National Information Technology Workforce Convocation

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Task Force Reports

Basic Math and Science Competencies
Image of the IT Professions
Quality and Productivity Issues
Recruiting Underrepresented Groups
Responsiveness of Industry and Higher Education to Each Other's Needs
Skill Upgrading of the Current Workforce

Introduction

For complete information, please see the full Task Force report

Task Force: Basic Math and Science Competencies

The Task Force for Basic Math and Science Competencies aims at increasing interest and competency in math and science so that potential Information Technology (IT) workers possess the necessary skill sets. This Task Force recognizes several problems facing US students. There may be too few students exiting American secondary education that have the requisite skills and aptitudes to fill the immense IT workforce shortage. The Task Force has explored the following issues:

- Teachers credentialing, and how it might contribute to students' math and science competencies.
- Professional development for math/science teachers, including the idea of providing experience in the high tech workforce.
- Rigorous curricular standards.
- Project-based learning approaches linking to application in business or industry.
- Corporate and business donations to schools.

Task Force: Image of the IT Professions

People generally have a distorted and often negative image of Information Technology (IT) professions among all age groups. Children and adults may embrace a negative image of IT professionals due to their constant exposure to unflattering media images of the profession and limited exposure to, and knowledge of, real-life IT professionals. As students progress in school the involvement with IT may also become a mostly male preserve. Many adults fear new technology because of potential job displacement and a sense that preparing for those jobs requires difficult to acquire knowledge and skills. The Image of the IT Professions Task Force is working to find ways to alleviate these misconceptions by emphasizing efforts to shift the popular perception of IT jobs to reflect the dynamic, exciting opportunities that the field offers. The Task Force has identified an number of areas to consider when examining the issue.

The Task Force recommends a national level, industry led, campaign based on a partnership among industry, labor, and education with four basic themes:

- "Technology is cool, it's the future, it's exciting."
- IT professions are mainstream.
- IT professions are lucrative and stimulating.
- IT professionals are not all geniuses nor engineers or scientists with degrees.

The Task Force also suggests that a publicity campaign be generated, incorporating the education community, employers, unions, media, and parents.

Task Force: Quality and Productivity Issues

The Task Force for Quality and Productivity Issues concentrates on efforts to maintaining a high-quality, cost-efficient Information Technology (IT) workforce.

The global competitiveness of US software development may be weakening in terms of the productivity and cost structure of its software engineering workforce.

There may be a need for new economic indicators relating to IT and the development of an educational/training infrastructure to allow the US to produce world-class software engineers. The Quality and Productivity Task Force has examined some of the following issues:

- Encouraging start-ups to attract outside investment.
- Developing new skills and competencies in the existing workforce; laying the foundation for the next generation high performance workforce.
- Increasing education opportunities to increase the body of trained people.
- Evaluating the efficacy of both 4-year colleges and community colleges in training people in the IT skills needed by industry.
- Re-training of mature adults (women re-entering the workforce) and downsized engineers from other fields (civil and mechanical engineers) desiring to enter the IT programmer/software engineering field has promise.
- Development of curricula by specialists who understand the industry needs.

Task Force: Recruiting Underrepresented Groups

The Task Force On Underrepresented Groups aims to expand the pool of potential workers in the Information Technology (IT) field to include more women, minorities, vocational students, and other nontraditional IT workers.

Currently, women, minorities, people with disabilities, and mid-career and older technical professionals are underrepresented and underutilized groups in technical fields. At the same time, employers are experiencing difficulties in fulfilling their needs for highly skilled IT workers. The Task Force on Recruiting Underrepresented Groups has examined the following issues:

- Determining if teachers and guidance counselors need better information and training to help them guide underrepresented groups into the IT education and career pipeline.
- Designing math and science programs to accommodate the learning styles of girls and minorities and to make these subjects more relevant to their lives.
- Evaluating the need for women and minority groups to have greater numbers of IT mentors and role models from which to draw inspiration and guidance.
- Exploring expanded recruitment options such as technical professional societies comprised of racial and ethnic minorities.
- Encouraging partnerships with Historically Black Colleges and Universities, predominantly Hispanic Colleges and Universities, and Native American junior and community colleges based on Indian reservations.
- Companies could form partnerships with racial and ethnic minority student societies at colleges and universities.
- Ensuring that underrepresented groups have access to adequate information about the IT labor market, skills needed, and potential employers.

Task Force: Responsiveness of Industry and Higher Education to Each Other's Needs

The Task Force for Responsiveness of Industry and Higher Education strives to facilitate the exchange of information and resources so that properly skilled workers enter the marketplace. Recently, the number of students in American higher education attaining a bachelors degree in computer sciences fell drastically. Students entering higher education are choosing fields of study which are not necessarily lucrative or in demand. These issues indicate that a disconnect between industry, education, and the academic and professional aspirations of yöung Americans. The Task Force addressed these current issues:

Industry Initiatives: Fund and Support

- Money to fund IT training should also go to two-year schools, as well as four year institutions.
- At the community-college and private training level, industry needs to continue the acceleration of partnerships to address industry-specific and regional training needs.
- The business community needs to articulate broader industry needs more effectively.
- Proprietary product information should be disseminated to institutions of higher education while still protecting intellectual property rights.
- Businesses can help colleges and universities stay current through investments in higher education's existing technology and providing relevant training to teaching staff.

Higher Education Initiatives: Higher Education should work towards...

- Revising curricula more quickly.
- Providing flexible delivery methods.
- Collaborating among higher education sectors.
- Increasing opportunities for local and national industry input.
- Shifting attitudes and perceptions about workforce responsiveness.

Working Together: Areas of Cooperation could include...

- Outreach to high school students.
- A look at curriculum in general, and how to bring the needs of workforce and colleges into closer alignment.

Task Force: Skill Upgrading of the Current Workforce

The Task Force for Skill Upgrading of the Current Workforce aspires to enhance the skills of current workers so that they do not become obsolete. At present, workers are not adequately aware of the advantages of working in this new, volatile, complex industry. They may also be unaware of how to join it. The industry is moving from one specific technology to another faster than it is building the skills to support these moves. Meanwhile, some educators have just begun to be aggressive in helping companies and workers build skills. They are often not in a position to manage the rapid change or the expense of technology currency required to be fully effective in this arena. The Task Force examined the following:

- Development of a system to define careers, provide job market data then educate/train for the opportunities.
- Creation of a formal or informal group (of employers, unions, workers, and educators) to guide the IT education system.
- The need for a process of renewal for an integrated, continuous system of skill building and job changing to keep up with the pace of change in the industry.

- Creation of a system of career path documentation that would be given to workers with job market information. It is key to distinguish meaningful skills from "fad" skills.

The Task Force asked the following questions:
-Where do the unemployed get training? Do they have the opportunities the employed do?
-Would tax incentives for industry-wide consortia to address training expedite the system?
-How can we achieve more user control in the system?
-How will data on the system be made available to workers and employers?

Basic Math and Science Competencies

Implement Rigorous K-12 Mathematics and Science Education:
Solution To America's New Deficit

Issues Identified by the Task Force on Basic Mathematics and Science Competencies National Information Technology Workforce Convocation (12-13 January 1998)

EXECUTIVE SUMMARY

A thorough grounding in the principles of mathematics and science are essential to individuals who aim to contribute as a skilled workforce in the interconnected fields represented by Information Technology (IT). This common sense observation is well supported even from a cursory look at the results of a survey conducted by this Task Force. The Task Force examined the challenge of strengthening mathematics and science skills for potential IT workforce entrants. What level of achievement is necessary for varying job categories within the IT industry? Is there a minimum level of mathematics and science competency necessary for every worker in the IT industry?

The Third International Mathematics and Science Study (TIMSS), which compared the U.S. with up to 40 other nations in curriculum, teaching, and student performance at the fourth, eighth, and twelfth grade levels, has focused increased attention on the lackluster mathematics performance of U.S. students, particularly in the middle school years. The U.S. was the only country in TIMSS whose students dropped from above average performance in mathematics at the fourth grade to below average performance in mathematics at the eighth grade. And, U.S. students exhibited the smallest achievement gain in mathematics from grades four to eight of any TIMSS nation.

These results call into question our practices in mathematics education: why is achievement lagging for our middle school students? In fact, this lost potential in learning has consequences far beyond the middle school years. Even by the twelfth-grade, U.S. students do not catch up in mathematics achievement. The twelfth-grade TIMSS results will not be released until February 24, 1998, but the Second International Mathematics Study (SIMS) found that U.S. twelfth graders scored in the bottom half of all nations in all mathematics subject areas tested.

In science, U.S. fourth graders and eighth graders scored above the international average on TIMSS. In fact, U.S. fourth graders are near the very top in science achievement in the world.

Albeit anecdotal, the following observations appears to be consistent from a preliminary scan of K-12 teachers responding to a survey conducted by the Task Force:

Very few teachers have access to instructional technology in the classroom. (Q #7-10)
Elementary and middle school mathematics were identified as highly important. (Q #13)
Reading comprehension, problem solving and analytical skills were highlighted. (Q #15)
Mathematics was the focus for IT related professions. (Q #16-17)

To seriously address the shortcomings of U.S. mathematics and science education and to address concerns raised by teachers, the task force raises the following issues:

Teacher Qualifications: From middle school to high school, teachers should be required to have earned at least a bachelor's degree in mathematics or science to qualify as a mathematics or science teacher. In states where middle school mathematics and science teachers can teach on a K-8 license, a middle school licensure should significantly upgrade the requirements of preparation for teachers in these subject areas. Elementary school teachers should demonstrate subject matter competency in math and science.

Credentialing: Schools of Education must change their credentialing process in order to better prepare teachers for the classroom.

Increased Salaries for Qualified Mathematics and Science Instructors: To attract, encourage, recruit and retain qualified candidates in the K-12 teaching profession it is essential to increase starting salaries for qualified teachers.

Professional Development for Mathematics and Science Teachers in the Workforce: University based and other professional development partnerships must be encouraged to equip current teachers with the content knowledge and pedagogical skills they need to teach challenging mathematics.

Rigorous Curricular Standards: To implement the proposed competencies, elected officials, parents, educators and business leaders must insist on rigorous curricular standards in mathematics and science.

Project-Based Learning: Approaches linked to application in business or industry are necessary.

Carefully-targeted Corporate and Business Donations: Corporate and business contributions for community activities may best serve the children by structuring gifts for public K-12 education in a manner that focuses on priority reforms. It is also important for business to help parents, students, and teachers understand why mathematics and science are relevant for a wide range of career opportunities.

In summary, educators, industry leaders and elected leaders need to understand that poor quality mathematics and science preparation does have an immediate and negative impact. They should use lessons learned from the IT workforce challenge as a welcome impetus to create the type of serious curricular, instructional and structural reforms in mathematics and science education that are long overdue.

Implement Rigorous K-12 Mathematics and Science Education:
Solution To America's New Deficit

Issues Identified by the Task Force on Basic Mathematics and Science Competencies National Information Technology Workforce Convocation (12-13 January 1998)

How Well are U.S. Students Performing in Math and Science?

According to the 1996 National Assessment of Educational Progress (NAEP), the percentage of 12th graders performing at or above the basic level in mathematics increased from 58 percent in 1990 to 69 percent in 1996. However, only 16% of America's 12th graders performed at a proficient or advanced level in mathematics in 1996. These 12th graders are facing a rapidly changing job market where information is the major driving force, and the demands for mathematics and science competencies needed to participate successfully in the IT job market are continually increasing.

From the Third International Mathematics and Science Study (TIMSS) we know that American eighth graders rate on equivalents levels with students from England and Germany while behind students from Japan, France, and Canada. In science, U.S. eighth graders were significantly outperformed by students from Singapore, the Czech Republic, Japan and Korea. Even though the . average score for U.S. eighth graders is behind these competitor nations, the total school-age population in the U.S. far exceeds these other nations. Therefore, in aggregate numbers, the U.S. is still able to produce a large pool of graduates with excellent qualifications in mathematics and science. However, our economic engine is also exponentially larger than many competitor nations, and the demand for qualified entrants in the IT workforce is almost overwhelming in its scale.

From the data collected by Information Technology Association of America (ITAA) in the report *Help Wanted: The IT Workforce Gap at the Dawn of a New Century* (February 1997) and reflected by the personal experiences of task force members, there are far too few students exiting U.S. high schools that have the requisite skills and aptitudes to fill the increased demand for IT workers.

Definition of IT Worker

Since this report is aimed at policy-makers, educators, IT professionals, business leaders and the public, we believe it is important to define Information Technology. The ITAA defined "information technology" as the "study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." The Task Force used the following definitions drawn the U.S. Department of Commerce report: "America's New Deficit: The Shortage of Information Technology Workers."

Computer Scientists: Computer scientists generally design computers and conduct research to improve their design, use, development and adapt principles for applying computers to new uses. They are distinguished from other computer professionals by the higher level of theoretical expertise and innovation they apply to complex programs and the creation of application of new technology.

Computer Engineers: Computer engineers work with the hardware and software aspects of systems design and development.
Systems Analysts: Systems analysts use their knowledge and skills in a problem solving capacity, implementing the means for computer technology to meet the individual needs of an organization.
Computer Programmers: Computer programmers write and maintain the detailed instructions, called "programs" or "software," that list in logical order the steps that computers must executive to perform their functions."

