Information Technology workers in the new economy

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Although the dot-com bubble has burst, demand continues to grow for skilled information technology (IT) professionals.[1] This is because IT products and services—and the workers who provide them—are found throughout the economy. The largest group is employed in computer services firms, but large fractions also work in manufacturing, financial industries, government, and retail and wholesale trade.[2] High turnover, as well as growing demand, contributes to employers' ongoing scramble to fill IT vacancies. At the same time, it is increasingly clear that IT plays a significant role in increasing national productivity and sustaining economic growth.[3] Therefore, it is important to look for solutions to meeting the Nation's need for IT and skilled IT professionals.

Some observers argue that the Bureau of Labor Statistics projection that the number of jobs for computer systems analysts and computer engineers and scientists would double between 1998 and 2008 is too low.[4] (According to BLS projections, computer programming jobs will grow at a more moderate pace, increasing by about 29 percent over the same 10-year period.) Those projections suggest IT jobs will grow slightly more than 7 percent per year over the decade, far more quickly than the 1.4-percent average across all jobs. Moreover, the ratio of annual job openings due to growth and *net* replacement needs is about twice that for all occupations. This indicates that the number of new domestic entrants to the occupation—an appropriate measure of minimum training requirements—is low relative to the rapidly growing number of available job openings.

One response to this situation has been an increase in the numbers of skilled foreign workers allowed to work in the United States under temporary "H-1B" visas.[5] Although offshore talent will help to fill some vacancies in the short term, much can be done to develop and deploy the IT skills of U.S. workers. Such initiatives would involve several levels of effort: (1) creative management of IT talent at the firm level; (2) an overall strategy for the public and private education and training communities; and (3) innovative training initiatives at the regional or industry level.

Education strategies aimed at increasing the supply of future IT workers can address employers' long-term needs for skilled workers. Many public and private providers of IT training are expanding their enrollments in response to growing demand. However, graduates of these programs who lack substantive work experience in the field for which they have trained will sometimes have difficulty finding work in that field. Education and training programs that include structured internships can help overcome this problem. Internships can be designed to allow students or trainees to test and refine theories and skills learned in the classroom or on the Web, providing a more complete set of technical and world-of-work skills needed to succeed and stay in the IT profession.

To keep pace with the rapid changes in the computer industry, IT graduates, such as those entering the workforce today, require ongoing formal training and informal learning opportunities, as well as a supportive work organization that encourages them to use and further develop their skills. A training consortium would enhance efforts to increase training and reorganize work for improved productivity. In the short term, more efficient management of current IT staff, including greater opportunities for formal training and informal on-the-job learning, would reduce turnover. In addition, well-developed training and staffing programs would allow employers to more easily fill vacancies by recruiting and retraining workers currently employed in other fields.

Redesigning initial IT education

In response to growing demand, more students are enrolling in IT fields at 2- and 4-year colleges. For example, the number of 2-year colleges offering degrees in computer science or information systems grew by about 15 percent during the first half of the 1990s,[6] and the number of associate degrees in these fields grew from 7,677 to 9,152 over this period.[7] Following a drop between 1986 and 1995, enrollment in 4-year IT programs began to rebound in the late 1990s, and the number of degrees awarded grew from 24,098 in 1995–96 to 26,852 in 1997–98.[8] However, institutional factors, including a lack of faculty and computing facilities, could restrain the growth pace at 2- and 4-year institutions.

Private providers of short-term, technology-specific IT skills training have also grown rapidly in response to growing demand. These training courses are offered via the Internet; some involve partnerships between colleges and private IT vendors to provide a mix of online, classroom, and hands-on training. Full-time students, working adults, and those who are interested in entering IT occupations often take these classes to prepare for an examination leading to certification of skills. Since 1989, when Novell awarded the first such certificate, the number has grown dramatically around the world, reaching an estimated total of 2.5 million IT skills certificates awarded to date.[9]

Even with this rapid growth in private training, and even if 2- and 4-year colleges could rapidly expand their enrollments, the increased numbers of graduates might not meet the Nation's

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need for IT products and services. This is because most current programs, whether offered in traditional classroom settings or on the Internet, often operate in isolation from the realities of the workplace. For example, many IT workers begin their training by majoring in electrical engineering. Both cognitive theory and an examination of actual engineering design practice suggest engineering is best learned through experiences that integrate learning and application. However, most current engineering education programs teach design and analysis as abstract concepts, in separate classes.[10] More integrated classroom experiences, and increased attention to the economic, social, and cultural factors influencing engineering practice in the workplace, could reduce this problem and enhance learning.

