one employer explained, “When you look at the least affluent, smallest hospital and they’ve got a dollar to spend, do they spend that dollar on patient care, taking care of a sick person in the bed, or do they spend that dollar on getting their IT person better prepared to deal with something that’s going to happen next year? It’s not even a second thought. It’s going to go to patient care.”

Return on investment is an issue that also concerns public and private investments in training designed to support overall economic development in a region. At one roundtable, participants expressed concerns that, with the economic downturn and fewer jobs available in their region, the students whose education had been supported by the region’s public and private dollars would seek jobs outside the region. The region would lose on two counts. First, it would lose its investment and any chance to gain a return on that investment. And second, it would not have those skilled workers when the regional economy rebounded and job openings were generated. As one roundtable participant put it, “So we lose on both ends. We can’t have the workers, and we really spent a lot of money and time on these students.”

Employer Support for Training: Financial, Time, and Training Resources.

Employers can contribute to IT workforce training by providing financial support to pay the costs of training, allowing workers to participate in training on company time, and providing training resources. However, employers’ ability or willingness to provide these varies.

Among IT workers who provided comments for this review, many had received support for training from their employers, such as partial financial support or time off for training. But a significant number of workers said that their employers did not provide support. Surveys indicate a similar mix:

- For example, in the 2002 salary survey by *Microsoft Certified Professional Magazine*, among 6,000 Microsoft Certified Professionals, 58 percent reported that they received training as a benefit of employment. In the same survey, 50 percent of respondents indicated that the company paid for their certification training, 39 percent paid for it themselves, and 11 percent shared the costs with their employers.²⁰²
- In Prometric’s 2001 Training and Certification Study,²⁰³ 53 percent of responding IT managers had allocated budgets for employee training. Among those who had a budget for employee training, 60 percent spent less than \$5,000 per employee annually, and 40 percent budgeted more. Among those managers who responded that there was no budget allotment, 77 percent reported spending less than \$5,000 annually per employee on training, with 58 percent spending \$2,500 or less. Similarly, in a survey of CIOs and

¹⁹⁶ The Supply of Information Technology Workers in the United States, 1999.

¹⁹⁷ A Study of Virginia’s Information Technology Workforce, August 23, 1999.

human resource professionals, about one-quarter to nearly one-third of respondents said that they did not have any budget for IT training.²⁰⁴

- In a techies.com Web-based survey, 39 percent of respondents indicated that their employer pays for training or reimburses their training costs, while 56 percent said that they pay for their own training.²⁰⁵ In another techies.com survey, 44 percent of respondents said they received no tuition reimbursement from their employer, 24 percent received more than \$3,000, and 32 percent received less.²⁰⁶ In a techies.com survey of 1,400 IT workers, more than two-thirds said their companies encourage training, and 64 percent said their employers offered tuition reimbursement for continued education. However, only a quarter of respondents said that they had taken advantage of the tuition reimbursement.²⁰⁷
- In a survey of Washington state software and Internet companies,²⁰⁸ 94 percent of responding companies indicated that they have a tuition reimbursement policy. Twenty percent said they always make this policy available to workers, while three-quarters said they make the policy available under certain circumstances. (Some tuition reimbursement plans cover only education and training programs that lead to a degree. However, many IT training programs are not offered for degree, or those pursuing the training—even within programs that offer credit toward degrees—are not pursuing a degree.)
- In the same survey of Washington state software and Internet companies, the median limit on total tuition reimbursements was in the range of \$500–\$1,000, an amount that is significantly lower than the cost of many IT training opportunities, such as training for certification, an IT certificate, or an intensive boot camp program. Overall, the Washington Software Alliance report indicated that there were 61,000 workers in Washington state’s software and Internet industries, and that the industry spent roughly \$2.5 million annually on initial and ongoing training. That is an average of about \$40 per employee.

Allowing workers to train on company time is another way employers support training. However, for some organizations, little time is available for training. In fast-growth IT companies, often every professional IT worker is deployed on current projects, leaving none available for retraining. As one West Coast Internet-based company representative who participated in a Commerce Department roundtable put it, “I came from [Company B], and we had over 400 training courses that people could take. They had an entire building dedicated to training. And we required that every employee take 40 hours of training. But it was the shortsightedness

¹⁹⁸ Findings of the 2000–2001 Workforce Study, WSA.

¹⁹⁹ Bouncing Back: Job Skills and the Continuing Demand for IT Workers, Information Technology Association of America, May 2002.

²⁰⁰ The Ongoing Crisis in IT Management, A Research Report Prepared for CompTIA, August 2001.

²⁰¹ John Kador, Learning to Stick a Landing, Job Jumpers: Coming Down, CNN.com Career, April 25, 2001.

²⁰² www.mcpmag.com/salariesurveys, August 2002.

of ‘Oh, I have a class tomorrow.’ ‘Oh, I’ve got this project,’ or the manager comes in and says, “Can you do it next time it’s offered?” A senior Federal Government IT manager described a similar situation: “In our case, often it’s just that employees are already stretched so thin doing their job that even though they want to take the training, their boss wants them to take the training, [and] we’ve got the money to let them take the training, you can’t pry them away from the people they’re supporting to let them go take the training.” As a National Research Council report on IT workers states:

“The most precious kind of support from employers is release time from the job to take training so that the worker does not have to take the time “out of hide.” Such support is rare compared to the support employers provide for tuition reimbursement and the like. For workers under the pressure of small and impending market windows, or other tight project-delivery deadlines, time for training is at a high premium—and since training does not contribute immediately to product delivery, training is not practical during these periods.”²⁰⁹

Because of these cost and time constraints, a number of employers and employees who participated in the Commerce Department review indicated that, increasingly, workers are responsible for their own skill development—often on their own time, sometimes at their own expense—as well as for their own overall career development. As an employer representative at a roundtable commented, “...the employee is going to be responsible for their own development. We as the employer will continue to have our performance contract with you, but we no longer have a development contract with you. That is your responsibility.” Another employer representative commented, “...training is now so self-directed. I mean, if you have people who are not willing to put forth that energy on their own, they are out of luck. I can remember a time in our organization (you might remember this) when your manager was responsible for your training. Well, gone are those days. You are responsible for your career.... We’ll give you tools, etc., but you are responsible to do that. Much of training is moving to the Web; about 80 percent of it is there. But that means you take the time to do it, because there’s not enough time to send you to class in all cases and send you away for several days.”

Other employers reported that their companies were adopting similar approaches. For example, another employer representative said, “We are making these resources available. You need to take responsibility for your own career and use them and—you know what?—we are paying for it. We expect you to spend some of your own time to improve your skills.” Another employer representative followed up with, “As long as you can get it in three hours, they’ll let you off to do it. But if it takes longer than that, then you need to be self-directed....”

While many of the employer representatives participating in this review pointed to the need for employees to take responsibility for training themselves, and to do so on their own time, some employers expressed willingness to reimburse workers for that training.

²⁰³ 2001 Training and Certification Study, Prometric, 2001.

IT workers are recognizing this need to take responsibility for their own education and training. One IT worker who participated in a Commerce Department roundtable commented, “The employee is now more responsible than ever before for their own self-directed training and education to prepare themselves.”

Another employer representative outlined the range of training opportunities offered on company time and on the employee’s time: “...if [the training] requires going during the day, they do it during the day. If they can do it at night, they do it at night. But we also have brown-bag lunches where our practice managers—like Oracle practice, Microsoft practice—will conduct training sessions. We also, on Saturdays, have a four-hour training session on different skills that would be required to work on the programs, and our people come to it.”

Many employers believe creating training opportunities for their IT workers is important for recruitment, retention, and high-quality work. Periodically, *Computerworld* identifies “Best Places to Work” for IT workers. In recent compilations, companies that made the grade had adopted a range of education, training, and career development practices, including the following:

- establishing internal IT “universities” offering a wide range of training,
- tapping outside training companies for classroom-based certification training,
- offering vendor-provided training onsite,
- maintaining relationships with local colleges to customize course offerings,
- offering Internet-based learning,
- tying training goals to employee reviews and performance measurement,
- holding managers accountable for annual training goals,
- offering online skill assessments,
- tracking training metrics,
- maintaining a staff of IT instructors and instructional designers,
- planning annually for skills and training needs,
- establishing programs to train promising IT workers for management positions, and
- offering training cost reimbursement.

Among the 2002 “Best Places to Work” in IT, the companies had spent an average of \$3,888 per IT employee on training during the past year, and IT employees averaged 9.4 days of professional development on company time.²¹⁰ One IT worker at a Commerce Department roundtable explained how one employer—a large defense contractor—included the cost of training in its

²⁰⁴ The Ongoing Crisis in IT Management, August 2001.

contract with the government and, as a result, there was a lot of training to bring people up to speed on the skills needed for the contract.

Generally, companies train IT workers in three areas: technical skills, soft skills (such as effective meetings and conflict resolution), and IT management-related skills (such as strategic management, business processes, project management, and leadership).²¹¹ Some companies also operate training programs to develop non-IT workers and turn them into IT professionals for the company. At a Commerce Department roundtable, a manager of IT training and development described such a program at a large retail chain:

“We have programs for existing employees who are not in IT at the moment but want to be. And so we’ll screen them for aptitude. And then if they pass that test and they have sufficient desire and, you know, they’re demonstrating analytical ability, that kind of stuff, then we will train them. And that’s an intensive but not quick process. We immerse them in technology, but we don’t expect, you know, like a boot camp scenario. We don’t expect that after six weeks they’re going to emerge ready to enter IT. But we provide them with a lot of resources. They provide the time. They haven’t transferred yet out of their old job....There are certain [career] portals in IT, and they can pick one of those. They can prepare for it. When they feel they’re ready, they can apply and compete with somebody from the outside.”

Similar employer programs at large financial institutions are described in figure 21.

Figure 21. Employer Programs to “Grow Your Own” IT Workers

Freddie Mac Career Transition Program: Freddie Mac, which provides a secondary market for mortgage loans, is rated by *Computerworld* magazine as one of the “100 Best Places to Work in IT.”²¹² Freddie Mac purchases mortgages from lenders across the country and packages them into securities that can be sold to investors.

Freddie Mac is an intensive user of information technology to reduce the time and cost of obtaining mortgage loans, for managing their portfolio of mortgages, and for packaging and offering mortgages for sale in the U.S. and international capital markets. Freddie Mac employs approximately 900 IT workers and consultants, representing more than a quarter of its total workforce. The IT consultants provide a buffer for fluctuations in the labor market and workload, so that during times of less need the company does not have to release employees.

Freddie Mac employs a wide variety of IT workers. In its IT development area, the company employs software developers, analysts, and project managers; in its operations group, it employs database administrators, systems programmers, network operators, and customer support specialists. The skill levels of Freddie Mac’s IT workforce vary from Ph.D. modelers to help desk workers.

To meet its IT workforce requirements, Freddie Mac hires experienced workers from outside the company, recruits recent college graduates with computer science and management information science (MIS) degrees, and has recently implemented a Career Transition Program (CTP) for Freddie Mac employees who are interested in making a change from their current occupation into IT. Career transition candidates come from a wide variety of occupations, including legal, human resources, accounting, finance, administration, and customer service.

²⁰⁵ Who Buys Training for You? www.techies.com/Main/WeeklyPollResults_m.jsp?QuestionID=1500075.

²⁰⁶ How Much Tuition Reimbursement Does Your Employer Offer per Year? www.techies.com/Main/WeeklyPollResults_m.jsp?QuestionID=1500067.

Figure 21. Employer Programs to “Grow Your Own” IT Workers, continued

The company reports that employees in CTP are “hungrier”—that they are highly motivated and work harder. They tend to be high performers who have earned high salaries and respect in their fields. For these workers, participating in this program can be a risky career move. In the transition they move to fields where they do not enjoy their previous level of expertise/prestige; they may take a salary cut; and they lose their place in the organization. Those seeking to transition to IT careers do so for a variety of reasons. For some, a career in IT offers higher salary potential. For others, it offers greater job stability. Some have seen their functions being automated by IT and want to “be on the right end of change.” Rather than watching their usefulness erode, they want to be on the creating/transformation end of the business. Others see it as a career progression move. Still others, in the midst of the dot-com phenomenon—especially prevalent in Northern Virginia, where Freddie Mac is based—were moved by peer pressure to seek careers in IT. The company also has used the program to ease the pain of merging divisions, giving priority consideration in the program to employees with redundant jobs.

In its CTP, Freddie Mac seeks candidates who are team players, with strong collaborative and communications skills. The company screens and assesses candidates for the program using several tools, including Wolfe-Spence Programming Aptitude Test (WSPAT)—a diagnostic instrument for selecting computer programmers—to assess logic, ability to follow simple instructions, accuracy, and ability to interpret simple specifications. In addition, Freddie Mac uses a personal interview to assess soft skills.

Sixteen candidates are selected for each CTP class. Participant training begins with 11 weeks of technical instruction, provided under contract by Lockheed-Martin, in areas such as design, analysis, and programming (especially object-oriented programming and JavaScript).

After completing the technical training, CTP participants undergo two to four weeks of inhouse training in soft skills, including leadership, project management, and diversity, as well as an orientation to Freddie Mac’s IT division. Following this training, CTP participants are paired with mentors for further development through on-the-job training.

CTP participants are paid their previous salary while they are in the program. Six months into the program, participants undergo a performance review. At this point, participants may see an increase or decrease in salary based on their performance and their previous salary.

In the first two classes of the Career Transition Program, no one dropped out. Nor had anyone who received the training left Freddie Mac. While there is no prohibition against leaving the company, those who leave within 12 months of training must repay Freddie Mac for the costs associated with the training provided under contract by Lockheed-Martin (approximately \$11,000). The total cost of training per participant is about \$30,000. Freddie Mac offers a \$1,000 bonus to each participant if all class members complete the program.

Views about the value of CTP vary in the company. On the one hand, the CTP participants have hands-on experience in the business operations of the company and understand how things really work. They have a strong appreciation for the value of IT tools in helping the company achieve its business goals. With their familiarity with and understanding of Freddie Mac business processes and challenges, the less technically complex nature of object-oriented programming enables CTP graduates to create timely, practical solutions to business problems or to take advantage of emerging business opportunities. In contrast, while recent college graduates in computer science and information management systems may have a deeper knowledge of information technology, they often lack a fundamental understanding of how the technology can be applied to address real-world business operations, especially those that are unique to Freddie Mac and the secondary mortgage market.