Areas of Increased Demand for IT Workers

According to the ITAA report, the increased demand for IT workers is spread across a wide array of job categories, each representing a differing level of mathematics and science expertise and preparation. Survey respondents did not provide a specific number of positions open in each category, but did identify the following job categories in urgent need of personnel: (1) Network operating systems, (2) Operating systems, (3) RDBMS, (4) Networking and (5) Languages/applications (source: ComputerWorld Survey).

Matching Mathematics and Science Competencies with Job Categories

The task force explored the challenge of strengthening mathematics and science skills for potential IT workforce entrants. What level of achievement is necessary for varying job categories in the IT industry? Is there a minimum level of mathematics and science competency necessary for every worker in the IT industry, for example, a network manager or programmer? Should even more challenging mathematics or science competencies be required for study in a specific field, such as computer science or systems analysis?

A thorough grounding in the principles of mathematics and science is essential to individuals who aim to contribute as a skilled workforce in the multitude of interconnected fields representing IT. This common sense observation is well supported even from a cursory look at the results of a survey conducted by the Chair of this Task Force. Sample copies of the survey are included here and may be reviewed on the web (www.vcsun.org/~smetzenb/teacher.html). The overwhelming response to this survey prevents us from providing the complete analysis at this time (follow-up will be released). Albeit anecdotal, the following observations appears to be consistent from a preliminary scan of responses from K-12 teachers:

Very few teachers have access to instructional technology in the classroom. (Q #7-10)
Elementary and middle school mathematics were identified as highly important. (Q #13)
Reading comprehension, problem solving and analytical skills were highlighted. (Q #15)
Mathematics was the focus for IT related professions. (Q #16-17)

From discussion with high school teachers who are well versed in IT and possess university degrees (in engineering, computer science, physics and mathematics) a partial list of skills and related areas were identified as helpful to those high school students preparing for the IT workforce. Teachers highly recommended integration of project-based learning while repeatedly emphasizing need for understanding of the "basics" in mathematics and physical sciences as a critical pre-requisite for students who may wish to be a part of the IT workforce that can weather with success the rapid pace of technological innovation. Thus, for each skill-related area below, we include a brief description of the academic foundation necessary.

Project-based Pre-engineering shop (e.g.: applications of robotics):
Geometry, simple machines and mechanics, lego designs; chemistry of materials; energy
Computer Programming Languages:
Number theory, set theory, matrices, logic, Boolean algebra, algorithms
Internetworking Technologies:
Algebra, calculus, rate of flow problems, topology; computer communications; optics
Analog/digital electronics:
Trigonometry; electricity, magnetism, heat transfer
Database, Spreadsheet Programs; Multimedia Web-applications:
Statistics; multiple algebraic variables; classification of information; programming
Computer-Assisted Design:
Topology, spatial relationships, visual thinking; circuits

These and other detailed description of skill standards for information technology for post-secondary candidates are contained in the NSF funded report *Building a Foundation for Tomorrow* authored by NWCET (Northwest Center for Emerging Technologies).

How Much More Mathematics Achievement is Needed to fill the Preparation Gap?

According to the 1996 National Assessment of Educational Progress (NAEP), only 24 % of America's 8th graders and 16% of America's 12th graders performed at a proficient or advanced level in mathematics in 1996. Without significant and focused curricular and instructional reform, it is difficult to imagine students improving in mathematics and science performance to the degree needed to meet increased demand for IT workers.

TIMSS Mathematics and Science Curriculum Analysis

A Splintered Vision offers an in-depth analysis of U.S. science and mathematics education from the Third International Mathematics and Science study (TIMSS). It clearly echoes the concerns of the Task Force about the confusion and lack of focus in U.S. education. The following are quotations from the executive summary:

"Our curricula, textbooks and teaching all are 'a mile wide and an inch deep.' This pre-occupation with breadth rather than depth, with quantity rather than quality, probably affects how well U.S. students perform in relation to their counterparts in other countries. In today's technologically oriented global society, where knowledge of mathematics and science is important for workers, citizens and individuals alike, an important question is: What can be done to bring about a more coherent vision and thereby improve mathematics and science education. The United States needs powerful mathematics and science education because they provide a strong basis for our democracy by helping create a literate and informed citizenry. (It) helps each individual to grow, develop, reach his or her individual potential and become more autonomous and empowered; (it) provides a sound basis for continuing national prosperity in a competitive, information-driven, technological and changing international arena."

COMPETENCIES

With the possibility of a million new jobs created in the area of information technology by 2005, the desired level of competencies are rapidly in flux. "Just a few years ago, Java was coffee, C was a passing grade and (the only) web masters (were spiders who) had eight legs. Today, experts in Java computing and C programming command a premium labor market, and an army of human web masters keeps information updated on the rapidly expanding World Wide Web." (*America's New Deficit: The Shortage of Information Technology Workers*, U.S. Department of Commerce, 1997). Information technology related jobs and their applications span the entire spectrum from aquiculture to zymurgy.

The level of competencies currently acquired by a public school graduate translate to statistics revealing that in 1994 only 1% of women and 3% of men earned bachelor's degrees in computer science. The numbers reflect a 42% decrease between 1986 and 1994. One reason for this decline may be found in the Carnegie Foundation survey indicating that 51% of mathematics teachers in public high schools did not take any course in mathematics during their years in college. Elementary and middle school teachers in the United States teach mathematics and science, legally, with non-content based, general credentials.

Project-based learning, particularly in areas of engineering, computer science and technology, is essential to understand the application of theory to practice. High school "hands-on" learning experiences provided by the Cisco Networking Academy are a prime example of the combination of academic rigor with real world application beginning at the ninth grade.

Case Study: Cisco Networking Academy

One particularly appropriate model for creating skilled IT workers is a program developed by Cisco Systems Inc., (San Jose, California) which spans high school and junior colleges. At all levels, students simultaneously proceed through a two-year rigorous academic and "hands-on" training program which makes them eligible to appear for an industry-certified qualifying examination. This program is in operation at several sites including the Thurgood Marshall Academic High School in San Francisco where students who succeed in the exam will be awarded a certificate from the Cisco Networking Academy. This certification shall enable graduates to compete for entry level positions in networking technologies.

In the view of this Task Force, it is futile to propose expected competencies, to address the demand for a skilled workforce, without articulating the **KEY** changes that must occur in order to implement the rigorous standards. Without such changes, we may be far from achieving proposed competencies in mathematics and science. In addition, there are several other subjects (geography, economics, etc.) which are equally important but outside the scope of this report. However, we wish to emphasize the need for advanced reading skills, verbal communication, writing and comprehension in English, as underlying and critically essential competencies.

Areas of Focus to Achieve Competencies

It is nearly impossible to provide suggestions, which, if adequately implemented, may solve all the problems of K-12 public education and approach the proposed level of competencies. However, in the view of this Task Force, the following **KEY** changes, if implemented, may provide solutions to a significant number of core problems and help stem the deficit of skilled workforce.

Teacher Qualifications: From middle school to high school, teachers should be required to have earned at least a bachelor's degree in mathematics or science to qualify as a mathematics or science teacher. In states where middle school mathematics and science teachers can teach on a K-8 license, a middle school licensure should significantly upgrade the requirements of preparation for teachers in these subject areas. For elementary school, all teachers, especially those who specialize in teaching of math or science for grades three through six, should demonstrate high levels of subject matter competence. Knowledge of content and expertise in subject matter must be an uncompromising pre-requisite for any teacher. Methods and process are important but second to content. For middle and high school, subject credentials granted by schools of education cannot be substituted in lieu of subject area degree.

Credentialing: Schools of education must change their credentialing process in order to better prepare teachers for the classroom. Collaborations with the mathematics and science departments are necessary for schools of education. The emphasis on methods and process should be replaced only with the essentials of pedagogy in a manner that college/university students may acquire those courses while pursuing their bachelor's or master's degree in a specific subject area. Classroom management, multicultural sensitivity and other social issues, essential as they are to being able to connect with students in an atmosphere conducive to learning, are best addressed during student teaching in a classroom with support from "mentor" teachers.

Increased Salaries for Qualified Mathematics and Science Instructors: To attract, encourage, recruit and retain qualified candidates in the K-12 teaching profession it is essential to increase starting salaries for qualified teachers ($30K bachelor's; $45K master's; $55K doctorate). Hiring teachers through direct correspondence with academic institutions and selective advertisement through academic societies are approaches that must be part of the recruitment process.

Professional Development for Mathematics and Science Teachers in the Workforce: University based and other professional development partnerships must be encouraged to improve the content base of in-service teachers. Effective classroom teachers who lack adequate training in content must be allowed release time to receive training in local colleges or universities to boost the knowledge of the subject matter they teach. School or school-district operated professional development measures must be restructured to provide meaningful useful assistance targeted to the needs of teachers.

Particular emphasis is required for teacher training in curricular integration of technology. Installing wires and acquiring computers will not automatically improve student outcomes or solve the problem of content-poor curricula and systemic lack of rigor. Technology is only a tool and effective only in the hands of instructors who are core knowledge experts as well as proficient in use of technology. Dual characteristics are difficult to acquire. It requires training contributed by experts in content, multi-media, software, hardware and veteran teachers skilled in delivery and management in the classroom. Significant resources are required to make technology useful as a tool for the delivery of instruction.

Rigorous Curricular Standards: To implement the proposed competencies, elected officials, parents, educators and business leaders must insist on rigorous curricular standards in mathematics and science. TIMSS found that the U.S. expects less of its middle and junior high students in mathematics compared to high performing nations. U.S. students typically study arithmetic through seventh or eighth grade.

Beginning in fourth grade, students in top-performing countries practice arithmetic but are also introduced to algebra, geometry, probability, and other topics. Between grades four to eight, U.S. students need to progress to more advanced mathematics, including algebra and geometry.

To monitor expected competencies and proper implementation of the required curricula, a rigorous national assessment of reading and writing in English, mathematics and science is essential to test the preparedness of K-12 students.

Project-Based Learning: Project-based learning approaches linked to application in business or industry are necessary. Mentorships and internships are helpful. In an appendix to be printed later, we shall mention some model programs including CAMS in Dominguez Hills and the acclaimed Cisco Networking Academy, network technology training for students.

Carefully-targeted Corporate and Business Donations: Corporate and business contributions for community activities may best serve the children by structuring gifts for public K-12 education in a manner that focuses on:

(a) retaining qualified teachers (summer stipends; creating "chair" positions)
(b) supporting teachers who return to the university for professional development
(c) upgrading technology by installing wires, switches, hubs (no cash contributions)
(d) in kind hardware and software contributions for access to information technology
(e) supporting full-time on-site technology resource for curricular integration
(f) stipends for tutors in mathematics, science and technology literacy
(g) installing science, engineering, and computer laboratories for project-based learning
(h) funding academic guidance counselors and educational field-trips
(i) helping parents, students, and teachers to understand the relevance of mathematics and science to a wide range of career opportunities.

Case Study: Thomas Jefferson High School

An excellent example of a school that exemplifies some of the ideals identified by the Task Force is Thomas Jefferson High School for Science and Technology, a magnet school in Fairfax, Virginia. Established in 1985, Jefferson is the result of a partnership between businesses led by the Fairfax County Public School Education Foundation and the school system. This unique public school offers a comprehensive college preparatory program emphasizing science, mathematics and technology. Student selection is a competitive process based on aptitude, test scores, academic achievement, teacher recommendations, essays and self-reported interests and activities. Students entering the program are required to have at least 26 credits for graduation: including five in mathematics, four in science, two in technology, one in computer science and one elective in either mathematics, science, technology or computer science. The school has an active outreach program, training teachers, student tutoring in elementary schools, web building for businesses, and www video broadcasts, to name a few.

Summaries of needed curricular reforms in Science

Excellence in Physics
It is imperative that teaching of core physics must begin from the 8th or 9th grade. All students must have completed a four year graduation requirement in physics. These competencies will never be achieved if we continue the current practice of teaching physics mostly at the 12th grade. At present, less than 25% of graduating seniors take physics in high school and less than 20% of high school physics teachers possess a bachelor's degree in physics. The proposed competency guide and curricular outline may be based on Feynman lectures (I & II). It is assumed that students will have adequate foundation in mathematics in order to learn the topics over four years (9-12) of high school physics. Integration of physics with astronomy, cosmology, mathematics, chemistry, biology, medicine and geology is highly recommended. Excellent "hands-on" physics curricula are available from the American Association of Physics Teachers.

Excellence in Chemistry
Chemistry is the bridge between physical and biological sciences. From rocket fuel to Alzheimer's disease and everything in between, chemistry is at the core. It is, thus, imperative that teaching of chemistry must begin from middle school or 5th grade. Demonstrations of chemistry must be included in general science teaching from as early as 3rd grade. These competencies will never be achieved if we continue the current practice of teaching core chemistry mostly at the higher grades. At present, few graduating seniors take chemistry and fewer chemistry teachers possess a degree in chemistry. Rigorous mathematics is a must.

Excellence in Biology
Modern biology is dependent on biochemistry and biophysics for most of its research. Genetics and medicine, in addition, rely on mathematics and instrumentation physics. Development of bio-technology has its roots in molecular biology and recombinant DNA technology but increasingly depends on chemical engineering, as well. Thus the study of biology is an amalgam of physical sciences. It is for this reason the physical sciences must be taught ahead of biology. That is not the current practice, and it is for this reason that greater appreciation of modern biology is often hampered. Though biology is always a part of general science, the focus of high school biology should shift to genetics and molecular biology. A curricular outline may be broadly based on Cell and Molecular Biology by Bruce Alberts, et al.