In addition to making IT education programs more reflective of the workplace, education and training providers should offer structured internships to all students. The work assigned in these internships should be closely aligned with the educational curriculum, and company supervisors should work closely with faculty. Some successful U.S. IT firms actively recruit computer science graduates from the University of Waterloo in Ontario, Canada, in part based on graduates' internship experiences.[11] Also, the Northern Virginia Regional Partnership supports a variety of short-term retraining programs aimed at adults wishing to enter IT careers. Among these, the program with the highest job placement rate is the Technology Retraining Internship Program, which includes a 3-month, half-time internship as part of the 6-month program.[12]

Situated learning

Discussions about ways to increase supply in order to meet growing demand for information technologists typically center on the number of college graduates with 4-year degrees in computer science or electrical engineering. Over the past 20 years, college-level IT majors have emerged and grown rapidly. The supply of college graduates with IT concentrations grew dramatically between 1976, when fewer than 6,000 degrees were awarded, and 1986, when nearly 40,000 students graduated.[13] In 2000, an estimated 42,000 bachelor's degrees in computer science and engineering were awarded by U.S. and Canadian institutions.[14] Despite this rapid growth, demand for IT professionals still outstrips the supply of graduates, and employers have developed other channels for obtaining a workforce with the necessary skills.

From the earliest days of computer development, when no formal education programs existed, until today, employers have hired individuals from a variety of backgrounds. Using BLS data, one analyst examined the educational credentials among people in four important IT professions—computer scientists, computer engineers, systems analysts, and computer programmers—in 1998. These professionals were generally highly educated, with two-thirds holding a bachelor's or postgraduate degree. However, one-third of them (mostly programmers) had either a 2-year degree or only a high school diploma. Perhaps most surprising, less than half had a bachelor's or higher degree with a major or minor in computer science or related discipline.[15]

The reality that many individuals without extensive formal IT education are employed in IT professions reflects the importance of an often-ignored route to skill development—informal, or "situated," learning on the job. Studies of software support personnel, and microcomputer and network technicians reveal the value of informal learning.[16] These studies indicate that individuals and groups were able to solve IT problems and develop innovative approaches based on the knowledge gained through day-to-day work experience with others and technical systems themselves. A more recent survey of young IT professionals reached similar conclusions, finding that these IT workers spent about half of their work time working with others and seeking information.[17] These young professionals turned frequently to their work team members for information, and found them to be the most valuable information sources. Those IT professionals who were able to build communications ties with experienced workers in their field had the most successful job performance. This research suggested that work experience of young IT workers might have a greater impact on their long-term job performance than formal education.

Recruiters and employers recognize the power of learning through experience. In job advertisements and in IT workforce committee testimony, employers often stressed that demonstrated ability and experience were the most important hiring factors—college degrees and ranking were secondary factors.[18] When the Information Technology Association of America recently interviewed hundreds of IT hiring managers about their preferences, 47 percent indicated that hands-on experience was an important qualification, second only to strong knowledge of the relevant technical area.[19]

Why do IT skills learned through formal education and training often fail to transfer into improved job performance? Experts identify social and contextual factors as critical. For example, if a worker receives training in a new skill, but has no opportunity to apply and refine the new skills at work, the training will have no impact on job performance. Similarly, the degree to which the trained worker is supported in applying the new skills also influences the degree to which training transfers to the job.[20] Keith Rollag's research into the experience of new engineers in Silicon Valley IT firms illustrates how social and work context affect transfer of skills learned in formal

education.[21] Rollag found that, in general, new engineers were often reluctant to express their opinions and lacked confidence in their abilities, reducing their contributions to the work at hand. However, new engineers lost these "newcomer" feelings more quickly in start-up firms than they did in more established companies, even though the start-up firms had fewer training and orientation programs. He suggested that this may happen because employees with only a few months of start-up experience were treated as newcomers by more senior coworkers, but as "old-timers"—with superior knowledge and skills—by more recent arrivals.