On the other hand, some managers at Freddie Mac have expressed concerns that CTP participants could be a potential drag on productivity if they are given too many to train and mentor. In addition, the CTP is viewed by some within the company as less valuable in today’s softer IT labor market, especially among managers who often express an interest in hiring IT workers with all the skills and experience required for the job so they can hit the ground running.

www.freddiemac.com

Fannie Mae Business, University, Engineering and Quantitative Systems Technologist Programs:

Fannie Mae, the nation’s largest source of financing for home mortgages, offers several promising models for recruiting and developing highly skilled IT workers. Often included among *Computerworld* magazine’s annual listings of the “100 Best Places to Work in IT,” Fannie Mae jumped to number four on the 2002 list.²¹³

²⁰⁷ Experience=Degree?, March 2001.

Figure 21. Employer Programs to “Grow Your Own” IT Workers, continued

Fannie Mae is a private, shareholder-owned corporation that was congressionally chartered to expand homeownership opportunities by creating innovative financial products and services. Fannie Mae purchases mortgage loans from mortgage lenders—replenishing those institutions’ supply of mortgage funds—then either packages these loans into mortgage-backed securities (MBS), which it guarantees for full and timely payment of principal and interest, or purchases the loans for cash and retains the mortgages in its portfolio. Fannie Mae is one of the largest financial services corporations in the world and an IT-intensive company. Fannie Mae has approximately 1,400 IT employees (accounting for approximately one-third of the company’s total employees), as well as several hundred contract IT workers. This workforce, which performs a variety of IT functions, is composed of project managers, software developers, programmers, network engineers, systems analysts, systems administrators, database administrators, and technical risk specialists. While the skill levels of the workforce cut across the entire range, the overall skill level is skewed toward the upper end. Among the skills in particular demand are Sybase, Unix, and Java.

Fannie Mae operates three intensive, 36-month programs designed to produce highly skilled IT workers for the unique business and technical requirements of the company: the Business Systems Technologist (BST) program, the University Systems Technologist (UST) program, and the Engineering Systems Technologist (EST) program. A fourth program, the Quantitative Systems Technologist (QST) program, runs 18 months and provides training in IT, finance, and the mortgage industry to employees with graduate degrees in quantitative disciplines. These programs are characterized by selection processes with varying degrees of rigor, a substantial investment in the education of program participants, and an aggressive compensation program designed to retain these workers (see below). Since 1985, Fannie Mae has graduated approximately 680 trainees from these programs. Fannie Mae updates its training about once a year for each class. Input for updating program curricula is gathered from inhouse users.

While Fannie Mae undertakes extensive efforts to “grow” its own IT workers through these programs, a majority of its professional hires are from the outside. Professional hires in IT must complete the company’s core IT curricula within two years of being hired. The company pays for some professional development and offers tuition reimbursement.

Business Technologist Program

Target Candidates. The BST program is directed at attracting candidates with three to five years of work experience and a demonstrated interest in technology. While not required, experience in information technology, business, and/or finance is a plus. Fannie Mae reports that more than half of those selected for the BST program are women and more than half are minorities.

Selection. Fannie Mae attracts approximately 3,000 applicants through advertising for each class of approximately 20 students. Managers and current BSTs review resumes to determine whether candidates meet the minimum requirements. This results in a reduction in the applicant pool to about 500. These candidates are invited to take the Aptitude Assessment Battery Programming (AABP) test and the Bio Data test. The AABP is a five-hour test that evaluates the applicant’s potential to learn IT skills, testing for ability to program in those who do not know programming. The Bio Data test focuses on soft skills, using “what would you do” multiple-choice scenarios. Applicants who successfully complete these tests are invited for face-to-face interviews with managers, technical staff, and current BSTs. This process winnows the candidates down to the final 20. Most BST participants have a bachelor’s degree, some graduate-level education, and between three and six years work experience.

Training. BST is a 36-month program divided into two phases. During the first 18 weeks, participants receive technical classroom training at Fannie Mae’s educational facility, a state-of-the-art client/server environment that uses the latest object-oriented techniques. Inhouse experts provide intensive training in Java, Unix basics, object-oriented analysis and design, Web technologies, and Sybase relational database concepts. Fannie Mae uses training customized for its needs, as well as commercially available programs. After completing this training, participants are assigned to a team within the Corporate Information Services division of the company, where they receive on-the-job training for the balance of the three-year program.

Compensation/Incentives. Participants receive an annual starting salary of \$40,000 (for those with bachelor’s degrees) to \$43,000 (for those with master’s degrees), as well as a benefits package that includes an employee stock purchase plan, 401(k), tuition assistance, onsite fitness/yoga classes, recreation club discounts, company-paid volunteer opportunities, and mentorship programs. Throughout the 36-month program, candidates undergo frequent performance

Figure 21. Employer Programs to “Grow Your Own” IT Workers, continued

reviews (the first review upon completion of the classroom phase, then again every six months) that can boost their salaries to more than \$75,000 by the end of the three-year program. Fannie Mae has experienced significantly lower turnover among BST participants (5 percent) than among its overall IT workforce (20 percent).

Program Cost. The cost to Fannie Mae of operating the BST program—for training, infrastructure, overhead, and the salaries of those managing the program—is approximately \$600,000–800,000 per year.

University Systems Technologist Program

Target Candidates. The University Systems Technologist (UST) program is directed at recent college graduates. UST participants come from a wide variety of academic disciplines, although degrees in information technology, business, or finance are preferred. Approximately half of UST participants have technical degrees in subjects such as computer science, engineering, or management information systems. Fannie Mae recruits strongly at historically black colleges and universities and at universities with large Hispanic populations (such as the University of Texas at Austin and the University of Florida in Miami). As with BST participants, Fannie Mae reports that more than half of those selected for the UST program are women and more than half are minorities. Due to the strong relationship that Fannie Mae has with colleges and universities, recruiting for this program costs less than for the BST program.

Selection. Fannie Mae uses the same selection process for UST as it does for BST, although the class size for UST is somewhat smaller (15–20 participants).

Training. UST candidates undergo the same two-phase training and development program as BST candidates—18 weeks of intensive, hands-on classroom training, followed by assignment to a team in the Corporate Information Systems division, where they receive on-the-job training for the balance of the three-year program.

Compensation/Incentives. Participants receive an annual starting salary of \$35,000. Throughout the three-year program, candidates undergo frequent performance reviews that can boost their salaries to more than \$65,000.

Engineering Systems Technologist Program

Target Candidates. The Engineering Systems Technologist (EST) program is directed at candidates with three to five years of work experience and a demonstrated interest in technology. In addition, a year of technology experience in Unix, Sybase, Oracle, or networking is considered a plus. Most candidates do not have degrees.

Selection. Unlike the BST and UST programs, EST does not use testing as part of its selection process, as company officials believe that there is no valid test to measure potential in this area. Fannie Mae selects candidates for the program using a two-round interview process that includes an in-depth discussion of the candidate’s background. Fannie Mae receives approximately 2,000 applicants for 10–15 slots. Given the less rigorous screening process, this is a riskier program for the company, with higher turnover.

Training. EST is a 36-month program divided into two phases. During the first 18 weeks, EST participants receive intensive training in network concepts, Unix systems administration, and database engineering. Candidates undergo soft skills training as well as training to prepare them for a CNE or CCNA certification, although the company does not require certification. After completing this training, participants are assigned to a team in the Corporate Information Services division, where they put their classroom training to work in challenging assignments for the balance of the program.

Compensation/Incentives. Participants receive an annual starting salary of \$40,000. Throughout the 36-month program, candidates undergo frequent performance reviews that can boost their salaries to more than \$75,000 by the end of the three-year program.

Quantitative Systems Technologist Program

The Quantitative Systems Technologist (QST) program targets those with graduate degrees in mathematics, statistics, physics, economics, and related disciplines. The QST program is an 18-month program, and participants receive a starting salary of \$55,000. They are taught IT skills (Unix, C and C++ programming, Web technology, Java, SAS, and Oracle); finance (valuation, interest rates and term structures, pricing, debt derivative pricing, interest rate modeling, credit/risk, earnings modeling); and the mortgage industry (mortgage finance, structured mortgage products, risk management portfolio). www.fanniemae.com

For IT training, companies increasingly rely on desktop training, provided through CD-ROM or online. While companies still rely heavily on instructor-led training methods, answers by CIOs and human resource professionals in a recent survey suggest that instructor-led training would be scaled back significantly in the future.²¹⁴

One company—a large global provider of information storage systems, software, networks, and services—that provided comments to the Commerce Department described a wide range of employee training opportunities it had developed inhouse and with outside partners:

“EMC offers numerous technical courses inhouse. Our own staff designs many, while others are industry standard, such as Microsoft Certification. EMC University brings together seven technical and professional development training groups to develop and deliver programs. We also partner with local schools and universities to provide courses at our facilities or to offer Web-based training courses and degree programs. These range from Unix operating system courses to Web-based Internet developer degree programs to database administrator or developer course work. Bachelor’s and associate degree programs are offered onsite with New England Institute of Technology. Courses and bachelor’s and advanced degree programs are offered onsite and via satellite with Northeastern University. A tuition reimbursement program pays for successful completion of any job-required or career-related programs taken by employees at accredited colleges and universities.”

EMC University courses are open to all employees. Tuition reimbursement is offered for career-related college programs for individuals wishing to train in a skill that could be used at the company. This employer also maintains relationships with several community colleges and technical high schools. A company representative commented that the strengths of these programs included the ability to deliver classes at the workplace, convenient to employees, and to customize examples and projects to the real working environment. EMC believes that having the programs onsite helps eliminate the barriers associated with time for training. The company also partnered with a local university to design a storage technology course, which is offered as part of the university’s computer science course selection. In a partnership with a community college, the company focused on a course developing skills that were highly desirable at the company. EMC gave the college a server and hired six students as interns, and then offered four full-time jobs. The company also partners with universities in areas such as mentoring students, work-study programs, donating equipment, and funding and directing research programs.

Another employer who responded to the Commerce Department’s request for comments provided information on the company’s corporate university, which provides education and training programs for more than 7,000 employees. This corporate university partners with universities, community colleges, and technical training vendors to offer external programs for technical and professional certifications, degree completions, and advanced degree programs for new hires and current employees. The company also provides inhouse IT learning opportunities

²⁰⁸ Findings of the 2000–2001 Workforce Study, WSA.

The Federal IT Workforce Challenge

The Federal Chief Information Officer (CIO) Council's Workforce and Human Capital for Information Technology Committee and its agency members have addressed the Federal Government's ongoing demand for highly skilled IT workers. Several activities address IT workforce education, training, and career development:

The primary goal of the **Federal Cyber Service (FCS) Scholarship for Service (SFS)** initiative is to pay students for two years of undergraduate or graduate education in an information security program in return for a two-year commitment to government service. Students who participate in the SFS program are evaluated against a set of qualification standards to ensure that they have acquired the competencies necessary to successfully perform information security work. Students also participate in internships at various federal agencies.

The committee champions the use of the **Clinger-Cohen Competencies** by the Federal Government. The competencies help agencies comply with Section 5125(C)(3) of the Clinger-Cohen Act by identifying the baseline competencies that an organization should possess to effectively utilize and manage information technologies. The competencies are widely used by the private sector, public universities, and federal agencies for educational, retention, and recruiting purposes.

Under the **IT Roadmap** initiative, the IT Career Planning Tool and accompanying Career Planning Guide will serve as a core component for federal agencies' IT workforce development programs. The tool is an interactive database application that enables workers to assess their own proficiency for the GS-2210 IT management specialist positions. The tool enables IT workers to manage their careers by analyzing where skill gaps exist, assisting in the design of a tailored strategy to help achieve proficiency in needed areas, and encouraging development of a Career Progression Plan that can be shared with or approved by the individual's supervisor or mentor. The accompanying Career Planning Guide serves as a users' guide for the tool and provides information about the career development process, including career options, education and experience opportunities, and competency requirements for federal IT specialists.

The Department of State's **IT Career Development Model** includes career paths, competencies, a 360-degree assessment tool, learning maps, and development plans. The model has been converted into an interactive Web-enabled career development tool, allowing State's IT employees to perform career assessment and planning at their desktops via the Department's intranet. A pilot is currently being conducted to introduce the application to new hires via train-the-trainer sessions and scheduled presentations.

The Department of the Navy's **Career Path Guide for Managing Technology, Information, and Knowledge** outlines a process for employees to use in planning their careers. It describes the general and technical competencies that are key to job success and gives employees and their supervisors a tool for enabling employees to excel in current and future jobs. The automated Career Planning Tool is based on the Career Path Guide and provides employees with a means to assess their proficiency, develop a plan to achieve needed competencies, and maintain a developmental history for information management, knowledge management, computer and information systems/engineering, information assurance, and telecommunications career areas.

The CIO Council-sponsored **CIO University** program is a consortium of universities that offer graduate-level courses related to the Clinger-Cohen Core Competencies. The CIO University serves to improve government by enhancing the skills of top federal executives. The General Services Administration (GSA) administers the program. More than 200 individuals have enrolled in courses offered by the CIO University's academic partners.

The **Strategic and Tactical Advocates for Results (STAR)** program is a graduate-level curriculum designed to advance effective strategic planning and coordination while achieving Clinger-Cohen results-based management. Created under the auspices of GSA and the CIO Council, the STAR program includes a business case exercise designed to integrate various aspects of the curriculum with each participant's real-world agency or organizational problems. The exercise results in a business solution that provides an immediate return for each participant, sponsoring executive, and sponsoring agency.

www.cio.gov

for all employees, including technical focus groups, and a large online and Web-based library of courses. Most of the college, university, and technical programs are offered onsite in the evening. Programs have also been tailored to the specific business requirements for career development.

The Federal Government is a large user of online training that employees can access at work or at home. For example, the Department of Transportation operates a “virtual university,” where other federal agencies can buy seats. A representative from the Department of Housing and Urban Development’s IT operations reported, “We bought seats for every employee on the virtual university, so every single employee has access to about 700 courses.” Similarly, the Department of Labor’s LEARN2UNIVERSITY provides hundreds of online courses on employee desktops in areas such as end-user desktop applications; Internet, programming, and Webmaster; MCSE and Microsoft Certified Professional; graphic design applications; and Microsoft Windows. The Department of Labor also provides external training for employees when management identifies a particular need, including training to prepare for IT certifications, and training programs tailored to the department environment, such as IT Investment Portfolio Management and IT Cost-Benefit Analysis. The Labor Department’s IT employees also maintain Individual Development Plans.

Employer Investment in IT Workforce Training at the National and Community Levels.