Task Force Summary

Suggestions made in this report are not new, nor is the analysis of the deficiencies in mathematics and science education original or unique. However, the impact that these deficiencies have on the economy and on individuals is astounding: 191,000 unfilled jobs and over 2 million high school graduates unable to seize this opportunity because they have been poorly prepared, particularly in their mathematics skills. Educators, industry leaders and elected leaders need to understand that poor quality mathematics and science preparation does have an immediate and negative impact. Let this lesson from the increased demand for IT workers serve as an impetus to create the type of serious curricular, instructional and structural reforms in mathematics and science education that are overdue and necessary for continued U.S. economic growth.

Task Force on Basic Mathematics and Science Competencies
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K-12 School and Teacher Survey

1. What is your gender?

Pick one

2. What is your age group?

Pick one

3. What is your level of education?

Pick one

Comments:

4. How many years of teaching experience do you have?

Pick one

Comments:

5. What grade levels do you currently teach?

Check all that apply:

☐K ☐1 ☐2 ☐3 ☐4 ☐5 ☐6 ☐7 ☐8 ☐9 ☐10 ☐11 ☐12

Comments:

6. What subjects do you currently teach?

Check all that apply:

☐Mathematics ☐Biology ☐Chemistry ☐Physics

☐Computer science ☐Earth science ☐Other (please comment)

Comments:

7. Do you have access to a computer for the teaching of students?

Pick one

If your answer was yes, how many hours per week do you use a computer for instruction?

Pick one

Comments:

8. Do you have access to a computer for lesson development or personal scholarship?

Pick one

If your answer was yes, how many hours per week do you use a computer for these purposes?

Pick one

Comments:

9. Do you have access to the World Wide Web for the teaching of students?

Pick one

If your answer was yes, how many hours per week do you use the Web for instruction?

Pick one

Comments:

10. Do you have access to the World Wide Web for lesson development or personal scholarship?

Pick one

If your answer was yes, how many hours per week do you use the Web for these purposes?

Pick one

Comments:

11. Which of these sources are trustworthy, in your opinion, in helping you decide what to teach students who may have career aspirations in an information technology field?

Please grade your opinions on a scale of 1 to 5, as indicated above the check boxes (at left), and the strength of your opinion on a scale of 1 to 3 (at right).

Your opinion **Strength of your opinion**

	Not trustworthy				**Highly trustworthy**
Your personal experience	○1	○2	○3	○4	○5

						Weakly held		Strongly held
Opinions of colleagues	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
Educational research	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
Professional journals	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
Media reports	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
National standards	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
State standards	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
District Standards	○ 1	○ 2	○ 3	○ 4	○ 5	○ 1	○ 2	○ 3
						○ 1	○ 2	○ 3

Please add your comments:

12. In your opinion, which fields of study or curricula in secondary education are most likely to contribute to a student's ability for comprehension, analytical reasoning, and problem solving?

(Rate your top three choices in order, with the 1st choice indicating "most important")

Pick one 1st choice (most important)

Pick one 2nd choice

Pick one 3rd choice

Please add your comments:

13. What are the most important factors at your level of teaching, that affect students' career opportunities in information technology fields?

	Your opinion Not important				Highly important	Strength of opinion
Elementary						

math and science education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Middle school mathematics	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Middle school science education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Middle school computer and technology education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
High school mathematics education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
High school science education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
High school computer and technology education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
A poor public image of information technology career professionals	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Good collaboration between corporations and K12 education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5
Good collaboration between universities and K12 education	◯ 1	◯ 2	◯ 3	◯ 4	◯ 5

Weakly held		**Strongly held**
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3
◯ 1	◯ 2	◯ 3

Please add your comments:

14. Which of these subjects may best serve students in the future, if they wish to enter a career in an information technology field?

(Rate your top three choices in order, with the 1st choice indicating "most important")

Pick one 1st choice (most important)

Pick one 2nd choice

Pick one 3rd choice

Please add your comments:

15. A Bureau of Labor Statistics projection estimates that there will be over one million existing vacancies in the information technology industry. If it is a national goal to fill these positions with bright and talented employees, what would you see as the most important factors in achieving that goal?

Your opinion

	Not important				**Highly important**
Facility with arithmetic	○ 1	○ 2	○ 3	○ 4	○ 5
Understanding of math principles	○ 1	○ 2	○ 3	○ 4	○ 5
Analytical skills	○ 1	○ 2	○ 3	○ 4	○ 5
Self-motivation	○ 1	○ 2	○ 3	○ 4	○ 5
Knowledge of physical principles	○ 1	○ 2	○ 3	○ 4	○ 5
Logic and reasoning	○ 1	○ 2	○ 3	○ 4	○ 5
Facility with measuring instruments	○ 1	○ 2	○ 3	○ 4	○ 5
Communication skills and teamwork	○ 1	○ 2	○ 3	○ 4	○ 5
Reading comprehension	○ 1	○ 2	○ 3	○ 4	○ 5
Problem solving abilities	○ 1	○ 2	○ 3	○ 4	○ 5
Ability to formulate models	○ 1	○ 2	○ 3	○ 4	○ 5
Computer and calculator skills	○ 1	○ 2	○ 3	○ 4	○ 5

Strength of opinion

Weakly held		**Strongly held**
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3

Please add your comments:

16. With regard to high school mathematics courses, which of these are most important in preparing a student who may (someday) desire a career in an information technology field?

(Rate your top three choices in order, with the 1st choice indicating "most important")

Pick one 1st choice (most important)

Pick one 2nd choice

Pick one 3rd choice

Please add your comments:

17. Thinking specifically of high school science courses, which of these are most important in preparing a student who may (someday) desire a career in an information technology field?

(Rate your top three choices in order, with the 1st choice indicating "most important")

Pick one 1st choice (most important)

Pick one 2nd choice

Pick one 3rd choice

Please add your comments:

18. Since students have a limited amount of time at school, we would like to know your opinions on how that time should best be spent. Keeping in mind a student who may (someday) desire a career in an information technology field, which of these subjects may best serve the student in the future?

Please indicate your opinion on the left panel (1= Not important, 5= Highly important) and your familiarity with the subject (1 = Novice, 3 = Expert).

Your opinion

	Not important				Highly important
Computer programming languages	○ 1	○ 2	○ 3	○ 4	○ 5
AP Computer science	○ 1	○ 2	○ 3	○ 4	○ 5
Local area networking	○ 1	○ 2	○ 3	○ 4	○ 5
Internet networking and technologies	○ 1	○ 2	○ 3	○ 4	○ 5
Analog/digital electronics	○ 1	○ 2	○ 3	○ 4	○ 5
PC hardware and repair	○ 1	○ 2	○ 3	○ 4	○ 5
Spreadsheet program instruction	○ 1	○ 2	○ 3	○ 4	○ 5
Database program instruction	○ 1	○ 2	○ 3	○ 4	○ 5
Multimedia / Web-based instruction	○ 1	○ 2	○ 3	○ 4	○ 5
Linguistics, semantics and context	○ 1	○ 2	○ 3	○ 4	○ 5
Keyboarding instruction	○ 1	○ 2	○ 3	○ 4	○ 5

Familiarity with subject

Novice		Expert
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3
○ 1	○ 2	○ 3

Computer-assisted design (CAD)	○1	○2	○3	○4	○5	○1	○2	○3
						○1	○2	○3
Robotics & Photonics	○1	○2	○3	○4	○5	○1	○2	○3
						○1	○2	○3
Pre-engineering	○1	○2	○3	○4	○5	○1	○2	○3

Please add your comments:

Please submit data by 11/30/97

Submit

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Thank you for your time

Shoumen Datta,
on behalf of the National Task Force on Basic Mathematics and Science Competencies

Image of the IT Professions

From Myth to Reality:

Changing the Image of Information Technology

EXECUTIVE SUMMARY

Task Force White Paper January 1998

Image of the Information Technology (IT) Professions

The sweep of digital technologies and the transformation to a knowledge-based economy have created robust demand for workers highly skilled in the use of information technology. In the past ten years alone, employment in the U. S. computer and software industries has almost tripled. The demand for workers who can create, apply and use information technology goes beyond these industries, cutting across manufacturing and services, transportation, health care, education and government.

America's New Deficit: The Shortage
of Information Technology Workers

INTRODUCTION

A number of recent reports, including a survey by the Information Technology Association of America (ITAA) that concluded that there are about 190,000 unfilled information technology (IT) jobs in the nation today due to a shortage of qualified workers, have cited evidence that the United States is failing to meet the demand for new information technology workers Further evidence suggests that the demand will grow in the decade ahead.

Among the many reasons cited for the shortage is the distorted and often negative image of information technology professions among all age groups. Research conducted by the "Image of the Information Technology (IT) Professions Task Force" revealed that elementary and secondary students often portrayed the IT professions as "geeky-nerdy individuals who wear bow ties, glasses, pocket protectors, pants that are too short and lab coats and who are typically bald males who are passive geniuses and work alone with their computers."

Clearly, the Task Force found that many children - and adults - embrace the stereotypical image because of their constant exposure to unflattering media images of the profession and limited exposure to, and knowledge of, real life IT professionals. Movies such as "The Nutty Professor" and "Honey, I Shrunk the Kids" combined with unflattering representations of IT professionals on television have contributed to this unfavorable image. Even ads for IT workers have used terms like "nerd" and pictures of individuals with "taped" glasses. In addition, there are few highly visible role models for students and adults.

The Task Force also found that as students move from elementary through middle to high school, the involvement with information technology becomes mostly a male preserve. This is corroborated by an IDG survey of its youth oriented magazine, "Game Pro," which is 95 percent boys, and its mature readership publication, "Computer World," which has an 80 percent male readership.

The Task Force found that many young people do not think of IT professions as "cool" and many adults fear new technology (this is not a new phenomenon) due to concerns of potential job displacement and a sense that preparing for those jobs requires knowledge and skills they do not have and believe to be difficult to learn.

The "image" problem, then, complicates efforts to attract young people into programs that will prepare them for jobs and careers in the IT profession and discourages adults from seeking the education and training to prepare them for new roles at work.

The Task Force believes that a comprehensive, coordinated and integrated marketing plan needs to be initiated with two different audiences in mind: young people through grade12 and postsecondary including adults. The initiative for young people would be of necessity, and design, a long term approach while for adults it should be more high impact and immediate.

The Task Force has identified a number of solutions to the image problem of IT professionals and specifically aims them at the target populations.

SUGGESTIONS

To accomplish these goals, the Task Force suggests that a variety of communities be involved in promoting a common "message" and make special efforts with their constituencies. The Task Force suggests a national level, industry led campaign based on a partnership among industry, labor, and education with four basic themes:

- "Technology is cool, it's the future, it's exciting"
- IT professions are mainstream
- IT professions are lucrative and stimulating
- IT professionals are not all geniuses nor degreed engineers or scientists.

Specifically, we suggest that ITAA take the lead in this effort and form a partnership with other industry and professional associations, with labor, education and other representatives to generate a publicity campaign that would have some of the following attributes:

Education community

- Integrate IT into the K-12 curriculum
- Integrate IT into staff development programs
- Target career counselors for special emphasis to assist them in providing students with IT career possibilities
- Invite IT professionals to schools for presentations
- Engage in the support of the publicity campaign
- Take full advantage of the "E-Rate Program" authorized under the Telecommunications Act of 1996 that will substantially reduce the amount that schools and libraries pay for wiring services including phone, fax, cable tv, satellite tv, wireless services (e.g. cellular phones, pagers) and the Internet

Employers

- Lead a concentrated publicity effort
- Work to give positive meaning to the term "IT"
- Promote outreach efforts to the school administrators, teachers, students and parents

Unions

- Provide information to members about the changing nature of the work place
- Incorporate the use of information technology in education and training programs
- Include training requirements in collective bargaining negotiations
- Identify IT role models among workers

Media

- Provide campaign resources through the American Association of Advertising Agencies
- Represent technically competent individuals accurately in movies, TV, etc.

Parents

- Provide opportunities for the entire family to use various forms of IT in the home including use of the Internet
- Support efforts of schools to enhance the use of IT in the classroom
- Utilize IT opportunities available in public libraries especially when unavailable at home
- Discuss possible IT career opportunities with children
- Model the use of IT technology for children.

BEST PRACTICES

In its research, the Task Force discovered a number of excellent and exciting initiatives that are "best practices" and should be cited in a national campaign as models for replication. The following is a brief description of some of them:

TECH CORPS

TECH CORPS, founded by Task Force member Gary Beach, is a national organization dedicated to improving K-12 education at the grassroots level through effective integration of technology into the learning environment. Its mission is to recruit, place and support volunteers from the information technology community who advise and assist schools in the introduction and integration of new technologies. Volunteers provide assistance with local planning, technical support and advice, staff training, mentoring, and class room interactions. Currently, 40 states and the District of Columbia have **TECH CORPS** chapters.

AIM INSTITUTE

The Applied Information Management (AIM) Institute is a unique consortium currently comprised of 34 businesses, ten local and regional colleges and universities, the Greater Omaha Chamber of Commerce and the State of Nebraska. It was created to support and promote business and community growth related to information technology. It has served as the catalyst to bring together the necessary parties from education, business and government to accomplish such goals as IT curriculum development, special events, research studies, internships and global recruitment.

