Matching IT Jobs with IT People

Margaret Hilton, The National Academy of Sciences[1]

Abstract: Employers experience difficulties filling vacancies for Information Technology (IT) positions because of rapid growth in demand for IT workers, high turnover, and the unique characteristics of IT work. In response to growing demand for IT workers, public and private education and training providers are expanding their offerings. Both younger, full-time students and older adults working in other fields have enrolled in these programs, and many trainees and education providers receive state and/or federal financial assistance. Public and private organizations, including recruiting firms, professional associations, and state employment and training agencies are also working to match job-seekers with IT vacancies. These education, training, assessment, and job-matching services might be more successful in meeting employer's and job-seeker's needs if they were more closely aligned with employers' internal labor markets and tailored to the unique characteristics of IT work and workers.

Successfully solving IT problems requires more than theoretical knowledge or abstract skills. The solutions depend on the social and technical context of the problem at hand, and skills learned in a classroom or training program may not be directly applicable or transferable to that context. Instead, IT workers improve their ability to solve technological problems through their day-to-day experiences of working with technology, discussing problems with colleagues and customers, and reflecting on what works and what doesn't.

Experiential learning and job performance are difficult to measure. Other aspects of IT work, including rapidly-changing technology, frequent changes in projects or tasks, and shifts in project teams or entire organizations, make it extremely difficult to describe IT jobs. Lacking stable, clearly-defined job descriptions, few employers and recruiters use structured assessment methods when selecting employees. Instead, as a proxy measure of informal learning, recruiters often seek individuals with proven experience as well as training in a specific technical area. To obtain these experienced workers, employers and recruiters "poach" from other firms, fueling high turnover rates and increasing the problem of vacant IT positions.

Aligning employment, training, and job-matching services more closely with the actual requirements of IT jobs requires increased integration of work and learning. Working together to create internships for students and trainees could be the first step toward more sustained partnerships between IT employers and education and training providers. Such partnerships have the potential to reduce vacancy rates both by yielding more employable graduates and by reducing turnover among current IT workers. The regional training consortium is a promising model for creating sustainable partnerships to integrate work and learning.

[1] This article draws on National Research Council, *Building a Workforce for the Information Economy* (Washington, DC: National Research Council, 2001). However, the views expressed are those of the author alone and do not necessarily represent the views of the Committee on Workforce Needs in Information Technology, the National Research Council, or the National Academies.

1. The Problem: Filling IT Vacancies

Although the Internet investment bubble has burst, and profits are down at such successful firms as Yahoo and Intel, demand for Information Technology (IT), and skilled IT workers, has continued growing. The number of people employed in computer and data processing services (which employs about one-third of all IT professionals), grew steadily over the past five months, from 1.96 million in October, 2000 to just over 2 million people in February, 2001.[2] And, despite newspaper headlines about layoffs from bankrupt dot-coms, those laid off during the last quarter of 2000 had worked in agriculture, manufacturing, and industries other than computer services.[3]

In response to high demand and rising wages, many IT professionals frequently change jobs. In addition, recent downturns in the dot-com sector have added to the churning and turnover in IT labor markets. Taken together with continued growth in demand, turnover fuels high vacancy rates.

What can be done to meet employers' needs for skilled IT workers? One short-term solution was the decision to increase the number of skilled foreign workers, allowed to work temporarily in the U.S. on H1-B visas. Over the long term, however, better approaches to linking U.S. workers with IT vacancies must be found.

2. Defining IT Work and Skills

[2] Source: Bureau of Labor Statistics, "The Employment Situation: February, 2001," March 9, 2001 [http://stats.bls.gov/newsrels.htm]. The increase of nearly 50,000 new jobs is greater than the job growth over the same five months in late 1999 and early 2000, when only 32,000 new jobs were added.

To fill current vacancies for skilled IT workers, employers and potential employees need information on the types of jobs and skills required. Such information would enable development of education and training programs well-targeted to firms' needs. Several recent studies have attempted to provide this information, identifying the "core" knowledge and abilities needed across many different types of IT work. Although they differ slightly, the studies converge on the following list:

1) Intellectual abilities[4], including the ability to:

- Define and clarify a problem, and know when it is solved
- Understand the advantages and disadvantages of apparent solutions to problems
- Cope with unexpected consequences and troubleshoot
- Think logically and reason quantitatively[5]
- Observe, and learn from one's observations[6]
- Conceptualize, gather, organize, and analyze data

2) Understanding of basic concepts supporting IT, including

- Algorithms
- How information is represented digitally
- Basic concepts of physics and electronics[7]

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[3] BLS, "Extended Mass Layoffs in the Fourth Quarter of 2000," February 22, 2001.
[4] NAS, "IT Fluency," 1999.
[5] Clifford Adelman, "Leading, Concurrent or Lagging? The Value of IT Education in IT Careers," (Washington, DC: U.S. Department of Education, 1999, p. 11).
[6] Northwest Center for Emerging Technology, Skill Standards, p. 22)
[7] Ibid.