Many IT companies spend substantial sums on education-related activities, including investments that contribute to the development of the U.S. technical workforce. However, there appears to be a lower level of participation in programs specifically aimed at training people to enter IT occupations. A survey of CIOs indicated that only one in five companies participates in local education or career programs designed to expand the pool of IT workers. However, of the larger companies surveyed, those with revenues of \$1 billion or more, almost half were involved in such efforts.²¹⁵ A Computing Research Association report noted, “There is little evidence, however, that companies are willing to spend resources on entry training that would allow a person with good general skills to change occupations at company expense. Many companies still believe it is the individual’s responsibility to learn the basic technological skills the occupation requires before being hired.”²¹⁶ In addition, employers’ interest in participating in these programs can wane as labor markets loosen and more IT job candidates become available.

Figure 22 provides examples of the types of initiatives and investments supported by some of the companies that are large users of the H-1B temporary professional worker visa program.²¹⁷ About half of H-1B visas are issued to IT professionals. High usage of this program may indicate that companies have difficulty acquiring the professional-level employees they need and may, therefore, be more motivated to invest in developing professional-level IT workers.

A number of the top users of the H-1B visa program are IT companies that either are headquartered in or have strong ties to India. The education and training investments made by these companies are largely focused on efforts in India.

²⁰⁹ Building a Workforce for the Information Economy, National Research Council, October 2000.

²¹⁰ Best Places to Work in IT, U.S., 2002, *Computerworld*, May 6, 2002.

²¹¹ Erik Sherman, Keeping Your Staff Marketable, *Computerworld*, June 12, 2000; Sharon Watson, Best Places to Work in IT, 1999, Train to Retain, *Computerworld*, June 28, 1999.

Figure 22. Company Investments in Education and Training

Intel Corporation and Intel Foundation: According to its Annual Report of Contributions, Intel invested more than \$103 million in education and training-related activities outside the company in 2001. More than \$41 million was contributed to initiatives in K–12 education, and nearly \$49 million was contributed to higher education initiatives. These contributions funded a range of initiatives, such as helping teachers integrate technology into classrooms, science competitions, equipment grants and donations, support for university curricula in Intel’s product and design areas, community computer learning centers for youth, and university research grants in the field of computing. Investments supporting the nearer term development of the technical workforce include postsecondary scholarships and fellowships for students pursuing studies in engineering, computer science, or related fields, with an emphasis on women and underrepresented minorities. In addition, Intel partners with a number of postsecondary educational institutions—for example, local universities near Intel facilities—providing support for course development, student labs, summer enrichment camps, scholarships, and more. The largest sums are devoted to teacher training, support of engineering and computer science curricula, support of research, and PC recycling and excess equipment programs.²¹⁸ Internally, Intel allocates more than \$300 million annually for ongoing employee education. Intel University offers more than 7,000 courses online and, on average, Intel employees participate in six courses each year. Intel also offers a tuition assistance program that covers tuition, required texts, and certain fees for work-related courses and/or degree programs outside Intel but with current or future applications at the company.²¹⁹

Nortel Networks and Nortel Networks Foundation: In initiatives related to nearer term expansion of the technical workforce, Nortel Networks offers three-month summer internships in technology or business for university students, hires university co-op students, and participates in the INROADS long-term internship program for minority students. Between 2000 and 2003, some 10,000 university students at the undergraduate and graduate levels worldwide will be awarded Nortel Networks scholarships to pursue their studies in subjects such as engineering and computer science. These scholarships are supported by \$13 million from the Nortel Networks Foundation. Nortel also provides the four-semester NetKnowledge networking curriculum to secondary and postsecondary schools, supported by teacher training at regional training centers. Other initiatives include six Nortel Networks Kidz Online programs, which involve training teachers in basic computer skills, students producing interactive webcasts, a technology Web site for girls, Web-based information on best practices in education and technology, a technology career site, and resources for educators who teach the math and science behind modern networks and communications. Company employees volunteer their time to train teachers in advanced Internet skills, and Nortel provides some support for museums devoted to science or innovation. Nortel also sponsors the Nortel Networks Optical Internet Certification, supported by technical courses at its own education centers and through partners.²²⁰

Lucent Technologies and Lucent Technologies Foundation: The Lucent Technologies Foundation provides grants in the area of learning and development. The projects supported focus on professional development for teachers, science literacy, K–16 education outreach for colleges and universities, early childhood education, and other student opportunities. Some projects more directly address the near-term development of the technical workforce. These include the annual Global Science Scholars program, which provides a \$5,000 award to 60 outstanding high school students and college freshmen and sophomores to use toward university costs and attendance at a summit of the scholars, where they participate in panel discussions, laboratory tours, and shadowing programs with mentors. These scholars are also offered paid internships at Bell Labs research and development facilities. In addition, Lucent is partnering with the National Academy Foundation and the Center for Occupational Research in a program to help prepare young people for careers in IT. The program promotes an IT curriculum for high schools around the country. Another Lucent Technologies Foundation effort supports precollege activities aimed at increasing the representation of women and minorities in science and engineering careers. Also, a dozen fellowships are awarded to outstanding women scholars and those from underrepresented minorities who are working toward doctoral degrees in technical fields such as computer science and engineering. Lucent sponsors Early Career Identification Programs for college students in a wide range of majors, including IT-related majors. These include a summer research program for minorities and women, which places participants in working contact with scientists and engineers; a summer internship program for college students and faculty that includes project-focused assignments and mentoring; part-time and full-time internships for college students who can

²¹² www.computerworld.com/departments/surveys/bestplaces/us_story/0,10992,70809,00.html.

²¹³ www.computerworld.com/departments/surveys/bestplaces/us_story/0,10992,70809,00.html.

²¹⁴ The Ongoing Crisis in IT Management, August 2001.

Figure 22. Company Investments in Education and Training, continued

meet Lucent's hiring criteria; and a co-op program that integrates classroom studies with paid work experiences for college students. Lucent also supports the INROADS long-term internship program for minority students. In addition, Lucent supports a cooperative research fellowship program for minorities that provides tuition, university fees, books, stipends, related travel fees, and summer employment opportunities with mentoring; a graduate research program that provides fellowships and grants for women pursuing full-time doctoral studies in science and engineering, which includes opportunities for summer employment with mentoring; and a GEM fellowship program that provides paid summer internships and graduate financial assistance for underrepresented minorities seeking master's and Ph.D. degrees in science and engineering. Lucent also sponsors the Lucent Certified Technical Expert Certification.²²¹

Motorola and Motorola Foundation: The Motorola Foundation provides funding to higher education institutions as well as programs for primary and secondary education, primarily in communities where Motorola has a major presence. Many programs focus on math, science, and engineering education. Priority areas include university engineering, technical, and science programs; programs for groups underrepresented in math, science, engineering, and business; and science and math education at the precollege level. The company is involved with Junior Achievement, which focuses on business and economics, and plays a role in the FIRST Robotics competitions, including sponsoring high school teams. Motorola sponsors graduate fellows at the MIT media lab. The company also sponsors internships and co-op experiences at its facilities around the country. Motorola offers a tuition reimbursement program for its employees and a wide range of training opportunities in support of its products and services.

Oracle: In addition to its Oracle Internet Academy, Oracle Academic Initiative, and Oracle Workforce Development Program (described in the previous chapter), through its Oracle Help Us Foundation, Oracle donates computer equipment and software to primary and secondary schools and youth-oriented nonprofit organizations. The company expected to donate more than 10,000 computers to 200 schools and youth organizations in 2001–2002. The Oracle-hosted Think.com provides a Web-based educational environment where teachers and students can create their own Web pages and access electronic learning and collaboration tools. Oracle also contributes grant funds to support K–12 math, science, and technology education programs at schools and community organizations. Oracle is partnering with the United Negro College Fund (UNCF) in an internship and scholarship program. African-American sophomores and juniors enrolled in UNCF schools and institutions—with an emphasis on college majors in computer engineering, computer science, and management information systems—are eligible to participate in an eight-week paid summer internship at an Oracle facility. After completing the internship, students are eligible for a \$10,000 scholarship for tuition and other school expenses. In addition, 35–40 computer science majors are hired by Oracle each year for paid summer internships. These interns receive \$4,000 monthly salary, housing in corporate apartments, stock options, a three-month car rental, and roundtrip travel expenses from school. For its employees, Oracle offers a range of career development opportunities along two tracks—knowledge leader (individual contributor role) and people leader (manager role)—including²²²:

- transfers to new projects;
- technical, professional, and personal development courses;
- technical training on Oracle products and other technologies offered in instructor-led, interactive satellite broadcast, video-based, and computer-based training formats;
- special classes for Oracle's product developers, consultants, sales professionals, support personnel, and managers;
- technical training through an interactive satellite broadcast system;
- reimbursement of up to \$6,000 annually for job-related training; and
- access to Stanford Instruction Television Network.

Cisco: In addition to its extensive Cisco Networking Academy initiative (described in the previous chapter) and other Cisco-related training products, Cisco sponsors a Community Investment Technology Giving Program that offers grants of Cisco products to nonprofit organizations including K–12 schools and other organizations focused on children and youth, computers and technology, and education and literacy. The company sponsors the Cisco Community

²¹⁵ The Ongoing Crisis in IT Management, August 2001.

²¹⁶ The Supply of Information Technology Workers in the United States, 1999.

Figure 22. Company Investments in Education and Training, continued

and Education Technical Advocates initiative, in which skilled technicians volunteer their time and labor to assist in implementing Cisco technology grants, for example, providing assistance in planning and installing network infrastructures. Cisco's Access Grants support nonprofit programs that prepare K-12 students for careers in a technological society, with an emphasis on groups underrepresented in college and technical careers. The company also participates in an Adopted School Program for schools located near Cisco facilities. With adopted schools, Cisco participates in student mentoring, work projects at the schools, Groundhog Job Shadow Day, and Take Our Children to Work Day. Cisco offers nonprofit organizations, instructors, and students up to a 50 percent discount on technology-based Cisco courses. Cisco also sponsors an internship and cooperative education program that offers paid positions of three to six months duration throughout the year.²²³

Microsoft: Microsoft invests millions of dollars annually in education, training, and technology-related initiatives. For example, Microsoft donates millions of dollars' worth of software to organizations working to increase access to and improve skills in using computer technology. In 2002, Microsoft committed to donate to the National PTA 5 percent of the purchase price of certain of its education-related software products. In efforts to increase technology access, Microsoft has committed to providing \$100 million in cash and software for a Club Tech technology outreach program in partnership with the Boys and Girls Clubs of American. Club Tech is expected to reach 3.5 million children and teens in more than 3,000 Boys and Girls Clubs by 2005 through technology centers and curricula for developing computer skills. Through its Working Connections partnership with the American Association of Community Colleges (AACC), Microsoft provides grants, software, and technical assistance to 63 community colleges for developing and improving IT training programs. These colleges have been supported to design model IT programs that include a career-ladder approach to prepare students for entry-level jobs and offer advanced training for experienced workers. The local programs feature business-industry partnerships, IT curriculum development, and faculty/staff development. The company has also made numerous smaller grants and given other forms of assistance to support a wide range of efforts, including programs to increase technology access; equipment and software donations; e-mentoring; training teachers on the latest computer technology; and career days focusing on minority, female, and disabled precollege students. Microsoft sponsors a paid summer internship program for college students who have at least some technical skills and abilities. Students spend a minimum of three months working in one of four intern positions—program manager, software design engineer, software design engineer in test, or software test engineer. The company provides interns with transportation costs, subsidized housing, support for attending training seminars, and mentoring. The company also participates in a high school internship program offered to inner-city students in the Puget Sound area. Microsoft offers full tuition scholarships for college students studying computer science and related technical disciplines, awarding a large majority to women and minorities underrepresented in computer science. For the 2002-2003 academic year, the company expects to offer scholarships totaling \$540,000, awarded to recipients for one academic year. All scholarship recipients are required to complete a paid summer internship of at least 12 weeks at Microsoft. For its own employees, Microsoft offers inhouse technical and nontechnical skills training programs, online self-paced training, management development training, and financial support for attending training seminars. After employees have been with the company for one year, Microsoft will reimburse the costs of taking one course at a time at a local accredited college, with the approval of the employee's manager.²²⁴

PricewaterhouseCoopers: PricewaterhouseCoopers (PWC) offers a range of training and development opportunities for its employees, including orientation programs for new hires, a learning and education group that provides access to information and other pertinent resources in support of employee work, professional and technical seminars and classes, e-learning programs, and coaching and mentoring. PWC sponsors an intern training program that includes an orientation; training specific to the type of service line that the intern chooses at the company, which may include case studies, practice exercises, and computer-based training; and mentoring. Interns participate in an internship development program that includes a one-week seminar at Disney World, focusing on professional skills development and excellence in client service and including the Disney Institute curriculum, speakers from outside the company, and interactions with the company's internal experts.²²⁵

²¹⁷ Leading Employers of Specialty Occupation Workers (H-1B): October 1999 to February 2000, U.S. Immigration and Naturalization Service, June 2000.

²¹⁸ Intel, Innovation in Education, Annual Report of Contributions 2001, Intel Corporation, 2002.

Employee Role in IT Education and Training

Because of frequent technological change and IT product introduction, IT workers' education and training needs are ongoing throughout their careers. As one IT worker participating in a Commerce Department roundtable commented, workers not only have to learn the “big new thing coming out” but also must deal with smaller, more frequent technology change in order to maintain their skills.

***Developing and Maintaining a Career in IT.* IT workers participating in the Commerce Department's review, as well as survey data described above, confirm the increasing need for IT workers to take charge of their own education, training, and career development.**

The Virginia Governor's Commission on Information Technology found that “Formal ‘career development’ in many technology companies is almost a non sequitur. Beginning in the early to mid-90s, after many downsizings, outsourcings, and other turbulence in the job market, companies began to formally inform employees of the obvious: they were no longer guaranteed long-term employment and they would have to be more aggressive about keeping their skills (and resumes) updated. Some companies offered improved training programs to assist in keeping skills current. Employees in the IT industry seem to have received the message clearly and have been looking out for their own interests with a vengeance. Many picked their current job with an eye to the next one and salaries have gone up as job tenure has gone down.”²²⁶ At a Commerce Department roundtable, an employer representative called this the “free agent market,” commenting, “You’ve got a lot of people who recognize they have the hot skills, and usually the first question that they are going to ask is, how can I get the skills that are going to take me to the next level?” The representative further commented that if potential hires do not get a positive answer, they will go somewhere else.

For IT workers, career progression often does not take the traditional form. Rather than moving step-by-step up a career ladder, IT workers often manage a portfolio of skills (the “skill set”). Acquisition of these skills can represent a step up or an expansion of the scope of the skill set. Individual technical skills in the portfolio may increase or decrease in value, depending on the skill currency or size of demand in the market. There is no common path to building the skill portfolio. This lack of transparency in career progression and training paths contributes to the difficulty in navigating the IT education and training landscape.