Although the majority of IT workers are not employed in start-up firms, Rollag also identified several practices in start-up firms that helped assimilate new engineers, motivating them to be "highly productive and satisfied with their careers."[22] These simple steps include giving new workers important projects, allowing them to open or close the office, inviting them to join more senior staff for lunch, encouraging them to ask questions, asking them questions and indicating that their opinions are valued and providing frequent feedback. By taking such steps, skills of IT workers could be more fully utilized.

Integrating work and informal learning

As well as assigning jobs and organizing work in ways that encourage transfer of skills to the tasks at hand, companies can restructure their training programs to draw on the power of informal learning. For example, in 1995, one large computer manufacturer reorganized its management training based on the assumption that most "students" already understood the basics.[23] Moving toward an experiential approach, the company introduced shorter training sessions, focusing on intact work groups to build teamwork. The training included classroom exercises based on participants' actual challenges and problems on the job, smaller class sizes, and providing training at the job's location. In short, the goal was to see training as an organizational intervention, rather than a program.

Another large technology-based company has also developed a training approach that recognizes and builds on the power of informal learning. The company found the performance of new sales representatives, following training at a central site, was unacceptably low. In addition, turnover was high among new sales representatives, many did not attend the formal training, and the training's travel costs were too high. To address these problems, the company worked with consultants to develop an innovative training program designed to support and leverage the learning that already happens on the job.

The new program was based on a corps of mentors who supported the new hires, helping them to incrementally build their knowledge and skills and develop relationships within their work communities. The goal was to help new employees put their training into practice. Following a successful pilot test, the corporation implemented this support system nationally in 1999.[24]

Overcoming barriers to training

Despite the potential benefits to improved management and IT worker training, high turnover and time pressures discourage employer investments in these areas. In IT firms rushing to bring products to market, and in manufacturing and other industries that rely heavily on IT, time pressures encourage assigning IT professionals to jobs or projects that match their current skills. This reduces opportunities for challenging job assignments that help employees develop new skills.

To overcome these disincentives to invest in training, employers of IT workers could share training costs. Shared training would help overcome the "free rider" problem that results when some firms (often the larger firms) invest in education and training; other firms then recruit the trained employees. Member companies would pool their training resources and achieve economies of scale.[25]

IT employers in several areas of the country already have taken steps in this direction. For example, Silicon Valley's survey of the many business-education partnerships working to educate and train current and future IT workers found that existing efforts were "fragmented and unsustainable," and called for a "comprehensive and regional approach."[26]

In another effort to share the costs and benefits of improving workforce skills, the Massachusetts Software Council sends volunteer IT workers into schools, both to improve network connections and to educate students about IT careers. The Council also arranges internships for college students and recent graduates. For 3 years, the Council operated a successful program that combined classroom training and internships to retrain and re-employ displaced IT career workers. Ninety percent of the workers, whose ages ranged from 40 to 60, were placed in new jobs at an average annual salary of $55,000, but the program was discontinued when State and Federal funds ran out.

To create more stable shared training initiatives, employers of IT workers may want to consider the model of a regional training consortium. In this model, employers not only identify skill needs, but also provide sustained funding and participate in training design and delivery. Active participation enhances member firms' commitment to the consortium, and is conducive to developing innovative education and training programs that link work experience with the classroom.