3) Social abilities

- Communications skills
- An understanding of one's own personality and learning style
- Translation competency (the ability to translate between the world of technology and the world of IT users)

In addition to these core, or "enduring" skills, IT workers require varying degrees of knowledge and skill in different types of technology. As hardware and software continue to change rapidly, some of these more specific skills may only be required for short periods of time. This suggests a typology of skills for IT work. Within both the "enduring" and "perishable" categories are skills that are "hard," or technological, and skills that are "soft," or more general.

Table 1: Types of IT Knowledge and Abilities

	Enduring	Perishable
Hard (technological)	Intellectual abilities, including logical reasoning and the ability to apply algorithms to solve problems Understanding of basic physics and electronics concepts supporting IT	Knowledge of particular hardware or software languages or systems (e.g., COBOL, client servers, JAVA)
Soft	Social abilities, including the ability to learn from others and develop "tacit" knowledge Ability to translate between technology experts and users Knowledge of basic	Knowledge of a particular company, or industry

	business practices	

It is clear from the diagram above that IT workers require a complex and changing array of skills. However, successfully performing IT work requires more than abstract skills. For example, problem-solving is not an abstract, theoretical process. At work, problems are solved in a particular social, technological and organizational context, and "success" is defined within that context. Skills learned in a classroom, on the web, or in another job may not be directly applicable to a particular problem. Instead of relying solely on "book" knowledge, IT workers develop and refine their skills through experience, and by collaborating with others and reflecting on which approaches have worked in the past. For example, Alistair Cockburn, object-oriented programming expert and authorargues that developing software is akin to writing epic poetry, as much a collaborative knowledge-sharing as an engineering activity: [8]

> Software development is a craft, it is an engineering discipline, it is mathematical, it is a mysterious art. It is like getting a whole community to write poetry together. There are temperamental geniuses, hard requirements, communication needs, and, under it all, humans working together building something they don't quite understand.

As indicated in the title of another book, Cockburn views software development as "a cooperative, finite, goal-seeking, group game.[9]"

[8] *Surviving Object-Oriented Projects* Addison-Wesley, 1997.
[9] In press, 2001. [http://members.aol.com/humansandt/crystal/game/].

Like software developers, software support personnel and [10] microcomputer and network technicians rely on "collaborative knowledge-sharing" to successfully perform their jobs. Working individually and in groups, these workers solve IT problems and develop new approaches, based on the knowledge gained through the day-to-day experience of working with others and with the technical systems. In response to a recent survey, young IT professionals also indicated that collaborating and learning informally enhances their job performance.[11] These young professionals turned frequently to members of their work team for information, and found team members to be the most valuable sources of information. Those who were able to build relationships with older, more experienced colleagues had the most successful job performance. The author of this study suggests that work experience of young IT workers might have a greater impact on their long-term job performance than formal education.

The makeup of the current IT workforce reveals the difficulty of defining IT skills and developing education and training programs to match those skills. One "snapshot" of educational credentials among people in four important IT professions--computer scientists, computer engineers, systems analysts and computer programmers--was taken in 1998. It revealed that the 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 two-year degree or only a high school diploma. Perhaps most

[10] Brian T. Pentland, "Bleeding Edge Epistemology: Practical Problem Solving in Software Support Hot lines," in Barley and Orr, op. Cit.
[11] 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.

surprising, less than half had a bachelor's or higher degree with a major or minor in Computer Science or related discipline.[12]

The reality that many individuals without extensive formal education in IT are employed in IT professions indicates the power of informal, or "situated" learning in performing these jobs.