Frequent change in IT, difficulties in forecasting future IT skill needs, the absence of employer communication on future IT skill needs, and lack of transparent career paths can frustrate IT workers, leaving them with little guidance on what training to acquire for long-term success in the IT field. An IT worker who participated in a Commerce Department roundtable described challenges faced by one city government's IT workers: “IT professionals were often saying, we don't know how to progress. We're not sure what's required of us and there is no guarantee that the more we learn the more we earn.” The individual went on to

²¹⁹ www.intel.com/jobs/usa/bencomp/education.htm.

CompTIA TechCareer Compass

The Computing Technology Industry Association (CompTIA) developed the TechCareer Compass to provide career development information to prospective and current IT workers. Through the TechCareer Compass, users can explore IT careers, compare their skills and experience against the requirements for specific IT jobs, and explore training options. Employers are encouraged to use the TechCareer Compass job descriptions in hiring and promotion. The project was developed in partnership with Cisco Systems, CompuCom, IBM, Intel, and Prosoft Training.

The TechCareer Compass explores careers in six IT disciplines: network services and operations, programming and software development, information support, interactive media, Internet and e-business, and database development and administration. In each of these disciplines, users select specific job titles at the entry, intermediate, and senior levels. For each of the titles and levels, detailed information is provided on essential job functions, tasks, and the knowledge, skills, and experience needed. Knowledge requirements outlined include formal education and technical certifications. In addition to technical skills, the outlines include a range of soft skills such as leadership, thinking, interpersonal, problem-solving, and communication skills. For each job title, suggestions are offered for training and certifications that could help prepare a worker for the job.

www.tcc.comptia.org

highlight the importance of skills forecasting in the union's discussion with management, not only forecasting in terms of technical skills but also skills in areas such as project management and business processes that the city may need to manage big projects in the future. An IT worker who provided comments wrote, "The other problem is not knowing what training will be valuable upon completion and within the next few years. The industry is constantly switching to new tools, and yet you must specialize to be productive. Schools are not always in tune with market demand."

IT Workers' Investment in Their Own Training. Many IT workers have a strong inclination for independent self-study and training. A large number of IT workers who provided comments for this review said that they regularly participate in independent self-study such as reading books and manuals, technical papers, IT magazines, and technical journals; participating in user groups and online and software-based training and tutorials; experimenting with new IT products and skills; and periodic participation in training courses. An IT worker commented at one of the Commerce Department's roundtables, "I have learned many of these hot skills as needed for a project. I get a book. I study. I ask a colleague, how do I do this, show me." In addition, this IT worker pointed out other types of informal training that IT workers can get themselves, including tutorials on the Internet, technical journals, and short courses.

Many IT workers cited the challenge of identifying appropriate, high-quality training so they can make the best decisions about where to spend their personal funds for skill development. An IT worker commented, "It is hard to find good quality. There are hundreds of poor technical schools and boot camps for becoming certified." Many IT workers also expressed frustration and questioned the value of participating in training, pointing to employers' strong preference for hiring individuals who have work experience in a particular IT skill. These workers fear that they will not get a return on their investment in training in the form of a better job or higher pay.

IT workers who provided comments for this review devote a significant amount of personal time to keeping their skills up-to-date. Of those specifying time spent, most reported spending 4 or 5 hours per week updating their skills. In a report on IT workers, the National Research Council cited observations that IT workers must spend 1.5–2 hours a day (or 7.5–10 hours a week) in continuing education or training.²²⁷ The employers listed in *Computerworld's* “Best Places to Work in IT” in the United States in 2002 provided an average of 9.4 days of training to their employees.²²⁸ This suggests that the lion’s share of IT worker skill maintenance and upgrading takes place on workers’ personal time.

Because a significant portion of the personal investment IT workers make in education and training does not lead to a credential, the investment and resultant skills may not be recognized by a potential employer who emphasizes credentials and work experience in evaluating job candidates.

For IT workers working as professional temporary workers or contract workers, there is no employer per se—neither the temporary agency nor the contracting employer—to provide support for training in terms of guidance on needed skills, training resources (such as online courses), or financial support.²²⁹ These workers must acquire all of these skill development resources on their own, and some may have fewer financial resources to invest in training than other IT workers because of more frequent periods of unemployment. Some of these contract IT workers find that the employer/employee relationship significantly affects their ability to access training. One IT worker at a Commerce Department roundtable said, “At Company A, if you’re an agency contractor you cannot access Company A’s training. You’re technically a W-2 employee, so you can’t claim tax deductions for any training you pay out of pocket, and for most people you don’t get any tuition or training reimbursement through your agency because you’re their paper employee.” Another IT worker commented, “Temps have access to training, but it’s separate and unequal. It’s also entirely up to you, as there isn’t anything like a development officer there to help you find your way through a maze of training and job possibilities.”

***Barriers to IT Workers Accessing and Participating in IT Training.* In striving to keep their skills up-to-date, IT workers face challenges—the cost of training programs, finding appropriate training, finding time for training, and balancing career development with their personal life and family responsibilities. For example, it can be challenging to attend school while holding a full-time job, and many IT professionals work long hours. In addition, IT workers who change jobs for purposes of acquiring new skills and experiences may have to relocate or take a cut in salary. IT workers who participated in this review cited finding time to participate in training and the cost of training as the biggest barriers to acquiring new skills.**

²²⁰ www.nortelnetworks.com.

²²¹ www.lucent.com.

²²² www.oracle.com.

²²³ www.cisco.com.



Boston Roundtable

Several IT education and training providers who provided comments for this review confirmed that their students have difficulty balancing training and a full-time job. As one commented, “My class is three hours long, at night, and these people have already worked an eight-hour job when I get them.” An IT worker who provided comments for this review said, “When I’ve put in a full day of programming at work, the last thing I want to do is more programming. Plus there is only so much I can effectively do in a day.” One IT worker described part of the dilemma, “An individual can take a course from a highly specialized IT workshop, but the cost is extremely high. Usually only large corporations can afford to send people to these. A college course takes two to three months to complete, so the cost in time is high. What the specialized, expensive courses will teach in a week takes the college or university three months, but the cost in dollars [at the college or university] is usually reasonable.”

Some IT workers spoke about the difficulty of maintaining a balance between keeping the IT skills up to date and being a parent. One IT worker said “getting [training] in between the kids’ baseball games” doesn’t happen. Another IT worker who participated in a Commerce Department roundtable pointed out that even when employers are willing to provide training, workers may not have the time to explore the many and varied training options outside the company. However, some employer representatives indicated that the careers of those who cannot or will not make an investment in self-development would suffer. One employer commented on the model of leaving work at 5:30 and spending time with the kids: “I think you can do that, and those will be the people who will see flattened salaries, who will never progress, so it’s really an individual decision about what one wants to make.” Another employer said, “The idea that continuing self-education is a burden—those aren’t the individuals you want to hire in any case. I mean, you don’t want them for anything.”

An IT worker at one of the Commerce Department’s roundtables discussed what some workers face in terms of employer expectations: “Company A recently mandated for certain job classifications below the director level that they all had to be Cisco certified. I was talking to guys and they all go, ‘Yeah, we need to get Cisco certified’ and he’s like ‘We don’t even know if we’re going to need Cisco certification.’ But I guess it’s a good thing to do it, but they’re not going to

give us any access. They're not going to help pay for this Cisco certification. They're not going to give us any time off to help get the Cisco certification."

Other IT workers cited the difficulty in accessing some types of training because of the infrequency of offerings and the time of day and place such training was available. As one IT worker who provided comments explained, "Courses designed for working folks are often held in the daytime or require a continued lengthy commitment for multiple evenings per week."

On the cost side, other than very short courses, IT training starts at a few thousand dollars and, for a longer program, can exceed \$10,000. As one IT worker who provided comments for this review put it, "Most people won't pay \$2,500 to \$3,000 out of their own pockets for a one-week course in a new technology." Another IT worker indicated that, while she does get paid premium dollars as a contractor, she has to set aside 20–25 percent of her salary to keep up with training.

Several education and training providers pointed to another barrier to developing IT knowledge and skills. They reported that some students in IT training programs do not have the written, verbal, math, or critical thinking skills needed for successful participation.

Another barrier cited was the conditions that must be met to access Federal Government support for training, even if a worker is unemployed. These include income tests that excluded workers who earned too much in the previous 12 months and exclusions for certain kinds of training programs because of their length and cost. Some conditions for program participation are set by the state and local entities that administer these federal funds.

APPENDIX A. FEDERAL REGISTER NOTICE

47016

Federal Register / Vol. 66, No. 175 / Monday, September 10, 2001 / Notices

The study and report will focus on the education and training paths and programs through which workers prepare for highly skilled IT jobs, and maintain the skills needed in an ever-changing IT environment. The study and report will explore: IT worker demand in terms of education and skill requirements, employer role in IT worker training, the IT education and training program landscape, including what education and skills various models of IT worker training program provide; and key elements for program success. Interested parties may include employers, IT workers, education/training providers, state and local governments, and area/regional training partnerships.

DATES: Tuesday, November 20, 2001, 10 a.m.

ADDRESSES: Technology Center, Technology Administration, U.S. Department of Commerce, 14th Street and Constitution Avenue, NW., Room 4813, Washington, DC 20230.

FOR FURTHER INFORMATION CONTACT:

Individuals who wish to attend this public meeting should contact Carol Ann Meares, Technology Administrations, U.S. Department of Commerce, Room 4823, Washington, DC 20230. Telephone (202) 482-0940, or e-mail cmeares@ta.doc.gov.

Dated: September 4, 2001.

Bruce Mehlman,

Assistant Secretary of Commerce for Technology Policy.

[FR Doc. 01-22632 Filed 9-7-01; 8:45 am]

BILLING CODE 3510-18-M

DEPARTMENT OF COMMERCE

Technology Administration

Announcement of Public Meeting on Existing Public and Private High-Tech Workforce Training Programs in the United States

AGENCY: Technology Administration, Commerce.

ACTION: Notice of public meeting.

SUMMARY: Notice is hereby given that a public meeting will be held on Tuesday November 20, 2001, 10:00 a.m. in the Technology Administration, Technology Center, U.S. Department of Commerce, Room 4813. Sections 115(a) and 115(b) of the American Competitiveness in the Twenty-First Century Act of 2000 (Public Law 106-313) require the Secretary of Commerce to conduct a study and prepare a report to Congress on existing public and private high-tech workforce training programs in the United States. In connection with this study and report, this public meeting is intended to provide an opportunity for individuals to offer comments on information technology (IT) workforce training.

DEPARTMENT OF COMMERCE

Technology Administration

[Docket No. 010626163-1163-01]

Notice, Request for Comments on Existing Public and Private High-Tech Workforce Training Programs in the United States

AGENCY: Technology Administration, U.S. Department of Commerce.

ACTION: Request for comments on existing public and private high-tech workforce training programs in the United States for Congressionally-mandated study and report to the Congress by the Secretary of Commerce.

SUMMARY: On behalf of the Secretary of Commerce, the Technology Administration (TA) invites interested parties to comment on existing public and private high-tech workforce training programs in the United States. Sections 115(a) and 115(b) of the American

Competitiveness in the Twenty-first Century Act of 2000 (Public Law 106-313) require the Secretary of Commerce to conduct a study and issue a report on this subject. In connection with this study and report, this Federal Register notice is intended to solicit comments and reply comments from the public in paper or electronic form. All written comments submitted in response to this notice will be posted on the TA website (www.ta.doc.gov/ittraining), and may be used in a report to Congress.

DATES: Interested parties are invited to submit comments no later than November 9, 2001.

ADDRESSES: Comments may be mailed to Carol Ann Meares, Office Technology Policy, Technology Administration, Room 4823 HCHB, 1401 Constitution Ave., NW., Washington, DC 20230. Paper submissions should include an electronic copy of the comments on a diskette in ASCII, WordPerfect (please specify version) or Microsoft Word (please specify version) format. Diskettes should be labeled with the name and organizational affiliation of the filer, and the name and version of the word processing program used to create the document.

In the alternative, comments may be submitted electronically to the following electronic mail address: techtraining@ta.doc.gov. Comments submitted as attachments to electronic mail should be submitted in one or more of the formats specified above.

Another alternative method for providing comment is an Internet-based form that can be completed and submitted online. The URL for this notice is www.ta.doc.gov/ittraining/form.

FOR FURTHER INFORMATION CONTACT:

Carol Ann Meares, Office Technology Policy, telephone: (202) 482-0940; or electronic mail: cmeares@ta.doc.gov. Media inquiries should be directed to the Office of Public Affairs, Technology Administration, at (202) 482-8321.

SUPPLEMENTARY INFORMATION:

I. Background

The development and application of new information technologies across virtually every segment of the American economy has resulted in rapid, sustained growth in demand for highly skilled information technology (IT) workers. Accordingly, between 1983 and 1998, the number of high-skilled IT workers increased from 719,000 to 2,084,000—an increase of 190 percent, more than six times the overall U.S. job growth rate during this period.

Rapid growth is expected to continue into the foreseeable future. The

Department of Labor Bureau of Labor Statistics' (BLS) most recent ten-year employment projections indicate that the number of core IT workers—computer scientists, computer programmers, computer engineers, systems analysts, computer support specialists, and database administrators—will rise from 2.2 million in 1998 to 3.9 million in 2008. Another 300,000 will be needed to replace those leaving the field during this period. As a result, BLS projects more than 2 million new core IT workers will be needed during this ten-year period. In addition, the five fastest growing occupations in the U.S. economy during this period are all core IT occupations—database administrators, 77.2 percent; systems analysts, 93.6 percent; computer support specialists, 102.3 percent; computer engineers, 107.9 percent; and “all other computer scientists,” 117.5 percent. These growth rates compare to a projected increase of 14.4 percent for all occupations during this period.

The jobs represented by these broad occupational classifications are varied, complex and specialized, as are the knowledge, skills and experience required to perform them. There is no single path to prepare a worker for a core IT occupation. Most get their education from four-year colleges and universities. Other paths include two-year degree-granting community colleges, special university/community programs designed to upgrade the skills of the current workforce, a growing number of private sector certification programs, in-house company training, short courses and self-study.

BLS's Current Population Survey indicates that two-thirds of the current core IT workforce have four-year college degrees, a quarter have less than a bachelor's degree but more than a high school diploma, and the balance have a high school diploma or less. In addition to formal education, many IT workers hold one or more technical certifications. Of those with four-year college degrees, 46 percent have IT degrees, minors or second majors; 86 percent have a degree in a science or engineering discipline.