In several U.S. areas, firms have partnered with workers and educational institutions to form regional training consortia.[27] The range of industries and

regions includes graphic arts companies in northern California, Wisconsin metalworking firms, San Francisco hotels, Philadelphia hospitals, and the New York City garment industry. Often, these consortia are incorporated as nonprofit organizations. For example, the Graphic Arts Institute of Northern California, founded in 1968, provides desktop publishing and commercial computer graphics training to advertising, printing, and graphic design professionals. These consortia provide a cost-effective way to upgrade current employee skills, improving individual job performance and organizational effectiveness.[28] Building on stable financial support from member firms, many consortia have received additional public funds to upgrade the skills of welfare recipients and disadvantaged workers, providing member companies with skilled workers from new and untapped labor pools.[29]

Management's role

Although some observers view job vacancy rates as the key indicator of an IT worker shortfall, high turnover appears to be a bigger contributor to job vacancies than actual growth in demand. Turnover among IT professionals is much higher than among professionals in other occupations with similar education levels.[30] Although high turnover is not unusual in any type of job characterized by growing demand and increasing wages, employers may reduce turnover rates among IT staff through several strategies: improvements in planning work, and organizing, staffing, and directing workers.

Computer work is notoriously high-speed, high-bandwidth, and high-stress. Because they often grow rapidly, software development firms may rely heavily on ad hoc approaches, resulting in many over-budget projects that fail to meet customer requirements or are never completed.[31] Improved planning, more careful matching of employee skills with job requirements, and ongoing oversight could result in more realistic timelines, in software development and also in other industries that employ IT professionals. These steps would reduce the need for long hours and weekend work, thus increasing the job satisfaction and retention of skilled workers.[32] Managers could also allow more flexibility in work hours and location (including telework) as a way of retaining experienced workers who have family responsibilities.

Providing increased opportunities for formal and informal learning at work can be a key element in retaining skilled IT workers. Surveys indicate that IT workers are motivated as much by the opportunity to develop new skills as by compensation.[33] Therefore, training, on-the-job development of new skills, and promotions may increase job satisfaction and retention, providing some immediate relief to the problem of filling vacant IT positions. □

Notes

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[1] For example, The number of people employed in computer and data processing services alone grew steadily over a recent 5-month period, from 1.96 million in October 2000 to just over 2 million people in March 2001. See *The Employment Situation*, USDL 01–57 (Bureau of Labor Statistics), Mar. 9, 2001, on the Internet at **http://stats.bls.gov/newsrels.htm** (visited March 2001). The increase of nearly 50,000 new jobs is greater than the job growth over the same 5 months in late 1999 and early 2000, when only 32,000 new jobs were added.

[2] Richard Ellis and B. Lindsay Lowell, *Core Occupations of the U.S. Information Technology Workforce,* United Engineering Foundation, January 1999, on the Internet at **http://www.uefoundation.org/report1.html** (visited June 5, 2001).

[3] See, for example, U.S. Department of Commerce, Economics & Statistics Administration, *Digital Economy 2000* (Washington, DC, June 2000).

[4] See "Occupational Employment Projections to 2008" on the Internet at **http://www.bls.gov/empmlr99.htm** (visited March 2000).

[5] On October 17, 2000, President Clinton signed S. 2045, increasing the H-1B cap and H.R. 5362, increasing the fees for H-1B visas into law.

[6] Peter Freeman and William Aspray, *The Supply of Information Technology Workers in the United States* (Washington, DC: Computing Research Association, 1999), on the Internet at **www.cra.org/reports/wits** (visited June 5, 2001).

[7] *Digest of Education Statistics 2000* (U.S. Department of Education, National Center for Education Statistics), on the Internet at http://nces.ed.gov/pubs2001/digest (visited June 5, 2001).

[8] Ibid.

[9] Clifford Adelman, "A Parallel Universe Expanded: Certification in the Information Technology Guild," *Change* Magazine, 32 (3), (May/June 2000), on the Internet at **http://www.aahe.org/change/parlleluniverse.htm** (visited June 5, 2001).

[10] Charlotte Linde, M. Brereton, J. Greeno, J. Lewis and L. Leifer, "An Exploration of Engineering Learning." (Palo Alto, CA, Institute for Research and Learning, ILR Project Report #49.112,1993).

[11] Based on site visits with IT firms in Austin, Texas, and Seattle, Washington.

[12] According to David Huhn, Northern Virginia Regional Partnership, 92 percent of Technology Retraining Internship Program graduates are placed—personal communication, June 28, 2000.