3. The Selection Problem

IT workers vary greatly in their productivity and quality, providing a powerful incentive to employers to select the best. For example, one study found that the performance of programs written in C and C++ varied by a factor of 30 or more, depending on which programmer had written it.[13] Because of these wide variations, organizations that can successfully identify and hire the most qualified job applicants are likely to be substantially more efficient and profitable than other organizations.[14]

[12] 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)

[13] Lutz Prechelt, "Comparing Java vs. C/C++ Efficiency Differences to Interpersonal Differences," *Communications of the ACM* , October 1999, v. 42, n. 10

[14] Kevin Murphy and Zinta Byrne, "Applications of Structured Assessment in the IT Workforce," paper prepared for the NAS Committee on Workforce Needs in Information Technology, April, 2000.

When choosing among alternative job candidates, some employers make use of structured assessment methods. These are procedures used to evaluate the skills, abilities, competencies, personal characteristics or experience of a job applicant or job incumbent. There are many types of structured assessment, ranging from interviews to pencil-and-paper IQ tests, but all have three features in common :

1. standardized administration;
2. consistent scoring rules; and
3. empirical evidence that scores are job-related.

Several types of structured assessment methods have a solid empirical basis, a long and consistent record of validity and cost-effectiveness, and have proven fair and practical.

Given employers' strong financial incentive to select the best workers, and the availability of such selection tools, one might expect that employers of IT workers would make use of them. However, in the IT industry, it appears that few employers use structured assessment methods in hiring.[15] Generalizing about assessment practices of large computer hardware and software firms is difficult, as few companies responded to a request for information about their assessment methods. In addition, many companies lacked formal Human Resources departments and most individuals contacted appeared to have little knowledge of assessment methods.

[15] Murphy and Byrne, op. Cit.

Rather than using structured assessment methods, IT firms tended to use the Internet and college campus visits to recruit and solicit resumes for entry-level positions. These resumes were then reviewed with automated screening tools. For positions requiring more skills and experience, managers screened the resumes of job candidates. Structured assessment methods, including standardized ability tests, personality inventories, biodata scoring systems, work simulations and assessment centers were rarely used. Although most IT firms relied on interviews as a key part of the hiring process, those interviews were rarely structured. Often, the Human Resources department created a structure which could then be followed, partly followed, or ignored by hiring managers. None of the organizations followed a strict structured interview approach, in which all interviewers asked the same questions and used a common scoring system. In general, IT firms seemed to prefer As an alternative, IT employers seem to prefer assessment methods that require minimal time (e.g., resume screening) or function as two-way communication (e.g., unstructured interviews) to the more uniform and precise, or "structured" assessment methods.

A few larger IT firms do use structured assessments in hiring. For example, Microsoft Corporation uses a work sample approach. All candidates for the large category of “design engineer” must take a series of software design and coding tests. Experienced programmers evaluate both the approach each candidate uses and also the specific skills the candidate applies. Microsoft managers feel that this type of detailed, one-on-one testing is the only way to determine if a job candidate really has the desired

skills. Other large firms use existing tools, including a computer aptitude test battery, to screen potential new employees.

Why do employers fail to use these available tools? There are many possible reasons, including a simple lack of information about their availability. Many small and start-up firms lack fully developed Human Resource departments, with experts in training, selection and other personnel matters. However, one important reason may be the unique characteristics of IT work. To make use of assessment tools first requires that employers decide which attributes of a job (and a potential worker) should be assessed. This, in turn, requires some systematic efforts to determine the duties, responsibilities, and requirements of the job. Although there are many methods for analyzing work and jobs, those methods have proved most successful in describing jobs that are relatively stable and well-defined. As noted above, IT workers not only require a wide-range of rapidly-changing skills and abilities (Table 1), they also develop and apply those skills in collaboration with others. Current methods of describing and analyzing jobs may be inadequate for capturing these aspects of IT work. In 1999, a National Research Council committee concluded:[16]:

> As work becomes increasingly team-based, it changes the mix of skills possessed by a typical worker and blurs traditional demarcations across occupations…To account for people factors, job analysis inventories must become sufficiently detailed to describe such work attributes as such work

[16] The Committee on Techniques for the Enhancement of Human Performance: Occupational Analysis, Changing Nature of Work: Implications for Occupational Analysis. (p. 276):

attributes as abstract analytical work, skill in the use of information technology, teamwork competencies, and skill in performing emotional work..