This study and report will focus on the education and training paths and programs through which Americans prepare for these jobs and maintain the skills needed in an ever-changing information technology environment.

The Office of Technology Policy, an agency of the Commerce Department's Technology Administration, has conducted research and produced reports on the Nation's challenge in meeting the high U.S. demand for

skilled IT workers. These reports can be downloaded for review at: <http://www.ta.doc.gov/reports.htm>

II. Statutory Language Requiring a Study and Report to Congress

The statutory language requiring the Secretary of Commerce to conduct a study and submit a report to Congress on existing public and private high-tech workforce training programs in the United States is found in Sections 115(a) and 115(b) of the American Competitiveness in the Twenty-First Century Act of 2000 (Public Law 106-313), and is set forth below:

Sec. 115(a) STUDY—The Secretary of Commerce shall conduct a review of existing public and private high-tech workforce training programs in the United States.

Sec. 115(b) REPORT—Not later than 18 months after the date of enactment of this Act, the Secretary of Commerce shall submit a report to Congress setting forth the findings of the study conducted under subsection (a).

III. Specific Questions

The Department seeks comment on the following specific questions. Parties need not address all questions, but are encouraged to respond to those about which they have particular knowledge or information.

A. Questions for Employers

Please provide some information about your company/organization to provide a context for your comments (e.g. type of business, geographic location, size of total workforce, size of IT workforce).

1. What types of IT workers does your company/organization employ (e.g. development, application, support; occupational/technical skill type; entry-level, mid-level, senior)?

2. In making IT workforce-hiring decisions, what priority do you place on:

Graduate degrees?

—Four-year IT degree (e.g. computer science, computer engineering, management information systems)?

—Four-year technical degree (e.g. math, science, engineering)?

—Four-year business degree?

—Four-year liberal arts degree?

—Two-year associates degree?

—Technical Certification(s)? Which certifications does your company rely on?

—General technical experience?

—Experience with specific applications, operating systems, programming languages, hardware, etc.?

—Industry-specific Experience?

3. What types of education/training programs (e.g. certification programs, private IT schools, short courses,

seminars, community colleges, universities) provide newly hired IT workers with the skills needed?

4. What types of education/training programs (e.g. certification programs, private IT schools, short courses, seminars, community colleges, universities) provide current employees with the skills needed to be successful in their jobs, career progression, and to adapt effectively to changing technology?

5. Does your company/organization undertake efforts to keep the skills of your IT workforce current? What types of education/training programs (e.g. certification programs, private IT schools, short courses, in-house training, contract trainers, vendor training, seminars, community colleges, universities) does your company/organization use to provide current IT employees with the skills they need? What are the strengths and weaknesses of these programs?

6. What barriers inhibit investment in the education/training of current IT employees (e.g., cost, time from the job, fear of losing employee, uncertainty about future skill needs)?

7. Is your company/organization engaged in any partnerships (with industry, government, academia, training providers, etc.) to develop IT workers? What are the strengths and weaknesses of these programs?

8. What factors are considered in deciding whether to fill an IT position (or class of IT positions) by providing training and education to upgrade the knowledge and skills of current employee(s) (“making”), or by hiring employees who already have the skills from the open labor market (“buying”)?

What are the characteristics (e.g., skill level, experience requirements, area of expertise) of IT position that your company/organization fills by making? By buying?

9. How important are “soft skills” (e.g., oral and written communications skills, teamwork, problem solving) for an IT worker? Which “soft skills” are most important?

10. How quickly do the IT skills needed by your company/organization change? How are these changing IT skills requirements met? What impact do changing skills requirements have on your IT workforce?

11. Are you aware of or been involved in any U.S. Department of Labor-sponsored or support IT workforce training programs in your area? Have you hired or considered for employment any employees trained through U.S. Department of Labor-sponsored or supported IT training workforce programs? If so, what is your assessment

of the value of the training of these employees received? How well did the skills of the graduates of these programs meet your company's IT skill needs?

12. Does your company/organization train non-IT employees for IT jobs in the company/organization? If so, what types of education and training programs are provided for this purpose?

13. For IT managers: When announcing a job opening, do the education/skills/experience articulated by your company/organization as required for specific IT positions accurately reflect the education/skills/experience required to be successful in the positions?

14. For human resource officials: Do the education/skills/experience articulated by your line managers as required for specific IT positions accurately reflect the education/skills/experience required to be successful in the positions?

15. What types of credentials would substitute for technical job experience for entry-level jobs? For more advanced jobs?

16. Does your company/organization, either directly or through another organization, provide information regarding your IT skills needs to local educational and training providers to help them tailor their curricula/instruction to your needs?

17. Aside from the education/training investment in your current IT employees, what types of investments does your company/organization make in developing the U.S. IT workforce (e.g. financial contributions, scholarships, internships, work study, hardware/software donations, employee mentoring of students, adopt-a-school, other)?

18. Of the IT education/training programs that you have experience with, which do you consider effective?

B. Questions for IT Workers

1. What types of education and training programs (e.g. certification programs, private IT schools, short courses, seminars, community colleges, four-year colleges, graduate schools) provide the most immediately marketable skills for obtaining an IT job?

2. What types of education and training programs provide the most valuable IT or other skills for success in the long run in the IT field? Career progression in IT? Ability to adapt to changing information technology?

3. What are the strengths and weaknesses of the IT education/training program(s) you attended in terms of their providing valuable knowledge and skills for the IT job market?

4. What barriers do current/potential IT workers face in obtaining IT education and training (e.g., cost, availability, scheduling, meeting prerequisites)?

5. In your experience, what types of programs provide the highest quality of IT education/training? Best value? Most effective?

6. What barriers have you faced in obtaining IT jobs (e.g., lack of education, certification, experience, specificity of skill requirements)?

7. Have your employers supported your efforts to obtain IT education/training/skills upgrading? If so, how (e.g., paid for training, provided training on-site, provided time away from work to attend classes)? What barriers did you face in getting your employer(s) support?

8. How do you keep your skills up-to-date (programs, cost, time)?

9. How important is formal training versus experience gained on the job?

10. In your experience, do you believe that employers' stated requirements—in terms of education, skills, and experience—closely match the actual requirements of the jobs advertised?

11. Are you aware of any U.S. Department of Labor-sponsored or supported IT workforce training programs in your area? Have you participated in any U.S. Department of Labor-sponsored or supported IT workforce training programs? If so, what is your assessment of the value of the training provided by these programs?

C. Questions for Education/Training Providers

Please provide some information about your company/school/institution to provide a context for your comments (e.g., contract trainer, private IT school, community college, college, university; number of students; type of IT programs offered; duration, cost, type of client served).

1. In your IT education/training programs, is there any tension between providing fundamental knowledge and skills that are broadly applicable, and providing IT skills (perhaps proprietary) that will make your graduates immediately marketable? If so, how do you deal with the tension?

2. Are you finding that students in your programs arrive with the fundamental skills to be successful in IT careers? What are the characteristics of students who are most likely to succeed in your programs? What are the most significant barriers your students face in completing your programs? What are the most significant barriers your students face in finding employment after completing your program?

3. In an era of rapidly changing technology, how flexible is your institution in adapting its curricula to meet the changing technical skill needs of students and employers? Other changing needs of students and employers (e.g., soft skills, business skills, hands-on training, internships)? What are the barriers to adapting to these changing needs?

4. Does your institution provide placement services for your graduates? What level of success do your students have in securing IT employment after receiving training/education from your institution? What barriers to securing IT employment do your graduates report?

5. How do you develop connections between the program (what is taught) and employers' needs?

D. Questions for State/Local Government Agencies and Area/Regional Partnerships

Please provide some information about your agency/partnership to provide a context for your comments (e.g. type of institution, when established, phase of development, scope of activities).

1. Does your organization have a strategic plan for developing the IT workforce in your area or region? What are the elements of your plan?

2. Who is involved in your plan (e.g. government agencies, companies, education/training providers, workforce investment boards)?

3. Who do your programs target for training (entry level, career changers, disadvantaged groups, special communities, current IT workforce—both staying current (retooling) and getting ahead (upgrading))? What are the barriers to providing this training (aptitude, lack of knowledge/skill needed to participate in training, interest, lack of available workers, lack of time in students' lives, employer resistance)? How do you attract students/clients to your programs?

4. Approximately how many people have received training through your programs (please include the timeframe)?

5. Which institutions (governments agencies, IT companies, non-IT companies) are financially supporting this effort? Do employers participate in supporting this effort?

Which IT training providers (e.g. contract trainers, private IT schools, community colleges, universities) participate in your effort?

6. What types of training programs (certification, community college, 4-year colleges, graduate schools) do your students participate in under your programs?

7. With respect to those you are training for IT jobs, besides the technical IT training what other kinds of education, training and employment-related services are available through your program?

8. How successful have your programs been in placing students in IT jobs? What are the barriers your program participants face in getting IT jobs after completing their training?

9. What feedback have you received from employers on the strengths and weaknesses of your programs?

10. Does your state/jurisdiction offer incentives (tax, financial, other) to employer or employees for IT education and training? How effective have these incentives been?

Notwithstanding any other provision of the law, no person is required to respond to, nor shall any person be subject to penalty for failure to comply with, a collection of information subject to the Paperwork Reduction Act, unless that collection displays a currently valid OMB control number.

Dated: September 4, 2001.

Bruce Mehlman,

*Assistant Secretary of Commerce for
Technology Policy.*

[FR Doc. 01-22633 Filed 9-7-01; 8:45 am]

BILLING CODE 3510-18-M

APPENDIX B. PARTICIPANTS IN THE REVIEW OF IT WORKFORCE EDUCATION AND TRAINING

Information Technology Education and Training Roundtable Series

New Jersey Roundtable

September 24, 2001

Roundtable Partner: Programmers Guild

Chair: **Bruce P. Mehlman**, Assistant Secretary for Technology Policy, Department of Commerce

Facilitator: **John F. Sargent**, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Lou Citarella

Jim Davidson

Joseph Friedel, Department of Defense

Linda Kilcrease

James Kuhta

Peter Lutz

John Miano, Chairman, Programmers Guild

Ed Petron, Fantasy Sports Enterprises, Inc.

Michael Rinaldi

Eric Sherman

Jeff Sunnergren

Jens Velasquez

George Zdanowicz

DEPARTMENT OF COMMERCE

Federal CIO Council Roundtable

October 19, 2001

Roundtable Partner: Federal CIO Council

Chair: **Bruce P. Mehlman**, Assistant Secretary for Technology Policy, Department of Commerce

Facilitator: **John F. Sargent**, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Bonnie Acoveno, Director of the Agency Training and Education Division, Office of the CIO, NASA

Alex Bennet, Deputy CIO, Department of Navy

Brian Cook, Division Director, IT Policy and Planning Division, Office of Environmental Information, Environmental Protection Agency

Paul D. Domich, Office of Science and Technology Policy, The White House

Richard Farrow, Deputy CIO, Defense Finance and Accounting Service, Department of Defense

Joyce France, Department of Defense

Dagne Fulcher, Department of the Treasury, Manager, IT Workforce Improvement

Sandra Ginyard, Computer Specialist, Office of the CIO/Information Resources Management, Department of Agriculture

Gillian (Jill) Heagy, Deputy Director, Office of Information Resources Management, National Endowment for the Humanities

Dabney J. Hibbert, Manager, IT Workforce Program, Office of the CIO, NASA

Sandra King, Chief, Enterprise Licensing Division, Information Operations, Defense Logistics Agency, Department of Defense

Greg Parham, Acting Associate CIO, Department of Agriculture

Trina Parker, Training Coordinator, Information Operations, Defense Logistics Agency, Department of Defense

Patrick Pizzella, Assistant Secretary for Administration and Management/CIO, Department of Labor

Bruce K. Rosen, Associate Director, Office of the CIO, National Institute of Standards and Technology (NIST)

Deb Schweikert, Department of Education

Sandra Smith, Department of Navy

Debra Stouffer, Deputy CIO, Department of Housing and Urban Development

Silicon Valley Roundtable

October 26, 2001

Roundtable Partner: Joint Venture: Silicon Valley

Chair: Phillip J. Bond, Under Secretary for Technology, Department of Commerce

Facilitator: John F. Sargent, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Dee Alcott-Rodriguez, Director of Human Resources Strategy and Planning, Sun Microsystems

Joanna Fennel, Manager of University Programs, e*Trade Group

Rebecca Guerra, Joint Venture Silicon Valley Network

Allison Hopkins, Director of Human Resources, e*Trade Group

Marianne Jackson, Cisco Systems

Karen Kilgore, Program Lead, IT Technical Workforce Development, Hewlett-Packard

Jason Rodriguez, Hewlett Packard

Diane Schlageter, Director, Employment, Adobe Systems

Katherine Schwertley, Xilinx

Chris Taylor, Xilinx

Marguerite Wilbur, Joint Venture Silicon Valley Network

DEPARTMENT OF COMMERCE

Chicago Roundtable

October 30, 2001

Roundtable Partner: Chicagoland Chamber of Commerce

Chair: Bruce P. Mehlman, Assistant Secretary for Technology Policy, Department of Commerce

Facilitator: John F. Sargent, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Nancy Bellew, City Colleges of Chicago

Joyce Coleman, Vice President of Human Resources, Chicago Transit Authority

Doreen DeLaney, Vice President and Senior Human Resources Officer for Technology, CNA Insurance

Brenda Ladipo, Assistant Vice President, Information Technology Services, Federal Reserve Bank of Chicago

Dale Larder, Manager, IT Training and Development, Walgreens

Maria Lin, Program Manager, Northwestern Memorial Hospital

Peggy Luce, Vice President, Education and Workforce, Chicagoland Chamber of Commerce

Gloria Morningstar, Director of Employment, YMCA of Metropolitan Chicago

Mary Olson, Director of National Workers, Tribune Companies

Mark O'Neill, Vice President, Senior Relationship Manager, Harris Trust and Savings Bank

David H. Pilling, Director of Technology and Training, Jenner & Block LLC

Adam Przeklasa, Branch Manager, Manpower International

Kevin Scanlan, Vice President, Metropolitan Chicago Healthcare Council

Dennis Sienko, Executive Director, American Electronics Association Midwest Council

David Swirnoff, Director of Human Resources, Chicago Manufacturing Center

Northern Virginia Roundtable

November 9, 2001

Roundtable Partner: Northern Virginia Technology Council

Chair: Phillip J. Bond, Under Secretary for Technology, Department of Commerce

Facilitator: John F. Sargent, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Susan Baker, Vice President, Professional Development and Director of Workforce, Northern Virginia Technology Council

William Carlson, Director, MetroTech IT Jobs

Michael Ferraro, President, Training Solutions, Inc.