AIM has developed a web site known as "CareerLink" (http://www.omaha.org/careerlink.html) to assist in recruiting. It has launched a publicity campaign including posters, pocket folders, post cards, mouse pads and Public Service Announcements to encourage students to consider careers in information technology. In order to address the "geek" stereotype, students from local schools were used as models.

Employment and recruiting efforts include an On-Line Mentoring Project where students are paired with IT Professionals; paid internships with local businesses where students develop web pages, provide programming, operation support, and data administration functions; and a Virtual Career Fair where job seekers participate with local businesses in a chat room format.

In the education system, AIM sponsors a one week summer Cyber Camp for students in middle and high school, offers scholarships to 22 teachers (representing both elementary and secondary levels) to develop their skills in technology and develop curriculum which is shared with other Nebraska teachers; conducts Satellite Conferences in cooperation with the United States Department of Education for high school students, counselors and teachers interested in information technology; developed two Information Technology Academies that cooperate with local businesses and colleges; and sponsor one and four week summer internships for teachers with an IT focus.

SEMICONDUCTOR INDUSTRY WORKPLACE RECRUITING CAMPAIGN

Spearheaded by SEMATECH, a consortium of U. S. semiconductor manufacturers, the semiconductor industry launched the "Partnering for Workforce Development" campaign. It spent over $1 million to perform research, create a communications plan that included a toll-free hotline, World Wide Web site and speakers' bureau to identify and develop sources of candidates who could train to become semiconductor technicians and operators.

The campaign results over the past six months have been impressive with enrollment doubling and science, math, and technology course offerings increasing dramatically.

DETROIT SCHOOL OF INDUSTRIAL ARTS (DSIA)

The Detroit School of Industrial Arts (DSIA) is a charter school founded in cooperation with local companies in the manufacturing, computer, and automotive service industry to prepare students for careers in Automotive Service Technology, Information Technology and Manufacturing Technology.

The automotive and manufacturing programs are based on national skill standards in those industries and the lead partner in the information technology "major" is Complete Business Solutions, Inc. (CBSI), a worldwide provider of technology services. All three majors will be expanded with funding expected from a pending School-to-Work grant.

LEARN TO EARN

In Clinton County in upstate New York, the Clinton County Development Corp., a regional nonprofit organization working to bring jobs to the community, hired a public relations firm, KSV Communications, to launch a "Learn to Earn" campaign pitched to the county's 900 sophomores with the goal of attracting them to careers in technology.

To dispel the notion that technicians are "geeky," KSV centered the "Learn to Earn" campaign around interactive presentations by technicians from local employers. In addition, a descriptive booklet was mailed to the parents of every sophomore and an interactive "Learn to Earn" CD-ROM was distributed to high school guidance offices and libraries. The CD-ROM featured a "myth vaporizer" which explains why technician jobs are interesting, and an "answer transducer" which lists salary levels for various technical jobs. In addition, with the click of a mouse, students can experience a performance by the rock group Smashing Pumpkins and learn that a concert-video technician needs to know math and science.

JEFFERSON CITY INFORMATION TECHNOLOGY COALITION

The Jefferson City Information Technology Coalition began during the summer of 1996 as a coalition between business and government with the shared goal of attracting and retaining qualified IT professionals. The goal was to "home grow" an IT workforce by advertising to the public the availability of IT careers and identifying ways people could enter the field. The focus of the alliance, which grew to include a number of local continuing education institutions, is to explore the employers' computer technology needs and educational requirements and to match those with continuing education curriculum degrees and certifications offered by local institutions.

Extensive outreach efforts were initiated including a public interest survey kicked off with a press conference with follow-up newspaper and radio coverage. An education fair which highlighted information technology was held and a five minute video was developed with the assistance of the local CBS affiliate KRCG TV-13. The video is followed by a multi-media presentation with some "hands-on" examples of information technology.

The Information Technology Coalition has developed a strategic plan to keep the original goals on track and includes a wide array of activities involving employers, education and local government officials.

JUNIOR ACHIEVEMENT (JA) PROGRAM

Junior Achievement is a national program whose purpose is to educate and inspire young people to value free enterprise, understand business and economics and be workforce ready.

Two of the JA programs, in New York City and Portland, Oregon, are working to include an IT dimension in the K-12 population. The K-6 curriculum is interactive and helps students focus on their role in society. The Middle Grades program focuses on managing personal finances, budgeting and the fundamentals of our economic system. The High School programs explores the international marketplace and global economy including an intensive program in the 12th grade where students form companies, produce products and make investments in a comprehensive computer simulated economy.

THE MILK CAMPAIGN

The milk industry felt it was experiencing an "image" problem. The California Milk Processor Board hired the San Francisco-based Goodby, Silverstein and Partners who developed a message different from preceding campaigns which focused on milk's contribution to good health. The hypothesis that most people drink milk in combination with other foods became the guiding force for the qualitative and quantitative research that led to a new focus on those who already drink milk to encourage them to drink more. That led to the "got milk?" slogan attached to occasions when people eat brownies, chocolate chip cookies and so on.

The campaign not only won an award but sold much more milk.

The Task Force believes there are lessons to be learned from the "image" of the milk campaign. A fresh new approach is needed. It should be based on a simple common theme and be national in scope.

CONCLUSION

These are but a few of the many creative and effective efforts to engage students and adults in the "real world" of information technology.

The Image Task Force lauds these efforts and encourages others to develop their own initiatives.

For all of them to achieve a critical mass, however, the Task Force believes that our suggestion of an industry led comprehensive, coordinated and integrated campaign be developed with a common message that is constantly reinforced through local efforts.

National IT Workforce Convocation
Image of the Professions Task Force

Chair
Paul F. Cole
Secretary-Treasurer
New York State AFL-CIO
Vice President
American Federation of Teachers
Albany NY

Delana Rauterkus
Director, Application Operations
US West Information Technologies
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Ms. Barbara Mitchell
Staff Manager
AT&T
Parsippany NJ

Mr. Jon Korin
VP, Strategic Development
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Rick Weingarten
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TechKnowledge Communications Inc.
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Complete Business Solutions, Inc.
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Office of Information Technology
State of Missouri
Jefferson City MO

Bill Castanier
Michigan Jobs Commission
Lansing MI

Paul Anderson
Communications Workers of America
Washington DC

Fall 1997 School Survey

The following schools participated in the survey:

- Alum Rock Union Elementary School (CA)
- Glen Ridge Public Schools (NJ)
- Jefferson City Public School (MO)
- Joseph George Middle School (CA)
- Livonia Public Schools (MI)
- South Orangetown Public Schools (NY)
- Taylor Parochial School (MI)
- Yerba Buena High School (CA)

Teachers were asked to answer two questions:

- What is Information Technology?
- What do Information Technology workers do?

Students were asked the following questions:

- What is Information Technology?
- What do Information Technology workers do?
- What do you want to do or be when you enter the workforce (what job do you want)?
- What or who has influenced your decision?
- What jobs or professions do you consider to be desirable?
- Why do you consider these jobs or professions to be desirable?

•OPTIONAL: On the reverse side draw a picture of what you think a person who works in the Information Technology field looks like. Your picture may be used at a large meeting in California in January.

The Responses

106	Teachers
224	3rd Graders
386	6th Graders
454	9th Graders
97	12th Graders

Interesting notes:

Responses of "no answer," question marks, or "I don't know" to one or both of the questions, "What is Information Technology?" and "What do Information Technology workers do?" were as follows:

Teachers	4%
3rd Graders	31%
6th Graders	34%
9th Graders	56%

12th Graders 52%

Observations:

- It is abundantly clear that Information Technology is not a well-recognized field.
- In general, 3rd and 6th graders are more diligent about answering the questionnaire. In contrast, 9th and 12th graders appear less interested in filling out the survey and have taken the offer to submit a drawing as an opportunity to doodle in class!
- While 3rd and 6th graders do not know what Information Technology is, the majority know that it involves computers and, in the 6th grade, begin to mention software.
- 9th and 12th graders describe Information Technology with additional words such as Internet, World Wide Web, web sites, and email.
- 9th and 12th graders are extremely cynical and view the main driver of career selection as money.
- Teachers are very tentative in their responses, preceding their answers with "I believe," "I think" and "I guess."
- Those teachers with decisive answers appear to have used a reference source for assistance.
- Overall, women appeared in drawings approximately 19% of the time. However, there was a consistent decline from the 3rd to the 12th grades.
- The drawings portray a profession that is populated with "geeky-nerdy" individuals, who wear bow ties, glasses, pocket protectors, "too short" pants, and lab coats. They are typically bald males who are passive geniuses who work alone on their computers.

The data collected from this survey, begs the questions:

- Are we starting to see the influence of technology on students as exposure to computers at a younger age has increased significantly over the past few years (i.e., earlier exposure, more knowledgeable)?
- Have we adequately prepared today's teachers to present technology and its future career applicability to students?
- How do we change the image of the Information Technology professional?

What is Information Technology?

Excerpts from Student Survey - Samples from 3rd Grade

- "The science that has to do with knowledge or facts."
- "I've never heard of it."
- "Technology is computer. Information is when you can look up things."
- "I think Information Technology is information you get from the computer."
- "To read books."
- "Technology is when people study places in the world."
- "I could get it from computers and telephones."

Excerpts from Student Survey - Samples from 6th Grade

- "Stuff that makes life easier like the radio."

- "I think of computers, TVs, radios, clocks that give information. Robots and people who use all these and more all the time."
- "When you get information and turn it into technology."
- "Advanced inventions."
- "Manufacturing or working with computers."
- "Information Technology is the thing we use to communicate with other people who are far away or right next door."
- "I think that Information Technology is a place you call for information or something that you don't know about and can't find out."
- "A very good job with strong people."
- "A technology company that stores information on technology."
- "A mechanical way to get information."
- "Knowledge you get from a variety of machines."

Excerpts from student Survey - Samples from 9th Grade

- "Information about things that are new to our generation like computers of different
- kinds."
- "What I think it is, is something or someone who gives you information about a job
- or something."
- "Where they are trying to find information from surveys."
- "Research on cancer finding out new things about the world."
- "Technology in the future."
- "Information Technology is the old equivalent of a librarian. However, nowadays it's a data processor, something that stores information."
- "Technology that allows you to retrieve information easily like the Net."
- "A technology that involves giving information and discovering new ways of doing
- things."
- "Information Technology is sophisticated ways of getting information."
- "A network of information which is transferred through telephone lines."
- "Researching over the computer and the Internet to explore and advance technology."

Excerpts from student Survey - Samples from 12th Grade

- "Being able to log onto the Internet for gathering information and utilizing it."
- "Computer, Internet, web site, email."
- "I don't know and I don't care."
- "Valuable information given to you to help you in life."
- "Information Technology is what informs the public on modern technology."
- "It is the field of work where people create things to produce an informative outcome. Example, Internet."
- "A way to learn about the computer epidemic we are facing."

What do Information Technology workers do?

Excerpts from Student Survey - Samples from 3rd Grade

- "Put in information into a computer."

- “They make machines like computers more fun and interesting. Also like TVs and telephones.”
- “They give you information.”
- “Make web sites.”
- “People who tell facts about technology that you want to know.”
- “Make computer programs to help people learn.”
- “Make math books.”
- “They make graphs.”
- “They make and draw plans to make everyday things.”

Excerpts from Student Survey - Samples from 6th Grade

- "They try the technology out to see if it works. Then they tell the people."
- "Invent things to help children learn better."
- "Make discoveries, research findings to let everyone know stuff."
- "Come up with different things like computers and jets. Kind of like inventors."
- "Surf the Internet getting information."
- "They work on getting information to different places throughout the world in different technologies."
- "Make computers."
- "Put information in microchips, or other technology."
- "I think they are like a science lab person or a teacher."
- "They probably find out more about the technology."
- "They invent stuff like TVs, CD players, phones, watches, earrings."
- "They make energy work. They look at stuff all over the world like the people at the news station."
- “They do research or work on essays on different topics.”
- “They might keep the computers clean and make sure they don’t get damaged.”
- “They develop Information Technology.”
- “They build things out of blocks or Legos.”

Excerpts from Student Survey - Samples from 9th Grade

- "Find out information about technology and explain it to people."
- "Don't have a clue."
- "Work to find the information of future technology."
- "Research on things we don't know much about."
- "Improve information."
- "Work on computers."
- "Learn and teach about technology."
- "Fix technical problems."
- "They try to make things to help us learn more, like computers, etc.”
- "They regulate the information transferred by technology."
- "Gather data."
- "Maybe they work on the Internet or something."
- “They study what technology we have now and how to get more advanced.”
- “They work on computers and try to examine the factors that can determine how far we can succeed in the world and for the future.”

Excerpts from Student Survey - Samples from 12th Grade

- "They make sure the information is accessible and free of any glitches."
- "Sit and scratch themselves."
- "They teach and help to distribute the information."
- "Create web pages, better ways to learn different things such as math and science."
- "Create programs for public or private use."
- "They drink coffee and play Doom and Quake."
- "They walk around buildings checking to see if everything works and write for grants to update the technology there."
- "Work on computers providing information for the business world."
- "Sit and work on the computer while drinking coffee and having conversations with custodians."

Excerpts from Teacher Survey

What is Information Technology?