Because IT work is particularly fluid, and because social skills and collaboration are particularly important, describing IT jobs is particularly difficult. All methods of structured assessment are designed to help identify individuals whose current attributes (I.Q., education, personality, etc.) are most likely to lead to excellent job performance in the future. However, if the job duties may change with time, and if successful job performance depends in part on informal learning in collaboration with others, existing methods of structured assessment methods may be weak tools for selecting the best IT workers.[17]

4. The Training Gap

Recognizing the power of informal learning, and faced with the difficulty of clearly defining all of the skills and abilities required for IT jobs, recruiters often focus on technical skills. They typically seek people with some years of experience (often 3 to 5) in particular programming languages, applications, or hardware systems.[18]

It is not surprising that employers search for IT workers with existing skills and experience, rather than training them in-house. According to human capital theory, firms are unwilling to finance the training of workers in "general" education or skills, because

[17] see, for example, Malcolm Gladwell, "The New-Boy Network: What Do Job Interviews Really Tell Us," *The New Yorker,* May 29, 2000.
[18] Thomas York, "Why are Employers so Picky?" *Infoworld*, November 22, 1999 [www.inforworld.com/articles/ca/xml/99/11/22/991122cajob.xml].

the workers might leave, taking this training with them. According to this theory firms are willing to make some investment in training workers in company-specific skills.[19]

Some economists have questioned the predictions of human capital theory because they are based on the assumption that labor markets operate in perfect competition, with each worker's salary reflecting his or her true productivity. Perfect competition does not describe all labor markets,[20] and, in some situations, employers do finance the costs of general training.[21] In one study, economists found that scientists and engineers whose firms paid for their graduate education were less likely to quit than other scientists and engineers who paid for their own education.[22] The authors of this analysis suggested that company investments in broad transferable training can provide "insurance" against the loss of investments in firm-specific training by reducing turnover.

Nevertheless, the high turnover in IT jobs does reduce employers' incentive to train IT workers. Yet, continual changes in technology require IT workers to continually update their skills. Knowledgeable observers suggest that, to maintain technology skills, IT workers must spend 1.5 to 2 hours per day (or 7.5 to 10 hours per week) in continuing education and/or training. For example, a representative of a large IT professional association told the Committee that IT workers spend 9 to 10 hours per week reading on

[19] Gary Becker, *Human Capital: A Theoretical and Empirical Analysis With Special Reference to Education,*. New York: 1975

[20] Daron Acemoglu and Joern-Steffen Pischke, "The Structure of Wages and Investment in General Training," *Journal of Political Economy* , 1999, vol. 107, no. 3, pp. 539-572.

[21] David Autor, "Why Do Temporary Help Firms Provide Free General Skills Training?"1999

[22] Feuer, Glick and Desai, "Firm Financed Education and Specific Human Capital: A Test of the Insurance Hypothesis, in 1989;

their own time "to keep up technically and professionally."[23] An IT job placement specialist[24] recommends that IT workers who want to remain employable, spend "a couple of hours a day" reading, attending conferences, and learning informally from other IT professionals. A representative of another job placement and retraining company who recommends that IT workers continually "relearn everything you've learned," follows his own advice by spending his 1.5 hour daily commute studying technical manuals.[25]

Some IT workers, like the person who reads on the train, may be willing and able to spend 10- 20% of their own time in educational activities. However, for those with families or other commitments, training provided at work by the employer is the only feasible route to keeping skills up to date. Available evidence indicates a rather large gap between the amount of training provided by employers in high technology industries, including IT firms, and the estimated one to two hours per day required to keep an IT worker's skills current. High technology companies, including IT companies[26], provide their workers with about 8 minutes of formal training per day (a level that is still higher than that provided to workers in non-high tech companies).[27] Adding informal training to these figures roughly doubles the amount of training, to about 15 minutes per day.[28]

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[23] John Keaton, Manager, Research and Planning, IEEE Computer Society, made up of 104,000 IT professionals. (The Society is a division of the Institute for Electrical and Electronic Engineering), testimony to the Committee on IT Workforce Needs, Tuesday, February 29, 2000.

[24] Steve Gallison, Professional Outplacement Assistance Center, testimony to the Committee on IT Workforce Needs, Tuesday, February 29, 2000.

[25] Jim Holder, Program Manager, Alternative Resources Corp. (a staffing company that retrains older, disabled, veterans, and welfare recipients for IT jobs), cited in Lisa Vaas, "Recycling Wiscom," PC Week Online, November 1, 1999.

[26] Both of the estimates included in this paragraph are based on a definition of IT that includes manufacturers of computer and communications equipment, as well as computer services.