Neal Grunstra, President, Mindbank Consulting Group of Virginia

Mary Hough, Director, AMS University, American Management Systems

David Hunn, Director, Northern Virginia Regional Partnership

Amanda Hunt, American Association for the Advancement of Science

Nancy Johnston, Northern Virginia Technology Council

Darrell Kary, Vice President for Human Resources, Mail 2000 (a UPS Company)

Audrey Kremer, Training Principal, MitreTek

Karla Leavelle, George Mason University

Jeffrey Nulf, Director of Human Resources, Ciraden

Edward J. O'Hare, Senior Associate, Booz-Allen & Hamilton

Michael Russiello, CEO, BrainBench

Janet Schuchmann, First Virginia Bank, Inc.

Zuzana K. Steen, Assistant Director, Workforce Development and International Relations, Northern Virginia Technology Council

Bill Thomasson, Director of Learning, DynCorp

Kathy Torrence, Federal Government Business Partner and Change Management, EDS

Scott A. Wilson, Eastern Region Manager, EDS

Sean Wilson, Vice President, Human Resources, Information Management Consultants, Inc.

Nancy Zsebo, Executive Vice President for Human Resources, Employment Enterprises

DEPARTMENT OF COMMERCE

Seattle Roundtable

November 14, 2001

Roundtable Partners: WashTech

**International Federation of Professional and
Technical Engineers Local 17**

Society of Professional Engineering Employees in Aerospace (SPEEA)

Chair: **Phillip J. Bond**, Under Secretary for Technology, Department of Commerce

Facilitator: **John F. Sargent**, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Wesley Aman, Software Engineer, The Boeing Company (SPEEA)

Margaret Bartley, Partner, The Bartley Group

Kathie Black

Mike Blain, Web Developer, CTSO LLC

Brenda Carlson, Senior Engineer, The Boeing Company (SPEEA)

Margaret Cary, Union Representative, International Federation of Professional and Technical Engineers Local 17

Marcus Courtney, Organizer, WashTech

Philip Gaines, Web Designer

Margit Gerow, Analyst—Applications, City of Seattle

David Gooding

Preston Hampton, Project Manager, City of Seattle

David Larsen, Small Business/Software Tester, Microsoft (Volo)

John Mann, Network Administrator, City of Seattle

Shirley Nelson, Program Manager

Q. Gary Pankey, Principal Engineer, The Boeing Company (SPEEA)

Julie Renick, Senior Systems Analyst, Applications, City of Seattle

Neil Sidhu, Owner, Drakka Computer Solutions

Tricia Stromberg, Associate Technology Fellow (Software Engineer), The Boeing Company (SPEEA)

Dean Tudor, Contract Administrator, The Boeing Company (SPEEA)

Tom VanBuren, IT Professional, City of Seattle

Rick Wykoff

Boston Roundtable

December 20, 2001

Roundtable Partners: Massachusetts Software and Internet Council TechNet

Chair: **Phillip J. Bond**, Under Secretary for Technology, Department of Commerce

Facilitator: **John F. Sargent**, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Jennifer Banks, Project Manager, Massachusetts Technology Collaborative

Maura Banta, Manager, Corporate Community Relations, IBM

Susan Bowman, Executive Vice President of Human Resources, Genuity

John Caffrey, Vice President for Human Resources, Sitara Networks

Zoltan Csimma, Senior Vice President for Human Resources, Genzyme Corporation

Cynthia Gallerani, Director of Staffing, EMC Corporation

Nick Gleason, President and CEO, CitySoft

Lisa Glebus, Career Services Manager, Cisco Systems

Paul Harrington, Professor, Center for Labor Market Studies, Northeastern University

Bruce Holbein, Vice President for Public Policy, Massachusetts Software and Internet Council

Regina Hutchinson, Learning and Development Executive Director, East Markets, AT&T Broadband

Alice Jelin, Director, Massachusetts Tech Corps

Kiji Kim, President and CEO, Harvard Design and Mapping Company, Inc.

Farron Levy, Executive Director, CitySkills

Rob Parrish, Director of Human Resources (Boston), Molecular

Joyce Plotkin, President, Massachusetts Software and Internet Council

John D. Stuart, Senior Vice President, Parametric Technology Corporation

Rick White, President and CEO, TechNet

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Maryland Roundtable

January 9, 2002

Roundtable Partner: Tech Council of Maryland/MetroTech

Co-Chairs: **Bruce P. Mehlman**, Assistant Secretary for Technology Policy, Department of Commerce
Benjamin H. Wu, Deputy Under Secretary for Technology, Department of Commerce

Facilitator: **John F. Sargent**, Senior Policy Analyst, Office of Technology Policy, Department of Commerce

Sadhna Agrawal, President, Systems Integration and Development, Inc.

Roma Brodecki, Manager, Training and HR Programs, Lockheed Martin/OAO Corporation

Brian Butts, Vice President, I/Tech Services, Inc.

Bill Carlson, Executive Director, MetroTech

Linda Checchia, Frederick County (Maryland) Metrotech

Tom Collins, Director of Sales and Marketing, Atlantech Online

Rosalind Cook, Director, Learning Performance Support Solutions—Resources, SI International, Inc.

Cheryl Croft, President, Tidal Zone Associates

Michael Dorio, Senior Education Requirements Planner, Lockheed Martin Mission Systems

Michael Driddy, CEO, Intervise

Warren Fleming, President, QST, Inc.

Lori Golino, Vice President, Human Resources, Social and Scientific Systems, Inc.

Ira R. Greenstein, Executive Director, Business Development, Global Systems and Strategies, Inc.

Patrick Haley, COO, GoEBusiness.Com

Vania Jacobs, Membership Manager and IT Network Coordinator, Tech Council of Maryland

Kenneth D. Karr, CEO, Achates Systems, Inc.

Paul Kowalski, Director of Program Management, SFA, Inc.

Robert Linehan, Executive Director, Cooperative.com, National Rural Electric Cooperative Association

Lillian Milliner, Vice President, Applied Systems Analysis and Processing, Inc.

Clement Munno, Vice President, Business Development, Client Network Services, Inc. (CNSI)

Howard Nevin, CTO/CIO, Integrated Systems, Inc.

David S. Ronis, Principal, Information Resource Associates, Inc.

Ivan Stangel, President and Scientific Director, BioMat Sciences

Mark Streger, Director IT Network, Tech Council of Maryland

Bob Taylor, Vice President and Director of IT, Phillips International

James Whang, AEPCO

Scott C. Whitfield, Manager, Business Development, Altvia Technologies, Inc.

Theodore Williams, CEO, AIMSTAR Information Solutions, Inc.

Web-based Respondents

NOTE: Respondents were permitted to remain anonymous or use pseudonyms

Employer Respondents (22)

Douglas Begay, CIT
 Robert J. Brown, The Comdyn Group
 Robert Epstein, Goodwill Industries International
 J. Gumz
 Sam Jones, ELDEC Corporation
 Jeff Kirkpatrick, Texas Instruments
 Cheryl Krug, United Parcel Service
 Melanie Lawrence, Ajilon

Steven Millman, M.I.S. Contract Services, Inc.
 Anita Murad, Satyam Computer Services, Ltd.
 Harrison Picot, Alcyon Technologies
 Jerry Scott, MMC Group
 Mary Ann Tracy, Crownpoint Institute Of
 Technology
 Jonathan Tsosie, computer tech in training
 Randy Unterseher, Key Technology, Inc.

Plus 4 anonymous respondents who indicated no name or company

IT Worker Respondents (200)

John M. Amsler
 Tim Barndt, SmartForce
 Margaret Bartley
 Anne L. Beardsley
 Douglas Begay, CIT
 Rita Blanchette-Smart, Edmonds Community
 College—Information Technology Department
 David K. Bond
 John Bourne, Programmers Guild
 Mike Bradley, National Writers Union
 Jim Braswell, self-employed
 Tony Brenke, CPR
 Tom Broughton, SmartForce Plc/Scottsdale
 Development Center
 K. Camloh, Tickets.com
 Joan Carlson, LMGT
 Ralph Carrino, Carrino Computer Consulting
 Reginald Carter
 Georgeanna Chan, Patent and Trademark Office
 Steven Clark
 Kartik Das
 Troy Davis, Cincinnati Programmers Guild
 August Depner, Sakson & Taylor, Inc.
 R. Dowell, Fedex IT Services
 David Dunham, Electric Fish, Inc.
 Mohamed Elzein, Department of Commerce,
 Patent and Trademark Office, Office of the CIO
 Jason Esser, lightoffice technology, inc.
 Haig Evans-Kavaldjian, Department of Commerce,
 Office of the CIO

Lex Fairfax
 Jonna Fonville, Lockheed Martin Space Operations
 Philip B. Gaines, WashTech, Communications
 Workers of America (CWA)
 Carol Galica, InDyne
 Patrick W. Gannon, OS/OCS
 Richard Gardner, RG Software Corporation
 Vladimir Gendler, Consultant
 Brian Lee Gnad, Arinc
 Mark Goldstein, Department of the Navy—
 SPAWAR
 Gus Gustafson, Programmers Guild
 Jay Courtney Hammond, Informed Ideas
 Vonnelle Hancock, Sheehan Consulting, Inc.
 Paul Hernandez, Programmer/Systems Analyst
 Jerry Hesseltine, Burnt-River Communications, LLC
 Tom Hickok, Department of Commerce, Patent and
 Trademark Office
 Marc Hoffman, Poison Dart Frog Media
 Wanda Jimmie, CIT
 Betty Jones, Crownpoint Institute of Technology
 Denise Jones, SolutionsIQ
 Wendell Joost, SolutionsIQ/Microsoft
 Don Kagle
 Paul T. Karch, Software and Systems
 Peter J. Kauslick, CIO/PRSD/PATSSB
 Thomas Kelly, Boca Software Development
 Frank J. Kime, Jr.
 Ryan Kipple, Microsoft Temp
 John F. Klinkert

DEPARTMENT OF COMMERCE

Ed Kranepool
Malcolm J. Kudra, Real Chaos Limited
Lenora Largo, CIT
D. S. Larsen
Ronald Larson, Larson's Computer Service
Joseph Leonard
LeRae, Crownpoint Institute of Technology
Gary MacDougall, FreeportWeb, Inc.
Sal Maglione
Jeanne C. Majors, Port Authority of New York and
New Jersey
Steven Martin, Pantheon
Kelly May
Nathan McCourtney, American Institutes for
Research
Joe McDonald
Bonesaw McGee
John Miano, Colosseum Builders, Inc.
Steve Millman, M.I.S. Contract Services, Inc.
Rebecca Montgomery, on contract at Microsoft
Judy Morgan, Crownpoint Institute of Technology
Fred Morris
Denise Morrissette
William M. Moss
Kathy Mrozek, Consultant
Linda Nesheim, Programmers Guild, Minnesota
Chapter
Eric Ness, Orion Software, Inc.
Staci Newsom, Blue Frog Computer
Terry Oldberg, Computer Programmer
Harold Olstad
Mark O'Reilly, Vanteon
Mark A. Owen, Amazon.com
Bob Parker
Natalie Parks, ArtSource, Inc.
Cynthia Peshlakai, CIT student
Michael Pettigrew, Vertex Systems
Ly Phan, Department of Commerce, Patent and
Trademark Office, Office of the CIO
Jim Quinlan, America II Corp
Khalid Rahim
Kimberly Ray, Inland Northwest Blood Center
Carolyn Rippy
Kyle Rode, SMOke SWirl Games
Bob Rose, ARC Advisory Group
Alec Rowell
Richard Rue, Cyberdata Systems Corporation
Lorine Sam, Crownpoint Institute of Technology
Franklin Schmidt
Tracy Scott
Walter M. Short
Jeff Silverman, WashTech
Dennis Soper, The University of Oregon
Jerry Sowell
Thomas Steed, CWA Local 1120/Verizon
Communications
Martin Stoesser
Rob Stuehler, PG&E
David Symolon
Yi Tang, LifeFitness
Susan Tescione
Brian Thomsen, Washington Inventory Service
Mary Ann Tracy, Crownpoint Institute of
Technology
Jonathan Tsosie, computer tech in training
Billy Turchin
Elizabeth Vail, Vail-Bargmann, LLC
Jeffrey J. Vigil, U.S. Hispanic Chamber of
Commerce
Harvey Vogel
Lew Watchman, Crownpoint Institute of
Technology, computer tech program
Thomas E. Webb, TWebb and Associates
Michael Williams, Lawrence Memorial Hospital
Thomas Raymond Wozniak, Fingerhut Companies
Charlene Wroblewski
Thomas Wucetich, Programmers Guild
Maryann R. Wysocki, PGMinn
Jon Yarbrough, JAY Enterprises
Angela Zachary, Reader's Digest Association
Charlene Zvolanek, Texas Memorial Museum of
Science and History
Cindy Peoples
Dustin S.
Sharon, Crownpoint Institute of Technology
Vicky, Nextel
"Anne Onymous"
Mega Brain, Department of Commerce
Anonymous, Accenture
Anonymous, Compaq Computer Corp.
Anonymous, Department of Commerce, Patent
and Trademark Office
Anonymous, Department of Commerce, Patent
and Trademark Office
Anonymous, Intel
Anonymous, LSI Logic
Anonymous, Programmers Guild
Anonymous, WashTech member
Anonymous, Z-Tech Systems, Inc.