- "The science of managing the onslaught of information in the 21st century and beyond, using computer technology."
- "It can be as simple as paper to pencil or as sophisticated as modern day multi-media software and equipment. It is a means of transcription and communication - a way in which information is found and communicated."
- "I believe it consists of the Internet and computer software related to it."
- "Methods of disseminating information that uses computers, satellites, TVs, etc."
- "Technology, such as computers, used to collect, organize and store data. The technology should allow users access to the information.
- "Study of computers."
- "Information Technology pertains to the knowledge and ability to use research, logic, and creativity to solve business problems."
- "Information Technology is the exchange or transfer of information through the use of current technology (i.e., computer, fax, e-mail, Internet, web pages)."
- "Internet."
- Computers, printers, radio technology, TV, and weather technology. My guess is any technology used to inform the public."

What do Information Technology workers do?

- "They store and retrieve data to / from appropriate data bases, and provide analysis of data for specific functions."
- "People who process information by using computers, or people who use multi-media to disperse information."
- "Without prior knowledge, I would guess an IT practitioner might be a person who designs mechanisms for the delivery of up-to-the-minute information via computer web sites or fiber optics, etc."
- "Information technology workers are responsible to train, teach and / or repair the equipment so others may utilize it's vast capabilities."

- "Information Technologists have many roles and they may be facilitators (liaisons) between the technology and the would-be users; they may be designers of new technologies in information."
- "Information Technology workers gather and sort data to enter it into the machines."
- "Programming."
- "Bookkeeping, payments, process information."
- "Facilitate the acquisition, maintenance, and dissemination of information / knowledge / data."
- "Train others in ways to use technology to gain information."
- "Run and maintain information technology?"
- "Information Technology workers do a wide range of jobs - write programs, operate the equipment, repair the equipment. They do all levels of jobs requiring various levels of training, education and expertise."
- "They gather information from various sources."
- "Make web sites for the Internet."

What do you want to do or be when you enter the workforce (what job do you want)?

Top 9 Occupations for 3rd Grade

1. Teacher
2. Professional Sports Player
3. Medical Professional
4. Police / Fire
5. Veterinarian
6. Scientist
7. Entertainment
8. Lawyer
9. Computer Field
10. Astronaut

Top Ten Occupations for 6th Grade

1. Professional Sports Player
2. Medical Professional
3. Teacher
4. Entertainment
5. Veterinarian
6. Scientist
7. Lawyer
8. Law Enforcement
9. Computer Field
10. Writer

Top Ten Occupations for 9th Grade

1. Entertainment
2. Medical Professional
3. Teacher

4. Scientist
5. Veterinarian
6. Lawyer
7. Professional Sports Player
8. Computer Field
9. Engineer
10. Physical Therapist

Top 10 Occupations for 12th Grade

1. Don't Know
2. Medical Professional
3. Business
4. Art Field
5. Teacher
6. Entertainment
7. Computer Field
8. Travel
9. Engineering
10. Professional Sports Player

What or who has influenced your decision?

3rd Grade Results

1. Parents
2. Family (siblings, grandparents, cousins, etc.)
3. Teachers
4. Myself
5. TV/Movies
6. Friends

6th Grade Results

1. Parents
2. Family
3. Role Models
4. Myself / skills, interests
5. Teachers
6. Friends
7. Experience/Environment
8. TV/Movies

9th Grade Results

1. Parents
2. Family
3. Myself / skills, interests
4. Role Models

5. Teachers
6. Friends
7. Experience / Environment
8. TV / Movies

12th Grade Results

1. Parents
2. Myself / skills, interests
3. Experience / Environment
4. Teachers
5. Role Models
6. TV / Movies / Music
7. Friends

What jobs or professions do you consider to be desirable?

3rd Grade Most Desirable Jobs
1. Teacher
2. Medical Professional
3. Professional Sports Player
4. Law Enforcement
5. Veterinarian
6. Entertainment
7. Scientist

6th Grade Most Desirable Jobs
1. Doctor
2. Teacher
3. Professional Sports Player
4. Veterinarian
5. Lawyer
6. Scientist
7. Computer Field
8. Law Enforcement
9. Writer

9th Grade Most Desirable Jobs
1. Medical Professional
2. Entertainment
3. Teacher
4. Lawyer
5. Scientist
6. Computer Field
7. Veterinarian
8 Law Enforcement
9. Professional Sports Player

12th Grade Most Desirable Jobs
1. Medical Professional
2. Entertainment
3. Business
4. Lawyer
5. Teacher
6. Professional Sports Player
7. Computer Field
8. Law Enforcement
9. Armed Forces/Gov't
10. Engineering

Why do you consider these jobs or professions to be desirable?

3rd Grade Results

1. Something I like to do
2. Fun
3. Money

6th Grade Results

1. Something I like to do
2. Enjoy helping people/animals
3. Fun

4. Enjoy helping people / animals
5. Sense of accomplishment

4. Money
5. Sense of accomplishment

9th Grade Results

1. Money
2. Something I like to do
3. Fun
4. Enjoy helping people / animals
5. Sense of accomplishment

12th Grade Results

1. Money, Money, Money
2. Influence, respect
3. Enjoy helping / interacting
4. Fun
5. Creative
6. Preserve the earth

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Quality and Productivity Issues

Building the 21st Century Information Technology Workforce:

Software Productivity and Quality Issues

Productivity and Quality Task Force

This document reflects the individual views of several members of the Task Force on Software Productivity and Quality Issues. It is a preliminary document and as such has not been reviewed by or concurred in by the full Task Force team.

Comments of Task Force Members

Dr. Howard A. Rubin[1]

The dramatic increase in demand for IT (Information Technology) workers appears to be real. When one considers that today business and IT are inseparable, an unmet demand for IT workers has the potential to be a major braking force on the economy because national economic productivity is definitely tied to the use of technology. Other than constraining what will get done, the increased demand for IT workers will cause what gets done to cost more. If labor accounts for 50% of IT budgets, then even at the lowest level of annual impact, IT budgets will have to grow at 10% per year because of increased labor costs. This is more than 3x the current average increase rate. Now, with these impacts in mind, add on the Year 2000 burden along with European Monetary Unit conversions and the situation becomes even more critical.

To "counter" these potential economic consequences and to enable the US to remain competitive , it is essential that immediate attention be given to improving the productivity and quality of US software engineering professionals. From the data and information collected for this study, I believe that:

- The global competitiveness of US software development is weakening in terms of the productivity and cost structure of its software engineering workforce.
- There is a need for new economic indicators relating to information technology.
- There is a pressing need to develop an educational/training infrastructure to allow the U.S. to produce world-class software engineers.

At a national level, opportunities for maintaining global competitiveness in software engineering abound. At the national level, industry, academia and all levels of government should consider ways of accomplishing the following goals:

- Making software quality a national priority through
    - national software certification programs
    - high visibility national awards focusing on information technology and software engineering both at the individual and organizational level
- Providing industry with "relativity tools":
    - development of new information technology indices similar toGNP, GDP, and CPI (perhaps an IT GNP)
    - information products that support assessment of competitiveness
    - information products for dissemination of best practices/national data bank
    - assess and model the world dynamics of the situation as described
- Encouraging start-ups to attract outside investment through
    - software "free trade" zones
- Developing new skills and competencies in the existing workforce; laying the foundation for the next generation high performance workforce, by
    - supporting collaborative industry/educational software engineering technical training centers below the university level similar to the regional programs in Canada

[1] ***All figure and appendix references refer to materials available in the main report. In the interest of saving space for the Convocation proceedings they have been omitted from this summary document.***

- encouraging universities to focus on software engineering through educational innovation in this specific area.
- certifying educational/training programs that use the SEI-CMM Level 4 or 5 model for their teaching structure

At an internal corporate level, a few key critical actions must be taken now:

- Develop and nurture new sources of labor through university alliances, creation of cross discipline training/retraining programs, and global labor sourcing.
- Reformulate internal compensation and reward programs to keep high-value staff, attract new staff at rates which make economic sense, and bind employees to the company; reward needed skills and behaviors and use core staff to attract new staff.
- Manage the skills inventory as an active portfolio; use forecasting and projections; and invest in redevelopment and reskilling.
- Focus on increasing the leverage of the existing staff, higher productivity and quality through reuse; capturing and disseminating knowledge, and reducing rework.
- Leverage external knowledge in the form of packages, systems outsourcing, and business process outsourcing.

And most importantly, the IT workforce should be considered a national priority and resource. As such, a dedicated body should be formed in the long run to oversee and propose initiatives to keep the US competitive.

<u>Background</u>

There is no longer any separation between information technology and business. While the distinction between IT and business is definitely blurred, the linkage between IT and productivity and business is clear (see Figure 1). In fact, it might be said that we are all part of a global technology economy (see Appendix II for data on global technology competitiveness.) The US Bureau of Labor Statistics (BLS) appears to support this view. According to the BLS, "Computer technology is altering the form, nature, and future course of the American economy, increasing the flow of products, creating entirely new products and services, altering the way firms respond to demand, and launching an information highway that is leading to the globalization of product and financial markets." A multitude of forces are impacting the performance of software engineering professionals (see Figure 2). In US corporations, the annual thirst for information systems is growing at 25% per year. While this number may seem high, consider the following change rate of information technology itself. We have seen as much technology infusion in business every two to three years in the 1990s as occurred in all the 1980s. By 2005, each year will be the equivalent of the 1980s twice over in terms of information technology acquisition.

However, raw technology is not enough to provide business leverage and opportunity. It is the systems and software that activate the hardware and they are a commodity that cannot manufactured through automated means or mechanisms. Systems and software are developed by people, and the "right people" are in short supply.

From techie journals to BusinessWeek, the increased demand for IT labor is finally attracting some degree of attention. Before discussing the numbers and labor force demographics of the shortage, here's a summary of the basic issues that I believe the nation is facing in this regard:

- Software is an increasing large component of the cost of computer systems (see Figure 3).

- There is a dramatically increased demand for software professionals in the US.(see Figure 4)
- The size of the graduating classes of US universities expected to fill newly created positions for software professionals indicates that the demand for this labor category will not be met in the near term from these ranks. (see Figure 5)
- The pool of graduates from US universities has the wrong skill set to meet the needs of US industry.
- The pool of graduates from technical programs in the US is also too small and under-skilled to meet demand.
- The global competitiveness of the US software development community is weakening.

Perhaps the biggest single issue has to do with the potential impact of the continuing demand for additional IT workers on the economy. Because of the fact that information technology and business are so interwoven today, the increased demand for IT workers may act as a braking force on the economy. Some simple numbers illustrate this point: 1)the impact of the shortage on the ability of businesses to expand and remain competitive, and 2)the cost structure of doing business in our information based economy.

One estimate is that 200,000 jobs currently remain unfilled. Based on the results of the 1996 Worldwide Benchmark Project, the amount of software produced by the 200,000 professionals if the vacancies were filled could support an additional $500 billion in corporate revenue and $10 billion in associated income. In other words, the unfilled positions may be taking as much as a half-a-billion dollars in revenue out of the economy.

In terms of the cost structure of doing business, the increased demand for IT workers appears to be impacting and inflating the salaries of the existing IT workforce. While the Department of Labor estimates that the average US worker is getting a 4.1% increase each year, I estimate that those in IT will soon average 20% or more. As a result, corporations will be paying a potential $10 billion more in raises than what would normally be expected.

Other factors are important too. The impact of the Year 2000 computer crisis on the IT workforce's workload, the need for Year 2000 conversion skills, and the cost of the crisis make the picture even more complex. In fact, the IT workforce shortage may prevent companies from building information systems they need, thus braking economic growth.

The Global Software Engineering Picture: A Global view of Software Productivity and Quality

Figures 6 provides approximations of the size of the software professional workforce in a number of nations around the world [supplemental data tabulated by Capers Jones is available in Appendix III while additional data from Howard Rubin is available in Appendix I]. While the U.S. has the largest workforce, it is not the work leader in productivity and quality. In fact, recent observations make it appear that the US is losing ground in both these areas.

Data collected by Dr. Howard Rubin in the 1997 Worldwide Benchmark Project indicates the following:

- U.S. productivity as measured by KLOC/professional per year is below world average (see Figure 7) [Note: More "mature" companies using the FP metric are showing higher than average productivity (see Figure 8)]
- US productivity has generally been declining since 1993

- US software quality is better than world averages, although a price is being paid during the development process (see Figure 10)
- US quality has been improving, although a "dip" has been observed in 1997.
- Process maturity (SEI-CMM) of US organizations has been generally lower than companies sampled offshore (see Figures 12 and 13)

Additional data on worldwide software engineering performance has also been supplied by Capers Jones (see Appendix III, Figures 1-11). Although the data does not contain trend information, it reinforces the view that the US is not the world leader in productivity and quality. The forces impacting productivity and quality have also been summarized by Jones (see Appendix IV).

Using the data presented, projections as to how the global levels of software production will be changing over the next eight years in response to labor and performance factors have been developed (see Figure 14). As can be discerned from industrial age lessons, the "balance of production power" may be changing in the information age. The key drivers are the availability of labor and worker productivity. Some insights into the shifting global dispersion of software production can be seen by examining the rise of India and Ireland.

Dr. Jerrold M. Grochow
American Management Systems
Major trends in our industry are creating productivity and quality problems even as they attempt to solve problems of usability and flexibility. All of these trends are interrelated making productivity and quality particularly difficult to solve. The extent of the issues and problems are exacerbated by the IT labor shortage.

1. Systems are getting larger.
The market is demanding more capability, more usability, and more flexibility. That requires more software to be developed to provide what might be thought of as the "same function." Today's "word processor" is easily 10x the size (in lines of code) but probably only 5x the total functionality (even less if you only count features used by more than 25% of the end-users) of word processors of ten years ago. Unfortunately, this means that we are seeing an overall decrease in industry-wide productivity. Add in the decreasing economy of scale in software development productivity, and the situation looks even bleaker.