[27] The small group of training-intensive IT firms that belong to the ASTD benchmarking forum report that, during 1998, they provided their employees with 29 hours of formal training annually, the equivalent of 7-8 minutes per day. This is quite similar to the Bureau of Labor Statistics estimate that high technology employers provide about 34 hours of formal training per year, based on a large, nationally representative

Formal training is not the only way to keep skills current. However, the same intense competitive pressures that discourage investments in workers' formal training may also discourage companies from allowing employees to learn through experience on the job. Companies racing to bring new products to market and encountering difficulties in recruitment and hiring have a strong incentive to keep workers where they are most productive. A worker who is highly adept and productive using "old" technology may be kept on jobs using just that technology. A worker who wants to move into a job involving the latest technology may have to quit, or threaten to quit, in order to gain that experience

5. Policies to Integrate Work and Learning

Cognitive scientists have found that expertise in many fields, including computer programming, is based on the ability to quickly apply content knowledge in response to a

survey.(See ASTD, State of the Industry Report 2000. (Alexandria, Virginia: American Society for Training and Development, 2000).

[28] In response to a request from the American Electronics Association, Bureau of Labor Statistics staff compared data on training in IT with training in all other industries. (Harley Frazis, et al, "Results from the 1995 Survey of Employer-Provided Training," Monthly Labor Review, June 1998.) Drawing on a large, nationally representative survey of firms and a smaller survey of workers, BLS estimated that IT firms provide employees with 64 hours of both formal and informal training per year, or about 15 minutes per day. (The data for the BLS survey was drawn from the BLS 1995 survey of a nationally representative sample of companies with 50 or more employees. About 1,000 employers completed detailed logs on formal training activities, and about 1,000 randomly-selected employees in the same firms provided detailed logs of informal as well as formal training. The employees were asked to report any activity in which they were taught a skill or provided with new information to help them do their job better. The resulting data are more detailed and accurate than previous estimates of informal training, but the small sample size and relatively short time period of the logs make the data on informal training less precise than the data on formal training.)

particular situation or problem.[29] Because expertise depends in part on the work context, developing it requires a greater integration of IT work and IT learning.

Some companies, and some education and training providers, both within and outside of IT, are experimenting with more integrated approaches. For example, the Xerox Corporation has adopted "situated" training for its new sales agents. The new approach supports and leverages learning that was already occurring by offering a support system to agents in the field. The new system builds on the new hire's knowledge and skill incrementally, and helps the new hire develop relationships within his or her work communities. Its goal was to enable the new hire's ability to put the training into practice in the context in which it would be used. Following a successful pilot test, this support system was implemented nationally in 1999.[30] Although national data are not yet available, anecdotal evidence indicates the program has been very successful. For example, one group of new hires, while still participating in the eight week training program, together sold over $1 million of Xerox equipment.

Companies that have drawn on the situated perspective to change their training programs have generally found that the new approaches are less expensive. They involve less time away from productive work, which is the most expensive component of most company training. In addition, they require less expense for classroom space and trainer

[29] National Research Council, *How People Learn: Brain, Mind, Experience and School.* (Washington, DC: National Academy Press, 1999).

[30] 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).

salaries, because they more frequently take place in the regular workplace and may use a manager or facilitator, rather than a training specialist.

Changes in curriculum and instruction within education and training institutions might also help to better prepare students for IT work. Many IT workers receive their initial education in electrical engineering, and, in most current engineering education, design and analysis are taught in separate classes. However, both cognitive theory and an examination of actual engineering design practice suggest engineering is best learned through integrated experiences. As an alternative, researchers engaged students in novel exercises, which integrated problem formulation, analysis, and synthesis.[31] These exercises encouraged students to ask questions. The researchers designed the new exercises based on videotapes that illuminate how students apply formal knowledge in practice, how they learn, and the social context in which they learn. Finally, they examined the use of the new exercises as a form of educational assessment.

Other experts argue that current engineering education focuses too exclusively on the abstract objects of engineering design,[32] ignoring the reality that design takes place within a larger social and organizational context. These authors suggest that engineering should teach all aspects of design, including the process of negotiating among interested parties, as well as the feasibility of manufacturing, construction, assembly, prototyping and cost. Students should be presented with open-ended problems that encourage them to

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

ask a variety of questions, not only questions specifically related to engineering. This, in turn, suggests that engineering faculty should act as coaches or mentors, and should have broad backgrounds, not narrowly specialized expertise.