Plus 59 anonymous respondents who indicated no name or company

DEPARTMENT OF COMMERCE

Education and Training Provider Respondents (47)

Suzie Andrews, Yellowbrick Technologies, Inc
Steve Belville, Bryant and Stratton College,
Milwaukee Campus
Russel Bruhn, University of Arkansas at Little Rock
Suzette R. Burckhard, South Dakota State
University
Mary Cahill, Software Council Fellowship
Program, Inc.
Wendy C. Chang, D'Youville College
Yupo Chan, University of Arkansas at Little Rock
Dennis Corrigan, American Systems Corporation
Jeanne Cosby, Copper Mountain College
Bruce Furino, University of Central Florida,
College of Engineering and Computer Science
Don Grubor, Effective Solutions/Mouse University
Brad Howard, Dakota County Technical College
Robert Ilbrink, Reuters
Ina Lancman, State University of New York,
Downstate Medical Center
Renee Lee, Cochise County Workforce
Development
Jaye Colorado Lill, Outsourced Systems
Cheryl Lower, IOICC
Jennifer L. McClure, DeVry, Inc.
Sharon T. McEntyre
Dan McKinnon, WashTech
Kate Moody, Beaver Technology Education Center
Judy Morgan, Crownpoint Institute of Technology
Chris Muellenbach, University of Wisconsin-
Milwaukee, University Outreach
Tricia Myers, Household International
Judith Pepper, La Plaza Telecommunity
Cynthia Peshlakai, CIT
Richard Harrison Roberts, Electronic Commerce
Resource Center, Bremerton, Washington
David J. Rosage, NASA/Goddard Space Flight
Center
Charles Sekafetz, Chemeketa Community College
Diane Shuda, Hennepin Technical College
Darren Stalder, Discordian Alliance for Teaching
Beth Sweetland-Bailey, CT Business Training
Networks
Thomas A. Teeter, University of Arkansas at Little
Rock
Flint Wild, NASA Teaching from Space
Kimberly Wrightson, East Georgia College
Jon Yarbrough, IMS, Inc.
Vladimir, SBS
Anonymous, Campus Boulevard Corporation
Anonymous, Crownpoint Institute of Technology
Anonymous, Hennepin Tech College BPC
Anonymous, Intel

Plus 5 anonymous respondents who indicated no name or company

State Agencies and Partnerships Respondents (9)

James Asselin, Hampden County Employment
and Training Consortium
Clare Dolan, Oracle Corporation
Neal Flaxman, 2ndjob.com
Calvin V. Lee, Computers
Tim McClung, West Virginia Development Office
Arlin Melgaard, North Country Business-
Education Partnership
Derenda Sweeney, Seattle Jobs Initiative
Anonymous, Indiana Department of Commerce
Anonymous, Department of Labor, Office of the
CIO

There were no anonymous respondents who indicated no name or company

Providers of Written Comments

Private Sector IT Employers

Booz, Allen & Hamilton

Client Network Services, Inc., Clem Munno, Vice President for Business Development

EMC² Corporation, Cynthia Gallerani, Director, Human Resources

I/Tech Services, Inc.

Intel

Microsoft

YMCA of Metropolitan Chicago

IT Workers/Representative Organizations

Evan Carew

Ramon Echevaria

Joseph Freidel

Jim Jordan

Linda Kilcrease

David Larrabee

John Lutz

Michael Rinaldi, Software Engineer, SunGard Treasury Systems

Programmers Guild, John Miano

Joint Statement by:

- Washington Alliance of Technology Workers (WashTech)
- International Federation of Professional and Technical Employees (IFPTE Local 17)
- Society of Professional Engineering Employees in Aerospace (SPEEA-IFPTE Local 2001)

Government

Department of Labor

- Office of the Chief Information Officer, Laura Callahan, Deputy CIO
- Office of Policy and Research, Gerard F. Fiala, Administrator

Education and Training Institutions

University of Arkansas at Little Rock, Thomas A. Teeter

DeVry Institutes

SUNY Downstate Medical Center, Medical Information Systems Technology (MIST) Program,
Ina Lancman, Executive Director

Meetings with Key Stakeholders

American Association for the Advancement of Science (AAAS)

Brainbench

CitySoft/CitySkills

Computing Technology Industry Association (CompTIA)

Fannie Mae

Freddie Mac

Information Technology Association of America (ITAA)

Institute of Electrical and Electronics Engineers—United States of America (IEEE-USA)

MetroTech

National Science Foundation (NSF)

Northern Virginia Regional Partnership (NVRP)

Software Council Fellowship Program, Massachusetts Software and Internet Council

U.S. Department of Labor (DoL)

APPENDIX C. HIGHLIGHTS OF 2002–2003 ACCREDITATION BOARD FOR ENGINEERING AND TECHNOLOGY (ABET) ACCREDITATION CRITERIA

Criteria for Accrediting Computer Programs²³⁰

Computer Science

Lead Society: Computer Science Accrediting Board (CSAB)

The curriculum is consistent with the program’s documented objectives. It combines technical requirements with general education requirements and electives to prepare students for a professional career in the computer field, for further study in computer science, and for functioning in modern society. The technical requirements include up-to-date coverage of basic and advanced topics in computer science as well as an emphasis on science and mathematics.

Curriculum standards are specified in terms of semester hours of study. Thirty semester hours generally constitute one year of full-time study and are equivalent to 45 quarter hours. A course or a specific part of a course be applied toward one standard.

General Component

- The curriculum must include at least 40 semester hours of up-to-date study in computer science topics.
- The curriculum must contain at least 30 semester hours of study in mathematics and science as specified below under Mathematics and Science Component.
- The curriculum must include at least 30 semester hours of study in humanities, social sciences, arts, and other disciplines that serve to broaden the background of the student.
- The curriculum must be consistent with the documented objectives of the program.

²²⁴ www.microsoft.com; www.aacc.nche.edu (link to resource center, products/partnerships).

²²⁵ www.pwcglobal.com.

Computer Science Component

- All students must take a broad-based core of fundamental computer science material consisting of at least 16 semester hours.
- The core materials must provide basic coverage of algorithms, data structures, software design, concepts of programming languages, and computer organization and architecture.
- Theoretical foundations, problem analysis, and solution design must be stressed within the program's core materials.
- Students must be exposed to a variety of programming languages and systems and must become proficient in at least one higher level language.
- All students must take at least 16 semester hours of advanced course work in computer science that provides breadth and builds on the core to provide depth.

Mathematics and Science Component

- The curriculum must include at least 15 semester hours of mathematics.
- Course work in mathematics must include discrete mathematics, differential and integral calculus, and probability and statistics.
- The curriculum must include at least 12 semester hours of science.
- Course work in science must include the equivalent of a two-semester sequence in a laboratory science for science or engineering majors.
- Science course work additional to that specified in [the previous bullet] must be in science courses or courses that enhance the student's ability to apply the scientific method.

Additional Areas of Study

- The oral communication skills of the student must be developed and applied in the program.
- The written communication skills of the student must be developed and applied in the program.
- There must be sufficient coverage of social and ethical implications of computing to give students an understanding of a broad range of issues in this area.

Criteria for Accrediting Information Systems Programs²³¹

The curriculum combines professional requirements with general education requirements and electives to prepare students for a professional career in the information systems field, for further study in information systems, and for functioning in modern society. The professional requirements include coverage of basic and advanced topics in information systems as well as an emphasis on an IS environment. Curricula are consistent with widely recognized models and standards.

Curriculum standards are specified in terms of semester hours of study. Thirty semester hours generally constitute one year of full-time study and are equivalent to 45 quarter hours. A course or a specific part of a course can only be applied toward one standard.

General

- The curriculum must include at least 30 semester hours of study in information systems topics.
- The curriculum must contain at least 15 semester hours of study in an information systems environment, such as business.
- The curriculum must include at least 9 semester hours of study in quantitative analysis as specified below under Quantitative Analysis.
- The curriculum must include at least 30 semester hours of study in general education to broaden the background of the student.

Information Systems Component

- All students must take a broad-based core of fundamental information systems material consisting of at least 12 semester hours.
- The core materials must provide basic coverage of the hardware and software, a modern programming language, data management, networking and telecommunications, analysis and design, and role of IS in organizations.
- Theoretical foundations, analysis, and design must be stressed throughout the program.
- Students must be exposed to a variety of information and computing systems and must become proficient in one modern programming language.
- All students must take at least 12 semester hours of advanced course work in information systems that provides breadth and builds on the IS core to provide depth.

²²⁶ Investing in the Future, September 1999.

Information Systems Environment Component

- The 15 semester hours must be a cohesive body of knowledge to prepare the student to function effectively as an IS professional in the IS environment.

Quantitative Analysis Component

- The curriculum must include at least 9 semester hours of quantitative analysis beyond precalculus.
- Statistics must be included.
- Calculus or discrete mathematics must be included.

Additional Areas of Study

- The oral and written communication skills of the student must be developed and applied in the program.
- There must be sufficient coverage of global, economic, social, and ethical implications of computing to give students an understanding of a broad range of issues in these areas.
- Collaborative skills must be developed and applied in the program.

Criteria for Accrediting Engineering Programs²³²

General Criteria for All Engineering Programs

Program Outcomes. Engineering programs must demonstrate that their graduates have

- (a) an ability to apply knowledge of mathematics, science, and engineering
- (b) an ability to design and conduct experiments, as well as to analyze and interpret data
- (c) an ability to design a system, component, or process to meet desired needs
- (d) an ability to function on multidisciplinary teams
- (e) an ability to identify, formulate, and solve engineering problems
- (f) an understanding of professional and ethical responsibilities
- (g) an ability to communicate effectively
- (h) the broad education necessary to understand the impact of engineering solutions in a global and societal context
- (i) a recognition of the need for and an ability to engage in lifelong learning
- (j) a knowledge of contemporary issues
- (k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice

Professional Component. The professional component requirements specify subject areas appropriate to engineering but do not prescribe specific courses. The engineering faculty must ensure that the program curriculum devotes adequate attention and time to each component, consistent with the objectives of the program and institution. Students must be prepared for engineering practice through the curriculum, culminating in a major design experience based on the knowledge and skills acquired in earlier course work and incorporating engineering standards and realistic constraints that include most of the following considerations: economic, environmental, sustainability, manufacturability, ethical, health and safety, social, and political. The professional component must include

- (a) one year of a combination of college-level mathematics and basic sciences (some with experimental experience) appropriate to the discipline
- (b) one and one-half years of engineering topics, consisting of engineering sciences and engineering design appropriate to the student's field of study
- (c) a general education component that complements the technical content of the curriculum and is consistent with the program and institution objectives.

²²⁷ Building a Workforce for the Information Economy, October 2000.

Requirements for Specific Engineering Disciplines

Software Engineering and similarly named engineering programs

Lead Society: Computer Science Accrediting Board (CSAB)

Cooperating Society: Institute of Electrical and Electronics Engineers (IEEE)

Applicability: Engineering programs that include software or similar modifiers in their titles.

The curriculum must provide both breadth and depth across the range of engineering and computer science topics implied by the title and objectives of the program. The program must demonstrate that graduates have the ability to analyze, design, verify, validate, implement, apply, and maintain software systems; the ability to appropriately apply discrete mathematics, probability and statistics, and relevant topics in computer science and supporting disciplines to complex software systems; and the ability to work in one or more significant application domains.

Electrical Engineering/Computer Engineering and similarly named engineering programs

Lead Society: Institute of Electrical and Electronics Engineers (IEEE)

Cooperating Society (for Computer Engineering Programs): Computer Science Accrediting Board (CSAB)

Applicability: Engineering programs that include electrical, electronic, computer, or similar modifiers in their titles.

The structure of the curriculum must provide both breadth and depth across the range of engineering topics implied by the title of the program. The program must demonstrate that graduates have knowledge of probability and statistics, including applications appropriate to the program name and objectives; and knowledge of mathematics through differential and integral calculus, basic sciences, computer science, and engineering sciences necessary to analyze and design complex electrical and electronic devices, software, and systems containing hardware and software components, as appropriate to program objectives. Programs containing the modifier “electrical” in the title must also demonstrate that graduates have a knowledge of advanced mathematics, typically including differential equations, linear algebra, complex variables, and discrete mathematics. Programs containing the modifier “computer” in the title must also demonstrate that graduates have a knowledge of discrete mathematics.

Criteria for Accrediting Engineering Technology Programs²³³

Computer Engineering Technology and similarly named programs

Lead Society: Institute of Electrical and Electronics Engineers (IEEE)

Cooperating Society: Institute of Industrial Engineers

Applicability: Engineering technology programs including “computer” or similar modifiers in their titles, leading to either an associate or a bachelor’s degree.

Technical science courses must be applications-oriented, with a majority having an accompanying laboratory with emphasis on measurement, data collection and analysis, documentation, and written/oral report preparation/presentation. Course work must include the fundamentals of electricity/electronics and digital principles.

Technical skills and techniques courses must include topics, as appropriate, to meet the stated goals and objectives of the program. They must be a balanced treatment of computer software and hardware, evidenced by courses reflecting each aspect of the discipline.

Courses at the associate degree level must prepare the student for immediate employment and must include sufficient foundation to enable the student to continue in upper-division studies without penalty. Upper-division course work must complement and expand lower-division work.

Technical design courses must emphasize flow charting, documentation, and the use of manuals, handbooks, language/equipment specifications, and computers, where applicable.

The basic sciences must include physics (with laboratory) presented in a rigorous algebra/trigonometry environment (as a minimum). A minimum coverage in mathematics includes beginning college-level algebra, linear algebra/matrices, and trigonometry. Baccalaureate programs must include differential/integral calculus, and instruction in numerical methods is strongly encouraged. Applied differential equations, transform methods, linear programming, and probability/statistics are appropriate electives. Application-oriented textbooks are preferred.

²²⁸ The Best Places to Work in IT, U.S., 2002, May 6, 2002.

APPENDIX D. COMPUTER SCIENCE BODY OF KNOWLEDGE AS DEFINED BY COMPUTING CURRICULA 2001²³⁴

Areas	Units
Discrete Structures (DS)	
<p>Discrete structures is foundational material for computer science; “foundational” means that relatively few computer scientists will be working primarily on discrete structures, but that many other areas of computer science require the ability to work with concepts from discrete structures. Discrete structures includes important material from such areas as set theory, logic, graph theory, and combinatorics.</p> <p>The material in discrete structures is pervasive in the areas of data structures and algorithms but appears elsewhere in computer science as well. For example, an ability to create and understand a formal proof is essential in formal specification, in verification, and in cryptography. Graph theory concepts are used in networks, operating systems, and compilers. Set theory concepts are used in software engineering and in databases.</p> <p>As the field of computer science matures, more and more sophisticated analysis techniques are being brought to bear on practical problems. To understand the computational techniques of the future, today’s students will need a strong background in discrete structures.</p>	<p>DS1. <i>Functions, relations, and sets</i> (6)</p> <p>DS2. <i>Basic logic</i> (10)</p> <p>DS3. <i>Proof techniques</i> (12)</p> <p>DS4. <i>Basics of counting</i> (5)</p> <p>DS5. <i>Graphs and trees</i> (4)</p> <p>DS6. <i>Discrete probability</i> (6)</p>
Programming Fundamentals (PF)	
<p>Fluency in a programming language is prerequisite to the study of most of computer science. This knowledge area consists of those skills and concepts that are essential to programming practice independent of the underlying paradigm. As a result, this area includes units on fundamental programming concepts, basic data structures, and algorithmic processes. These units, however, by no means cover the full range of programming knowledge that a computer science undergraduate must know. Many of the other areas—most notably programming languages (PL) and software engineering (SE)—also contain programming-related units that are part of the undergraduate core.</p>	<p>PF1. <i>Fundamental programming constructs</i> (9)</p> <p>PF2. <i>Algorithms and problem-solving</i> (6)</p> <p>PF3. <i>Fundamental data structures</i> (14)</p> <p>PF4. <i>Recursion</i> (5)</p> <p>PF5. <i>Event-driven programming</i> (4)</p>
Algorithms and Complexity (AL)	
<p>Algorithms are fundamental to computer science and software engineering. The real-world performance of any software system depends on only two things: (1) the algorithms chosen and (2) the suitability and efficiency of the various layers of implementation. Good algorithm design is therefore crucial for the performance of all software systems. Moreover, the study of algorithms provides insight into the intrinsic nature of the problem as well as possible solution techniques independent of programming language, programming paradigm, computer hardware, or any other implementation aspect.</p> <p>An important part of computing is the ability to select algorithms appropriate to particular purposes and to apply them, recognizing the possibility that no suitable algorithm may exist. This facility relies on understanding the range of algorithms that address an important set of well-defined problems, recognizing their strengths and weaknesses and their suitability in particular contexts. Efficiency is a pervasive theme throughout this area.</p>	<p>AL1. <i>Basic algorithmic analysis</i> (4)</p> <p>AL2. <i>Algorithmic strategies</i> (6)</p> <p>AL3. <i>Fundamental computing algorithms</i> (12)</p> <p>AL4. <i>Distributed algorithms</i> (3)</p> <p>AL5. <i>Basic computability</i> (6)</p> <p>AL6. <i>The complexity classes P and NP</i></p> <p>AL7. <i>Automata theory</i></p> <p>AL8. <i>Advanced algorithmic analysis</i></p> <p>AL9. <i>Cryptographic algorithms</i></p> <p>AL10. <i>Geometric algorithms</i></p> <p>AL11. <i>Parallel algorithms</i></p>

²²⁹ Disparities Within the Digital World: Realities of the New Economy, Washington Alliance of Technology Workers and the Worker Center-King County Labor Council, AFL-CIO.