2. Increased complexity of architectural styles (distributed objects, etc.).
The systems we are developing today are significantly more complex than their predecessors. This complexity is not always hidden from the application developer or operator, often resulting in lower productivity (in terms of developing the same functionality) and quality (in terms of latent errors in today's multi-computer, network-based asynchronously operating application systems).

3. The systems integration component of development has been increasing rapidly.
This is related to the earlier points: no single vendor can provide all the pieces necessary to make today's systems work (even software distributed by one vendor, even Microsoft, has been developed by many different organizations). And systems integration takes time and effort.

4. Reuse. One way to improve productivity (measured as functionality produced per unit of work expended) is to buy rather than build. But that has resulted in "buying" a dozen components and trying to make them work together (see Systems Integration above). When this process gets too difficult (which it often does), the tendency is to build rather than buy so that the only "vendor" you have to deal with is your own organization. It is not clear that we have figured out the proper trade off between building and buying/integrating to maximize either productivity or quality.

5. Requirements capture.
Just what is it that the end-users want or need or are willing to pay for? Granted that they may not know, and that they may change their minds over time, but if developers and end-users cannot communicate on these key issues, then we are doomed to doing "rework" forever. And rework is a direct negative contribution to productivity (and quality, depending on your definition). It is clear that problems in requirements definition have been the culprit in a wide range of system failures and overruns.

6. Microsoft dominance in the software industry.
It is difficult to talk about productivity of system development without talking about the key purveyor of the tools and languages that we use. One possible scenario is that productivity improves at exactly the rate that Microsoft allows it to.

7. Personnel shortage.
With demand increasing rapidly, salaries for new and experienced workers are bid up apace. Wages for current employees of a company rarely keep up, and that leads to increasing turnover. With turnover, however, firms lose critical domain and application knowledge (not to mention technical skills). Replacements rarely have the same level of domain knowledge, and certainly don't have the same level of company and application knowledge. All other things being equal, productivity drops.

In developing and growing our nation's labor force what must be done to address these issues and/or promote practices to ensure competitive productivity and quality levels? Unfortunately, none of the solutions are simple or easy to implement. Labor shortages are related to how much we have to get done, how productively we can work, and how many people are available to do that work. If we measure how much we have to get done in function points, productivity in function points per labor year, we get:

IT Labor Shortage = FP needed / Productivity rate - Available labor

Obviously, we can reduce the labor shortage in three ways:

1. Reduce the FP needed
2. Increase productivity
3. Increase the available labor pool

For the past two decades, the amount that needs to be done has increased seemingly without bound, productivity has remained constant or declined, and the labor pool has increased at a decreasing rate. It is interesting to see how we have dealt with each of the three factors making up the labor shortage equation:

1. In certain pockets of the industry, we have taken steps to decrease how much we need to develop. The acceptance of application packages to satisfy more and more organizational functions is the best example of this. This is perhaps most vividly seen in the number of organizations converting to packages to deal with their Year 2000 problems - they just don't have the time or resources to take any other approach. This trend should be encouraged so that we can focus on adding function points where they are uniquely needed.

2. Productivity is our biggest problem. Just as we talk about the latest improvements in languages and tools, we also talk about how hard it is to get people to adopt them or to make them work in the complex system environments we are working in (see points above on complexity of new system environments).

3. For reasons that no one seems to fully understand, the number of people interested in IT careers is not increasing anywhere near demand. We need to work on improving the attractiveness of the software industry to high school students (where the seeds of many careers are sown) as well as college students. We also need to expand the idea of training IT professionals in the organizations that need them. In the not so distant past, large companies hired much of their work force from liberal arts colleges and trained them in whatever area they needed. They attracted staff based on their reputation as a good place to work, rather than as a company in a specific field. Companies need to work on their image in the workplace (as many are now doing, evidenced by the importance of surveys by Fortune Magazine, Computerworld, and Working Mother on good places to work) if they are going to compete effectively for raw talent that they can then train.

Another point about the labor pool has to do with who we consider to be part of the IT industry. Spreadsheets allowed thousands of people to become "computer programmers" without even knowing it (and some would say, without understanding the implications of what they were doing!). We need to encourage more and more work on making computers accessible to everyone, in the same sense that the telephone system has become accessible to everyone and we have all become telephone programmers!

Capers Jones
Software Productivity Research
There is no quick solution to meeting the increased demand for IT workers and no easy answer to how we can stay competitive. From a historical perspective, the United States has followed a pattern in other industries that may also turn out to be true for software.

We start with a tremendous burst of energy and wonderful inventions (such as automobiles, airplanes, electric lights, etc.). These new products trigger the formation of large new industries, and benefit the national economy and the balance of trade. However after the industries are fully formed, something happens to slow down progress. We begin to look toward the past instead of toward the future. Both innovation and new investments lag, and other countries begin to catch up or even move past us in revitalizing the mature industries. I would say that the U.S. is one of the best countries in history for pioneering new industries, but not more than average in keeping industries ahead of global competition after they have been around for 50 years or more.

While universities might be blamed for the shortage of trained software professionals, I don't think they are totally at fault. The ultimate solution is to move computer and software literacy training down below the university level so that it starts in grade school and is far advanced by high school. The use of computers and software is so important to white-collar and knowledge work that it should begin at the same age as other basic skills: say at or before the age of 5. At the college level, computer literacy should be a required entry-level skill. It should also be a required course for all freshmen, regardless of their ultimate majors.

Larry Putnam
Quantitative Software Management
Market forces will adapt to the increased demand in the intermediate/long term. Remember the. For example, the US auto industry overcame quality and cost problems with automobiles 10 to 15 years ago by focusing serious attention on the problem . Twenty to twenty-five years ago the steel industry was high cost, inefficient and was the high cost producer internationally. Japan and Europe had new plant built after WWII. New technology came along; our steel companies invested; they became the low cost, high quality producer again.

Increase Education Opportunities to increase the body of trained people.

- The regular 4-year colleges are ill equipped to train the people in the skills needed by industry. Community colleges are better suited to this task.
- Re-training of mature adults (women re-entering the work force) and downsized engineers from other fields (civil and mechanical engineers) desiring to enter the IT programmer/software engineering field has promise.
- Special curricula need to be developed by specialists who understand the industry needs.
- Industry seems able to respond rapidly to IT needs.
  - New Horizons has full classes all the time for people learning common computer applications (Word, Excel, etc.). Their classes are expanding. Eighty percent of the students are women; many re-entering the workforce.
  - The CEO (Alan Salisbury) of Learning Tree International says they are growing at 40 percent per year or higher. They can add a new class very quickly when they are asked by their industry customers. They take on new languages (Java, HTML) and media (networks, Web) as soon as the need is established. Clearly this type of training satisfies only the short-term needs for specialty subjects but they do show that industry will respond when the market opportunity is there.

The QSM software equation (Size ~ Process Productivity Parameter* Effort$^{(1/3)}$* Schedule$^{(4/3)}$) shows there are two ways that management can do something about the shortage by the strategies they adopt for application development. One of these is to use QSM's trade-off law (above equation solved for effort) to reduce the requirement for people. For example, for one system of 100,000 SLOC, [1000 FP; 400 objects]

- Use 5 v. 8 people [- 3 people; -38%]
- What penalty? [+1.8 months] What benefit? [-31 PM]
- What saving in cost? [-$313,000]; improvement in reliability? [+2.2 days MTTD]

Can this be done on a large scale? Yes. Has it ever happened? Yes. About 25% of the completed projects in the QSM data base exhibit this behavior. The reasons are diverse and they are not as focused as we want to do with this IT labor shortage problem. But it can be made to happen for any new project (underway projects probably can't be influenced very much).

Another approach is to invest in process improvement.. This notion is implemented by investment in IT tools, training, etc. to increase the Process Productivity Parameter. This has been hard to convince many organizations to do seriously, probably because they have not been able to visualize the payoff or because inertia was too hard to overcome. Industry leaders have done it and the payoff for them has been handsome. One way to encourage this kind of change more broadly would be to provide incentives in contracts for moving up the SEI scale by splitting the possible savings between the developer and the customer.

- The benefits of process improvement are significant. For example, in going from a high level 1 (QSM PI of 17) to a level 2 (PI of 19) we make these kind of savings:
- Fewer people - 8 to 5.3; [-34%]
- Other benefits - less cost [- $455,000], longer MTTD [5.6 v. 3.7 days; - 51%], shorter schedule [15 v. 18 months; - 17%]
- Disadvantage: Takes time to implement; it might take 2 to 3 years to see the payoff as the process improvement program is implemented. Nevertheless, it easily pays for itself and deals with the staffing shortage right away.

This concept can be applied to all the software development and maintenance projects fairly quickly, with the benefits scaling proportionally.

These ideas have been around for a long time. I wrote about them in papers 20 years ago. They have been slow to catch on. Perhaps it has been because people in the industry were threatened by the notion that reducing staff on projects would be manifested in job loss to get the money savings. In the current shortage environment you would still do all the work but you would just take a little longer on each project (for the tradeoff cases). For a process improvement scenario you can even reduce the schedule along with staff, cost and defects.

Attitudes concerning measurement and metrics also need to be changed.

- Fear of Measurement is very prevalent.
- We need to face the unpleasantness of dealing with it - by leadership, motivation.
- Changing the culture and building confidence in the organization is part of process improvement- it is on the road to level 4 and 5.

All this is hard work, but it does happen and the payoff is handsome. Maybe it is time to mobilize the effort.

Michael Sinneck
IBM Global Services

The labor shortage is real and we in IBM Global Services and across IBM overall are beginning to feel it in our day to day business operations. While the problem is not yet acute enough to cause a panic we are already experiencing abnormally high organic attrition rates (close to 10 % in some parts of our business). This coupled with job transfers due to travel burnout and work/life balance issues has pushed the aggregate rate close to 20% for brief periods of time.

By historic IBM standards this is without precedent. We are learning to cope and so far our business has not been adversely impacted by these phenomena, however we are increasingly focused on retention activities to preserve the skills from outside attack. IBM has established impressive recruiting machinery to attract new employees that has been most effective for us to date although there are significant skills gaps in the available talent pool.

Today we have identified several critical skills which are very difficult to find in the professional workforce and are essentially non existent in the college graduate population. These include: project management, especially for large scale integration projects; IT Architecture to do complete systems engineering; application software engineers; distributed systems design and development (includes client/server, inter/intra/extranet, etc.); business modelers especially with OO/Java experience; and data management to support the red hot business intelligence markets. Also in short supply are all forms of legacy development and maintenance skills (largely fueled by Y2K).

By and large, the universities are not preparing their graduates to work in the commercial marketplace. The focus of most programs seems more oriented to computer science and not to commercial systems development. This is quite evident in that most graduates lack any applied formal methods or process training and there isn't a requirement to demonstrate these skills in a project setting. Without equivocation most firms have to invest significantly in training graduates in very basic concepts so that they can be effective on the job.

I think universities and commercial enterprises should consider tighter bonds so that students are trained in real world methods/tools/processes for commercial application, reinforced through on the job project experience as a pre-requisite to conferring a degree (much like a thesis).

I think government can help by doing more to encourage IT as a national priority for industry and society at large. I agree that the potential economic considerations are too large to ignore. We don't need regulation but a gentle push and some important follow through (difficult to conceive how the government can do this for me. We need Washington to realize that the information economy is our future and that other governments are targeting this sector at our expense. I think some national policy changes and emphasis would do the trick.

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Additional contributions by Frank McGrath of the Software Program Managers' Network of the DoD

New factors are driving economic and business success in today's information and knowledge based economy.

Ideas and technological discoveries are the driving engines of economic growth.

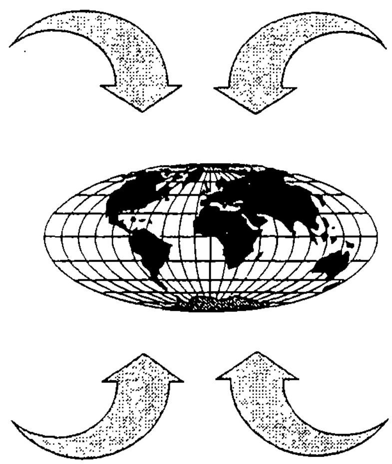
Source: Wall Street Journal, 1/21/97

In the future, the ability to learn faster than your competitors may be the only sustainable competitive advantage.

Source: Peter Senge

The problem with the future is that it's not what it used to be!

Source: Michael Hammer, 10/89



In order to remain competitive, today's corporation must develop and understanding of global technology economics.

Software development work now can flow freely to whomever can deliver the most effective and efficient product regardless of time zone or national border. Adam Smith would be proud!

Source: CIO Magazine, 2/1/97

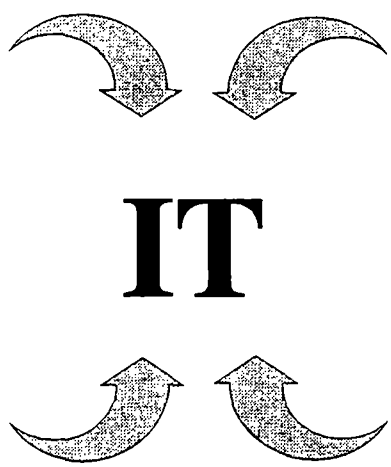
Howard Rubin: Figure 1

New forces must be reckoned with in managing an IT organization in the information age.