Information Technology itself allows the development of new tools that build on the social aspects of learning. For example, computer scientists at Georgia Institute of Technology have developed a virtual on-line learning environment where children aged 8 to 14 (as well as interested adults) log on to create and program objects, places, and creatures.[33] By writing about and conversing in a text-based programming language, they enhance their writing skills. At the same time, as the children interact with the environment (for example, by teaching their pet creature to bark or roll over), they learn object-oriented programming skills. MOOSE Crossing users log on to the virtual environment from home, school, and after-school programs at times that are convenient for them.

MOOSE Crossing was designed to create a social learning community. Because the on-line community includes strong female as well as male role models and an appreciative audience for completed projects, it encourages self-motivated learning, and helps to overcome "technophobia." Most young people participating in MOOSE Crossing have learned to write basic input-output scripts, a few have learned to incorporate conditionals, variables, and properties into their scripts, and a few have learned skills of list manipulation and control flow.

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[32] Louis L. Bucciarelli and Sarah Kuhm, "Engineering Education and Engineering Practice; Improving the Fit," in Stephen R. Barley and Julian E. Orr, Between Craft and Science , op. Cit.

However, changes in educational institutions, or in companies, by themselves, may be inadequate to enhance job performance, reduce training costs, and match people with IT vacancies. Programs that bridge the gap between training programs and companies are needed. All education and training programs may want to consider including structured internships as part of their curriculum. Because of the difficulty of assessing IT skills and future job performance, internship experiences provide a critical opportunity for managers to see first-hand what an individual might bring to the workplace. Education and training programs that include internships as a central part of the curriculum often have high job placement rates. For example, 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.[34] 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[35] is the Technology Retraining Internship Program (TRIP), which includes a three-month, half-time internship as part of the six-month program.

Ongoing internships and other efforts to integrate work and learning require sustained partnerships between IT employers and education and training providers. In many regions of the country, IT employers have formed alliances to undertake such efforts through organizations such as Joint Venture: Silicon Valley, the Massachusetts

[33] Amy Bruckman, "Community Support for Constructionist Learning," CSCW 7:47-86. 1998.
[34] Based on site visits with IT firms in Austin, Texas and Seattle, Washington.
[35] According to David Huhn, Northern Virginia Regional Partnership, 92% of TRIP graduates are placed—personal communication, June 28, 2000.

Software Council, the Maryland High Technology council, the Northern Virginia Regional Partnership and the New York New Media Association.

To date, these regional groups have focused primarily on training new entrants to the IT field. Often, the first step in this process is to analyze the local education and training system. For example, Joint Venture: Silicon Valley commissioned a study that not only examined the availability of skilled IT workers, but also surveyed local high school students to assess their knowledge of, and interest in, pursuing IT careers.[36] This study found that the many business-education partnerships already working to educate and train current and future IT workers in Silicon Valley were "fragmented and unsustainable," and called for a "comprehensive and regional approach."

One such alliance, the Massachusetts Software Council (MSC) sends volunteer IT workers into schools, both to improve network connections and also to educate students about IT careers, and arranges internships for college students and recent graduates. In addition, for three years, the MSC operated a successful "software fellows" program that combined classroom training and internships to retrain and re-employ displaced workers in IT careers. 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. Lacking stable financial

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

support from employers, this program was stopped when state and federal funding ran out.[37]

As these regional initiatives seek sustainable approaches to meeting employers' needs for skilled IT workers, they might learn from the example of the training consortia that exist in other industries. These training consortia receive sustained funding from companies in a variety of industries and regions, including metalworking firms in Milwaukee, Wisconsin, and hospitals in Philadelphia and New York. Including educational institutions and workers as partners, the consortia typically focus on increasing the skills of current employees as well as improving the education and training system that prepares new entrants. For example, the graphic arts industry in San Francisco supports a consortium that provides workshops and courses to advertising, printing, and graphic design professionals, using the latest computer hardware and software. Some firms have found that participating in a training consortium offers a cost-effective way to upgrade the skills of current employees, improving workers' job performance and enhancing customer satisfaction.[38] In addition, many consortia have created ongoing education and training programs to prepare new entrants for jobs with member companies, often with state and federal training funds.

[37] According to Suzanne Teegarden, former director of the Massachusetts Corporation for Business, Work, and Learning (CBWL), a quasi-public workforce and economic development agency, the small numbers of trainees involved (about 50 per year) made it impossible to justify further public funding.

[38] 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.