²³⁰ Criteria for Accrediting Computer Programs, 2002–2003, Accreditation Board for Engineering and Technology, November 2001.

Architecture and Organization (AR)

The computer lies at the heart of computing. Without it, most of the computing disciplines today would be a branch of theoretical mathematics. To be a professional in any field of computing today, one should not regard the computer as just a black box that executes programs by magic. All students of computing should acquire some understanding and appreciation of a computer system's functional components—their characteristics, their performance, and their interactions. There are practical implications as well. Students need to understand computer architecture in order to structure a program so that it runs more efficiently on a real machine. In selecting a system to use, they should be able to understand the trade-off among various components, such as CPU clock speed vs. memory size.

- AR1. *Digital logic and digital systems* (6)
- AR2. *Machine level representation of data* (3)
- AR3. *Assembly level machine organization* (9)
- AR4. *Memory system organization and architecture* (5)
- AR5. *Interfacing and communication* (3)
- AR6. *Functional organization* (7)
- AR7. *Multiprocessing and alternative architectures* (3)
- AR8. Performance enhancements
- AR9. Architecture for networks and distributed systems

Operating Systems (OS)

An operating system defines an abstraction of hardware behavior with which programmers can control the hardware. It also manages resource sharing among the computer's users. The topics in this area explain the issues that influence the design of contemporary operating systems. Courses that cover this area will typically include a laboratory component to enable students to experiment with operating systems.

Over the years, operating systems and their abstractions have become complex relative to typical application software. It is necessary to ensure that the student understands the extent of the use of an operating system prior to a detailed study of internal implementation algorithms and data structures. Therefore, these topics address both the use of operating systems (externals) and their design and implementation (internals). Many of the ideas involved in operating system use have wider applicability across the field of computer science, such as concurrent programming. Studying internal design has relevance in such diverse areas as dependable programming, algorithm design and implementation, modern device development, building virtual environments, caching material across the Web, building secure and safe systems, network management, and many others.

- OS1. *Overview of operating systems* (2)
- OS2. *Operating system principles* (2)
- OS3. *Concurrency* (6)
- OS4. *Scheduling and dispatch* (3)
- OS5. *Memory management* (5)
- OS6. Device management
- OS7. Security and protection
- OS8. File systems
- OS9. Real-time and embedded systems
- OS10. Fault tolerance
- OS11. System performance evaluation
- OS12. Scripting

NetCentric Computing (NC)

Recent advances in computer and telecommunications networking, particularly those based on TCP/IP, have increased the importance of networking technologies in the computing discipline. Net-centric computing covers a range of subspecialties, including computer communication network concepts and protocols, multimedia systems, Web standards and technologies, network security, wireless and mobile computing, and distributed systems.

Mastery of this subject area involves both theory and practice. Learning experiences that involve hands-on experimentation and analysis are strongly recommended, as they reinforce student understanding of concepts and their application to real-world problems. Laboratory experiments should involve data collection and synthesis, empirical modeling, protocol analysis at the source code level, network packet monitoring, software construction, and evaluation of alternative design models. All of these are important concepts that can best be understood by laboratory experimentation.

- NC1. *Introduction to net-centric computing* (2)
- NC2. *Communication and networking* (7)
- NC3. *Network security* (3)
- NC4. *The Web as an example of client-server computing* (3)
- NC5. Building Web applications
- NC6. Network management
- NC7. Compression and decompression
- NC8. Multimedia data technologies
- NC9. Wireless and mobile computing

Programming Languages (PL)

A programming language is a programmer's principal interface with the computer. More than just knowing how to program in a single language, programmers need to understand the different styles of programming promoted by different languages. In their professional life, they will be working with many different languages and styles at once, and will encounter many different languages over the course of their careers. Understanding the variety of programming languages and the design trade-offs between the different programming paradigms makes it much easier to master new languages quickly. Understanding the pragmatic aspects of programming languages also requires a basic knowledge of programming language translation and runtime features such as storage allocation.

- PL1. *Overview of programming languages* (2)
- PL2. *Virtual machines* (1)
- PL3. *Introduction to language translation* (2)
- PL4. *Declarations and types* (3)
- PL5. *Abstraction mechanisms* (3)
- PL6. *Object-oriented programming* (10)
- PL7. *Functional programming*
- PL8. *Language translation systems*
- PL9. *Type systems*
- PL10. *Programming language semantics*
- PL11. *Programming language design*

Human-Computer Interaction (HC)

Emphasis is placed on understanding human behavior with interactive objects, knowing how to develop and evaluate interactive software using a human-centered approach, and general knowledge of human-computer interaction design issues with multiple types of interactive software.

- HC1. *Foundations of human-computer interaction* (6)
- HC2. *Building a simple graphical user interface* (2)
- HC3. *Human-centered software evaluation*
- HC4. *Human-centered software development*
- HC5. *Graphical user-interface design*
- HC6. *Graphical user-interface programming*
- HC7. *HCI aspects of multimedia systems*
- HC8. *HCI aspects of collaboration and communication*

Graphics and Visual Computing (GV)

The area encompassed by graphics and visual computing is divided into four interrelated fields:

- *Computer graphics.* Computer graphics is the art and science of communicating information using images that are generated and presented through computation. This requires (a) the design and construction of models that represent information in ways that support the creation and viewing of images, (b) the design of devices and techniques through which the person can interact with the model or the view, (c) the creation of techniques for rendering the model, and (d) the design of ways the images can be preserved. The goal of computer graphics is to engage the person's visual centers alongside other cognitive centers in understanding.
- *Visualization.* The field of visualization seeks to determine and present underlying correlated structures and relationships in both scientific (computational and medical sciences) and more abstract datasets. The prime objective of the presentation should be to communicate the information in a dataset so as to enhance understanding. Although current techniques of visualization exploit visual abilities of humans,

- GV1. *Fundamental techniques in graphics* (2)
- GV2. *Graphic systems* (1)
- GV3. *Graphic communication*
- GV4. *Geometric modeling*
- GV5. *Basic rendering*
- GV6. *Advanced rendering*
- GV7. *Advanced techniques*
- GV8. *Computer animation*
- GV9. *Visualization*
- GV10. *Virtual reality*
- GV11. *Computer vision*

Graphics and Visual Computing (GV), continued

other sensory modalities, including sound and haptics (touch), are also being considered to aid the discovery process of information.

- *Virtual reality.* Virtual reality (VR) enables users to experience a three-dimensional environment generated using computer graphics, and perhaps other sensory modalities, to provide an environment for enhanced interaction between a human user and a computer-created world.
- *Computer vision.* The goal of computer vision (CV) is to deduce the properties and structure of the three-dimensional world from one or more two-dimensional images. The understanding and practice of computer vision depend on core concepts in computing but also relate strongly to the disciplines of physics, mathematics, and psychology.

Intelligent Systems (IS)

The field of artificial intelligence (AI) is concerned with the design and analysis of autonomous agents. These are software systems and/or physical machines, with sensors and actuators, embodied, for example, within a robot or an autonomous spacecraft. An intelligent system has to perceive its environment, to act rationally toward its assigned tasks, and to interact with other agents and with human beings.

These capabilities are covered by topics such as computer vision, planning and acting, robotics, multiagent systems, speech recognition, and natural language understanding. They rely on a broad set of general and specialized knowledge representations and reasoning mechanisms, on problem solving and search algorithms, and on machine learning techniques.

Artificial intelligence also provides a set of tools for solving problems that are difficult or impractical to solve with other methods. These include heuristic search and planning algorithms, formalisms for knowledge representation and reasoning, machine learning techniques, and methods applicable to sensing and action problems such as speech and language understanding, computer vision, and robotics, among others. The student needs to be able to determine when an AI approach is appropriate for a given problem and to be able to select and implement a suitable AI method.

- IS1. *Fundamental issues in intelligent systems (1)*
- IS2. *Search and constraint satisfaction (5)*
- IS3. *Knowledge representation and reasoning (4)*
- IS4. *Advanced search*
- IS5. *Advanced knowledge representation and reasoning*
- IS6. *Agents*
- IS7. *Natural language processing*
- IS8. *Machine learning & neural networks*
- IS9. *AI planning systems*
- IS10. *Robotics*

Information Management (IM)

Information management (IM) plays a critical role in almost all areas where computers are used. This area includes the capture, digitization, representation, organization, transformation, and presentation of information; algorithms for efficient and effective access and updating of stored information; data modeling and abstraction; and physical file storage techniques. It also encompasses information security, privacy, integrity, and protection in a shared environment. The student needs to be able to develop conceptual and physical data models, determine what IM methods and techniques are appropriate for a given problem, and be able to select and implement an appropriate IM solution that reflects all suitable constraints, including scalability and usability.

- IM1. *Information models and systems (3)*
- IM2. *Database systems (3)*
- IM3. *Data modeling (4)*
- IM4. *Relational databases*
- IM5. *Database query languages*
- IM6. *Relational database design*
- IM7. *Transaction processing*
- IM8. *Distributed databases*
- IM9. *Physical database design*
- IM10. *Data mining*
- IM11. *Information storage and retrieval*
- IM12. *Hypertext and hypermedia*
- IM13. *Multimedia information & systems*
- IM14. *Digital libraries*

Social and Professional Issues (SP)

Although technical issues are obviously central to any computing curriculum, they do not by themselves constitute a complete educational program in the field. Students must also develop an understanding of the social and professional context in which computing is done.

Undergraduates also need to understand the basic cultural, social, legal, and ethical issues inherent in the discipline of computing. They should understand where the discipline has been, where it is, and where it is heading. They should also understand their individual roles in this process, as well as appreciate the philosophical questions, technical problems, and aesthetic values that play an important part in the development of the discipline.

Students also need to develop the ability to ask serious questions about the social impact of computing and to evaluate proposed answers to those questions. Future practitioners must be able to anticipate the impact of introducing a given product into a given environment. Will that product enhance or degrade the quality of life? What will the impact be upon individuals, groups, and institutions?

Finally, students need to be aware of the basic legal rights of software and hardware vendors and users, and they also need to appreciate the ethical values that are the basis for those rights. Future practitioners must understand the responsibility that they will bear and the possible consequences of failure. They must understand their own limitations as well as the limitations of their tools. All practitioners must make a long-term commitment to remaining current in their chosen specialties and in the discipline of computing as a whole.

- SP1. *History of computing* (1)
- SP2. *Social context of computing* (3)
- SP3. *Methods and tools of analysis* (2)
- SP4. *Professional and ethical responsibilities* (3)
- SP5. *Risks and liabilities of computer-based systems* (2)
- SP6. *Intellectual property* (3)
- SP7. *Privacy and civil liberties* (2)
- SP8. Computer crime
- SP9. Economic issues in computing
- SP10. Philosophical frameworks

Software Engineering (SE)

Software engineering is the discipline concerned with the application of theory, knowledge, and practice for effectively and efficiently building software systems that satisfy the requirements of users and customers. Software engineering is applicable to small-, medium-, and large-scale systems. It encompasses all phases of the life cycle of a software system. The life cycle includes requirement analysis and specification, design, construction, testing, and operation and maintenance.

Software engineering employs engineering methods, processes, techniques, and measurement. It benefits from the use of tools for managing software development, analyzing and modeling software artifacts, assessing and controlling quality, and for ensuring a disciplined, controlled approach to software evolution and reuse. Software development, which can involve an individual developer or a team of developers, requires choosing the tools, methods, and approaches that are most appropriate for a given development environment.

The elements of software engineering are applicable to the development of software in any computing application domain where professionalism, quality, schedule, and cost are important in producing a software system.

- SE1. *Software design* (8)
- SE2. *Using APIs* (5)
- SE3. *Software tools and environments* (3)
- SE4. *Software processes* (2)
- SE5. *Software requirements and specifications* (4)
- SE6. *Software validation* (3)
- SE7. *Software evolution* (3)
- SE8. *Software project management* (3)
- SE9. Component-based computing
- SE10. Formal methods
- SE11. Software reliability
- SE12. Specialized systems development

Computational Science and Numerical Methods (CN)

From the earliest days of the discipline, numerical methods and the techniques of scientific computing have constituted a major area of computer science research. As computers increase their problem-solving power, this area—like much of the discipline—has grown in both breadth and importance. At the end of the millennium, scientific computing stands as an intellectual discipline in its own right, closely related to but nonetheless distinct from computer science.

Although courses in numerical methods and scientific computing are extremely valuable components of an undergraduate program in computer science, none of the topics in this area are part of the CC2001 core knowledge. This knowledge remains a vital part of the discipline but need not be a part of every program.

For those who choose to pursue it, this area offers exposure to many valuable ideas and techniques, including precision of numerical representation, error analysis, numerical techniques, parallel architectures and algorithms, modeling and simulation, and scientific visualization.

- CN1. Numerical analysis
- CN2. Operations research
- CN3. Modeling and simulation
- CN4. High-performance computing