The rate of technology change and new technology introduction.

The essential and increasing role (and cost) of technology as a differentiator in business performance.

The acceleration of demand for information systems.



The overall dilution of the IT dollar and its value in support to business.

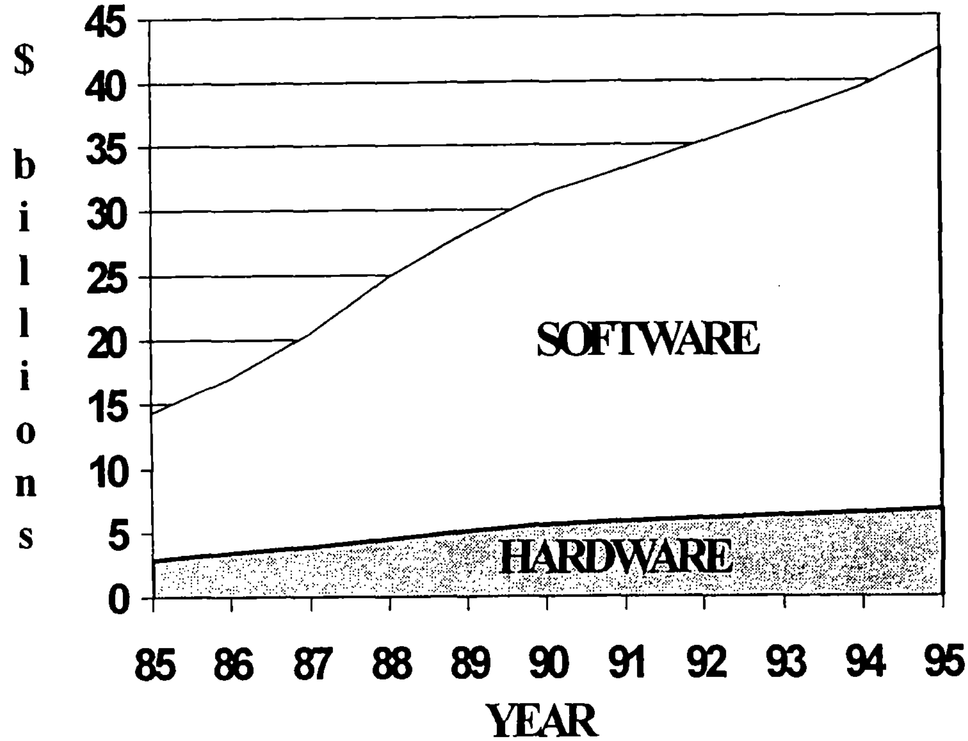
The increase in complexity of creating new information systems

The IT workforce labor shortage.

The Global software and systems economy.

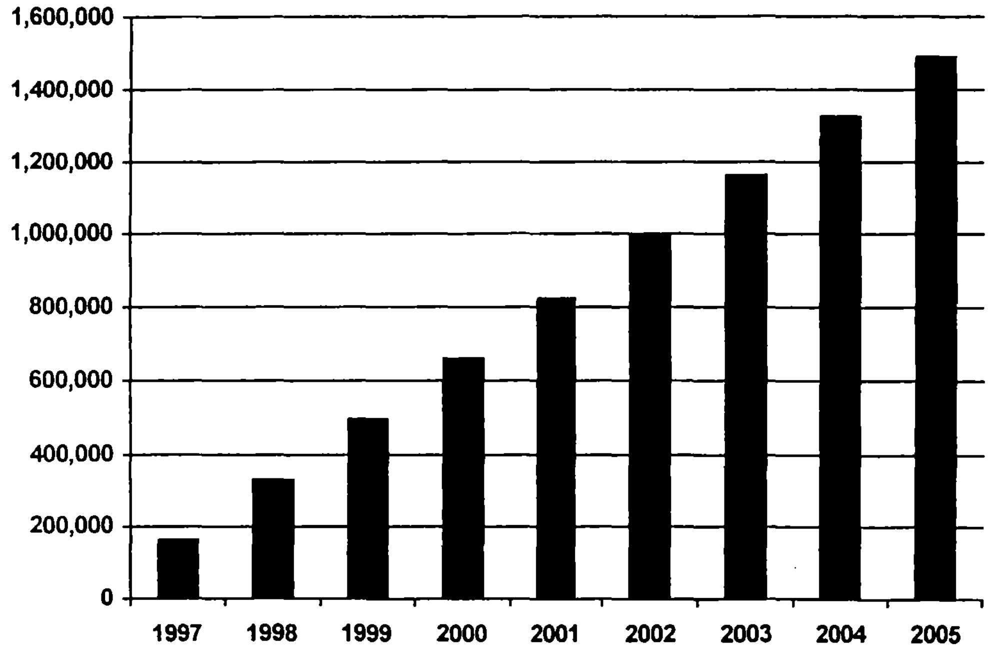
Howard Rubin: Figure 2

DoD computer systems costs from 1985 to 1995.



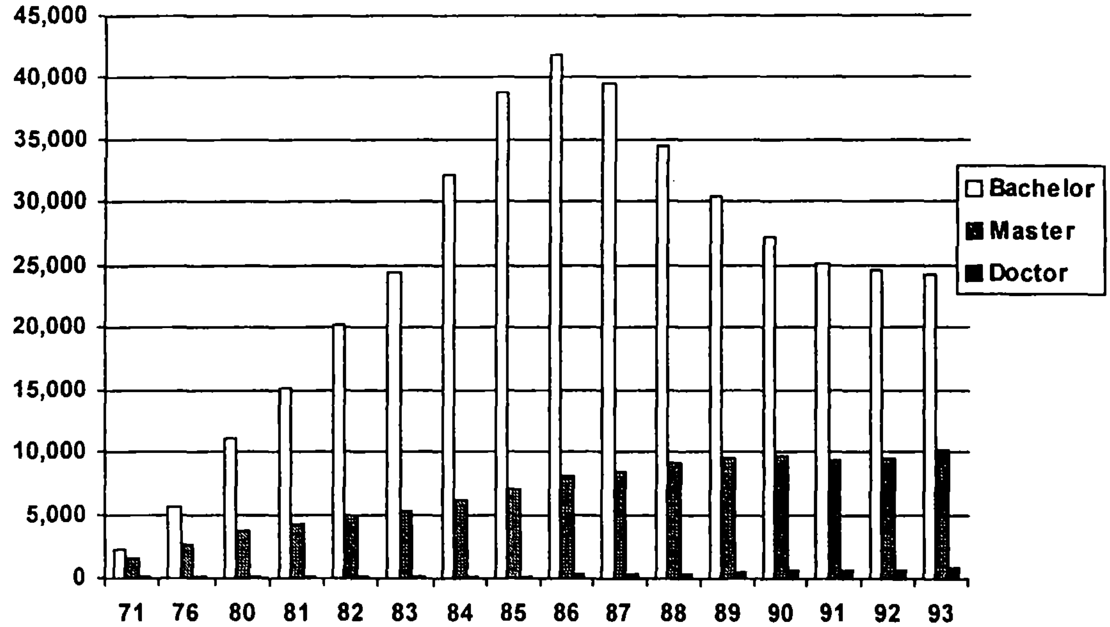
Howard Rubin: Figure 3

Projected cumulative software job openings not filled by US college graduates



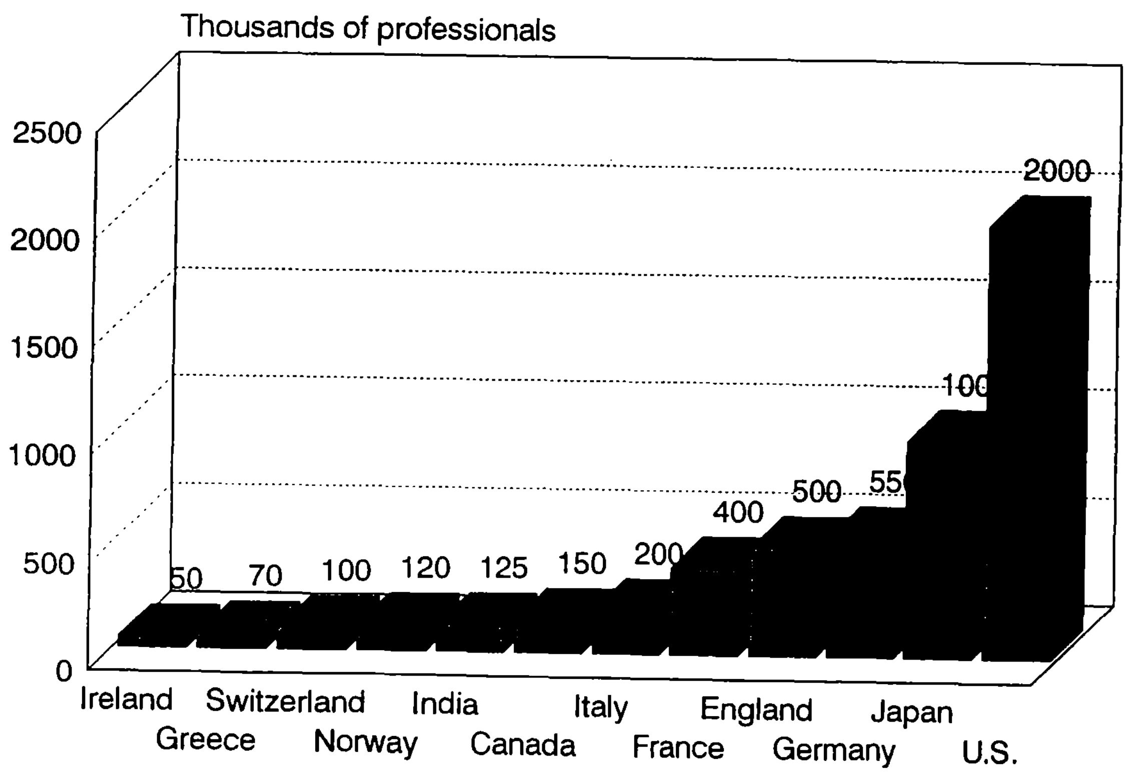
Howard Rubin: Figure 4

Computer and information systems degrees awarded in the US between 1970-1971 and 1992-1993



Howard Rubin: Figure 5

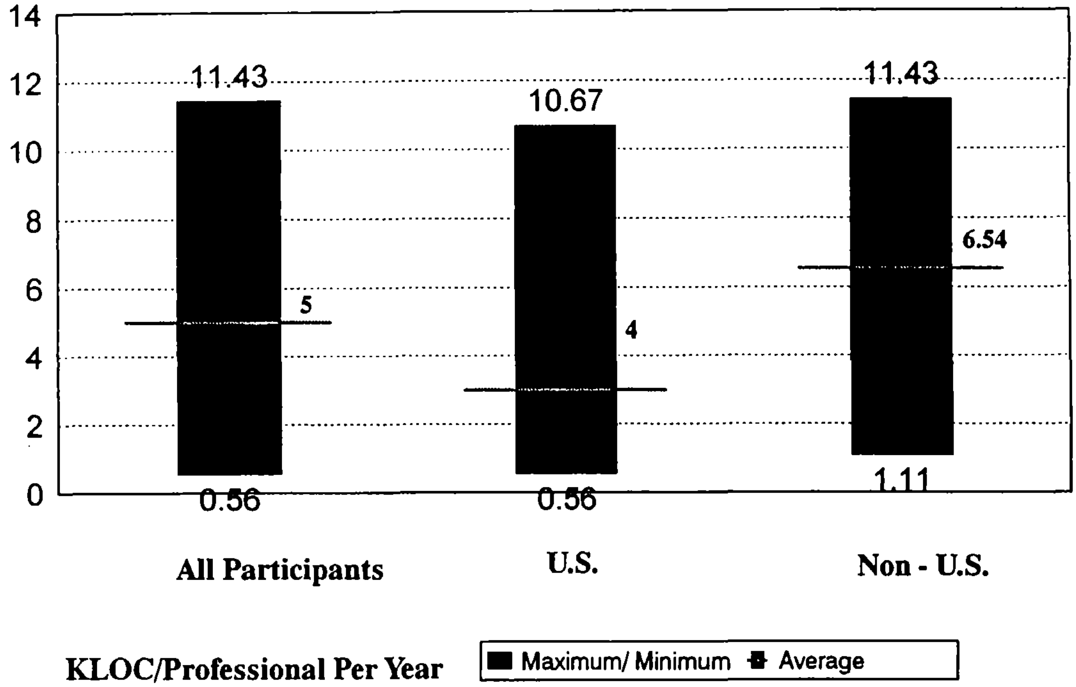
Software professionals by country



Howard Rubin: Figure 6

Worldwide Benchmark Report 1997

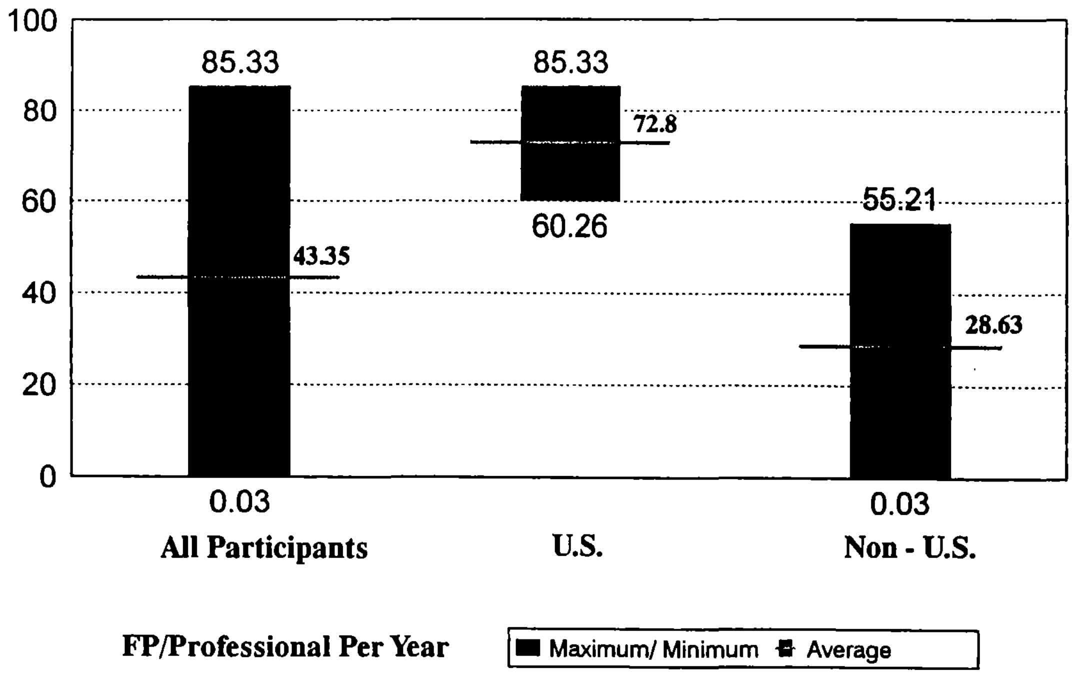
New Development Productivity (KLOC)