[13] Clifford Adelman, *Leading, Concurrent, or Lagging? The Knowledge Content of Computer Science in Higher Education and the Labor Market* (Washington, DC, U.S. Department of Education, 1997).

[14] Ibid.

[15] Richard Ellis, "A hard look at the factors contributing to the so-called high-tech labor shortage," *Dr. Dobb's Journal*, April 2000. (Ellis designed and directed the IT Workforce Data Project, sponsored by the United Engineering and Alfred P. Sloan Foundations.)

[16] Brian T. Pentland, "Bleeding Edge Epistemology: Practical Problem Solving in Software Support Hotlines," in S. Barley and Julian Orr, *Between Craft and Science: Technical Work in U.S. Settings* (Ithaca, NY: Cornell University Press, 1997).

[17] Denis M.S. Lee, "Information Seeking and Knowledge Acquisition Behaviors of Young

Information Systems Workers: Preliminary Analysis." Paper presented at the 1999 Americas Conference on Information Systems, Milwaukee, WI, Aug. 13–15, 1999.

[18] Hal Salzman, "Information Technology Labor Markets." Preliminary Report to the NAS Committee on Workforce Needs in Information Technology, December 8, 1999.

[19] *Bridging the Gap: Information Technology Skills for a New Millennium* (Alexandria, VA, Information Technology Association of America, 2000).

[20] J. Kevin Ford, "Transfer of Training: An Updated Review and Analysis," *Performance Improvement Quarterly*, 10 (2), pp. 22–41.

[21] Keith Rollag, "From Newcomer to Oldtimer: Organizational Assimilation as an Outcome of Social Comparison" (unpublished paper, Department of Industrial Engineering & Engineering Management, Stanford University).

[22] These practices included: giving them important projects; handing them the keys to the company, by placing them in charge of opening or closing the office; inviting them to join their colleagues for lunch; encouraging them to ask questions; asking them questions to show their opinion is valued; giving them frequent feedback; sharing humor; informal mentoring by high-level managers; and feeding them pizza and stock options. See Keith Rollag, "How Start-ups Motivate New Engineers," *IEEE Spectrum*, November 1997.

[23] Linda Keegan and Betsy Jacobson, "Training Goes Modular at Apple," *Training and Development,* July 1995.

[24] Melissa Cefkin, "The Integration of Work and Learning for Xerox's New Hire Sales Representatives: A Project Review" (draft, The Institute for Research on Learning, 1999).

[25] See Margaret Hilton, "Shared training: learning from Germany," *Monthly Labor Review,* March 1991, pp. 33–37.

[26] Joint Venture: Silicon Valley, *Joint Venture's Workforce Study: An Analysis of the Workforce Gap in Silicon Valley* (San Jose, CA, 1999).

[27] *High Road Partnerships Report* (Washington, DC, AFL-CIO Working For America Institute, 2000).

[28] For example, the 12 hotels participating in the San Francisco Hotel Partnership Project have found that involving workers in designing and implementing training programs has resulted in higher scores on guest satisfaction surveys.

[29] For example, between 1997 and 1999, the Wisconsin Regional Training Partnership (WRTP) placed more than 400 workers in metalworking firms, doubling their average income. Overall, WRTP trains about 6,000 individuals annually, most of them employees of the 56 member firms.

[30] See Chapter 3, *Building a Workforce for the Information Economy.*

[31] Surveys conducted in 1994, 1996, and 1998 indicate that more than one-fourth of software development projects were canceled before completion and more than 40 percent went over their original budgets—see Jim Johnson, "Turning Chaos into Success," *softwaremag.com* (December 1999), on the Internet at **www.softwaremag.com/archive/1999dec/Success.html**.

[32] For example, inspecting for quality at the beginning of software projects reduces the need for rework and debugging at the end.—see Steve McConnell, *Software Project Survival Guide* (Redmond, WA: Microsoft Press, 1998), pp. 20–33.

[33] See, for example, Robert A. Zawacki, Carol A. Norman, Paul A. Zawacki, and Paul D. Applegate, *Transforming the Mature Information Technology Organization: Reenergizing and Motivating People.* (Colorado Springs, CO, Eaglestar Publishing, 1995).