Howard Rubin: Figure 7

Worldwide Benchmark Report 1997

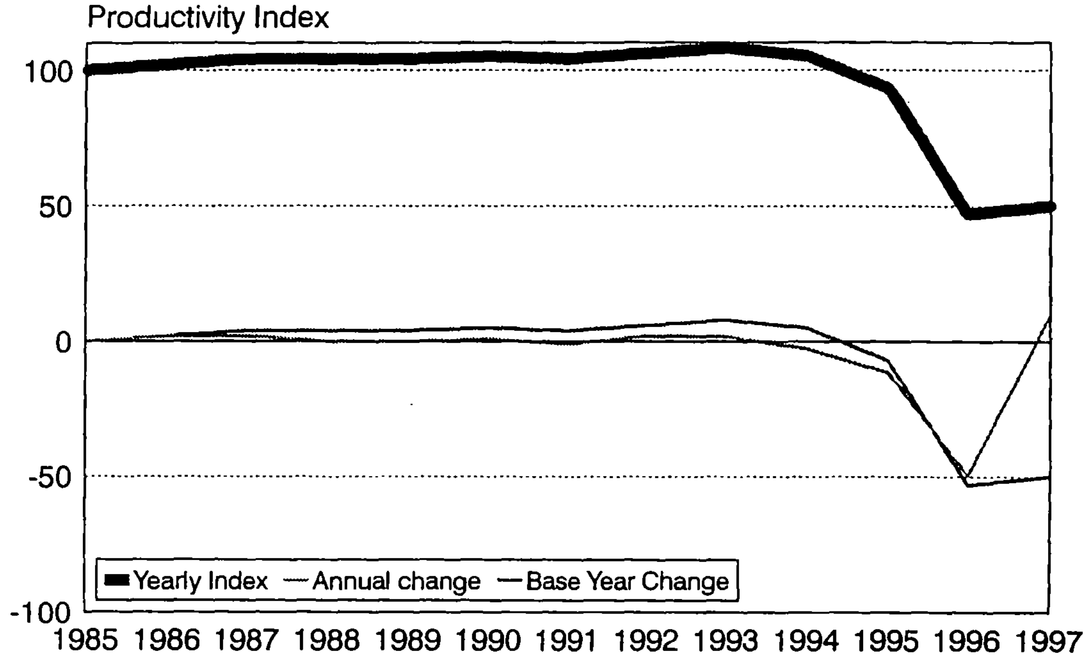
New Development Productivity (FP)



Howard Rubin: Figure 8

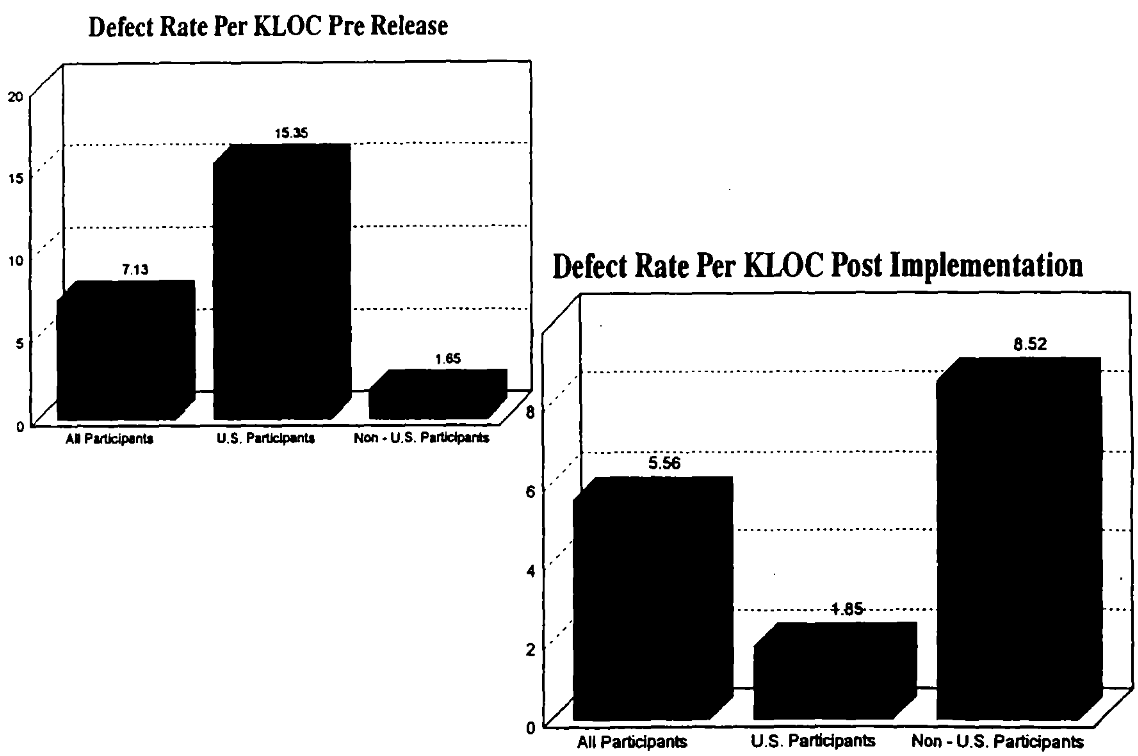
Worldwide Benchmark Project Results 1997

Software productivity in the U.S. is showing a major decline



Howard Rubin: Figure 9

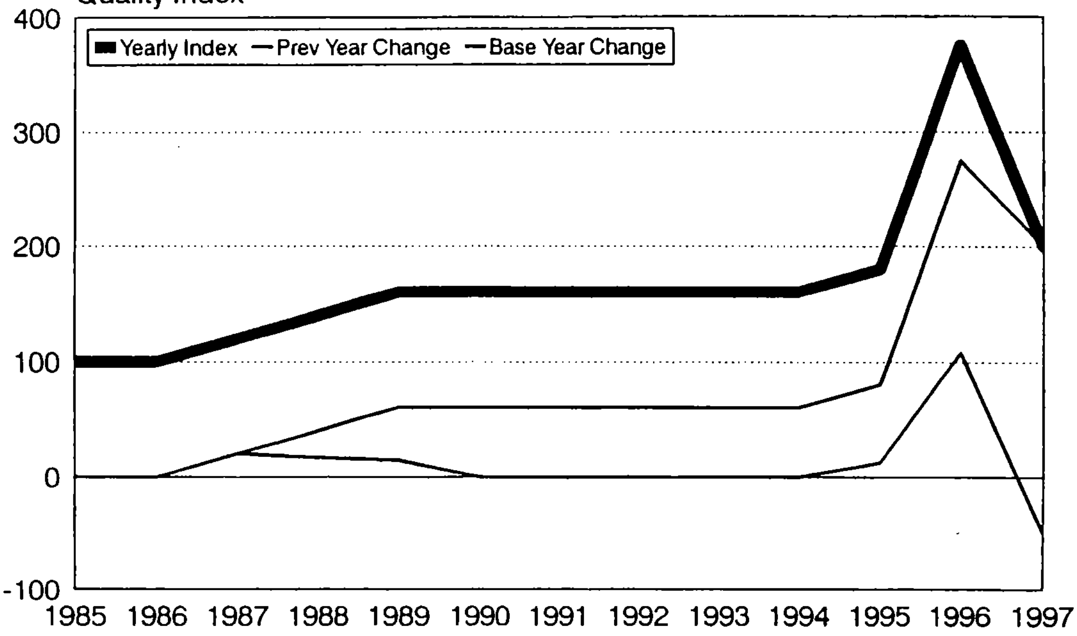
Worldwide Benchmark Report 1997



Howard Rubin: Figure 10

Worldwide Benchmark Project Results 1997

Since 1985 the quality of software developed in the U.S. has increased dramatically

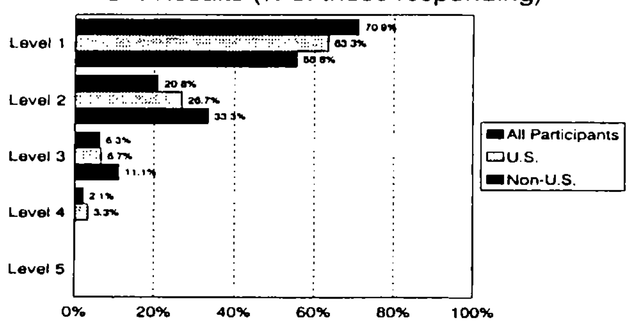


Source: 1995-6 Worldwide Benchmark Project

Howard Rubin: Figure 11

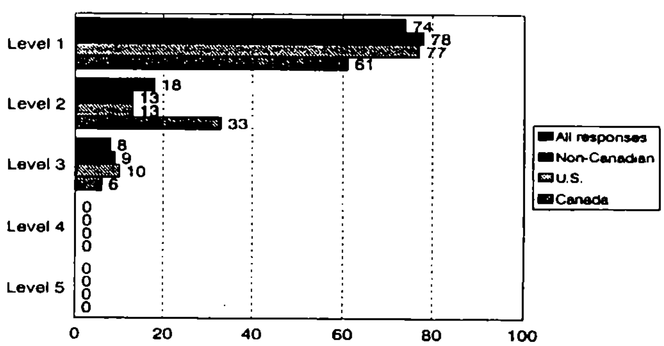
Worldwide Benchmark Report 1996

SEI Results (% of those responding)



...enchmark Report 1995

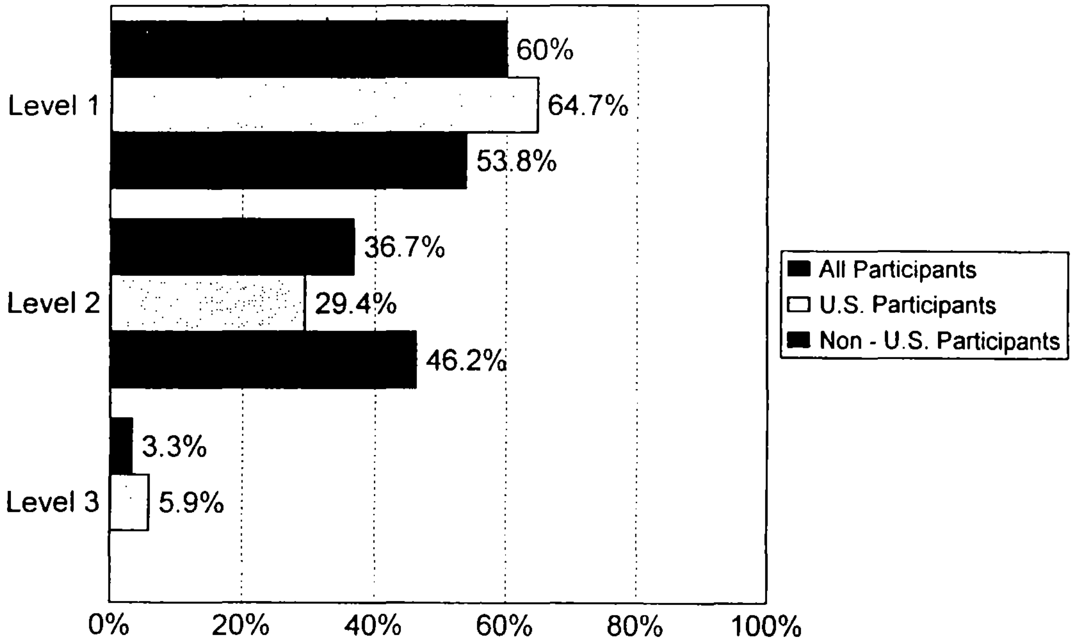
Self-administered SEI Results (% of those responding)



Howard Rubin: Figure 12

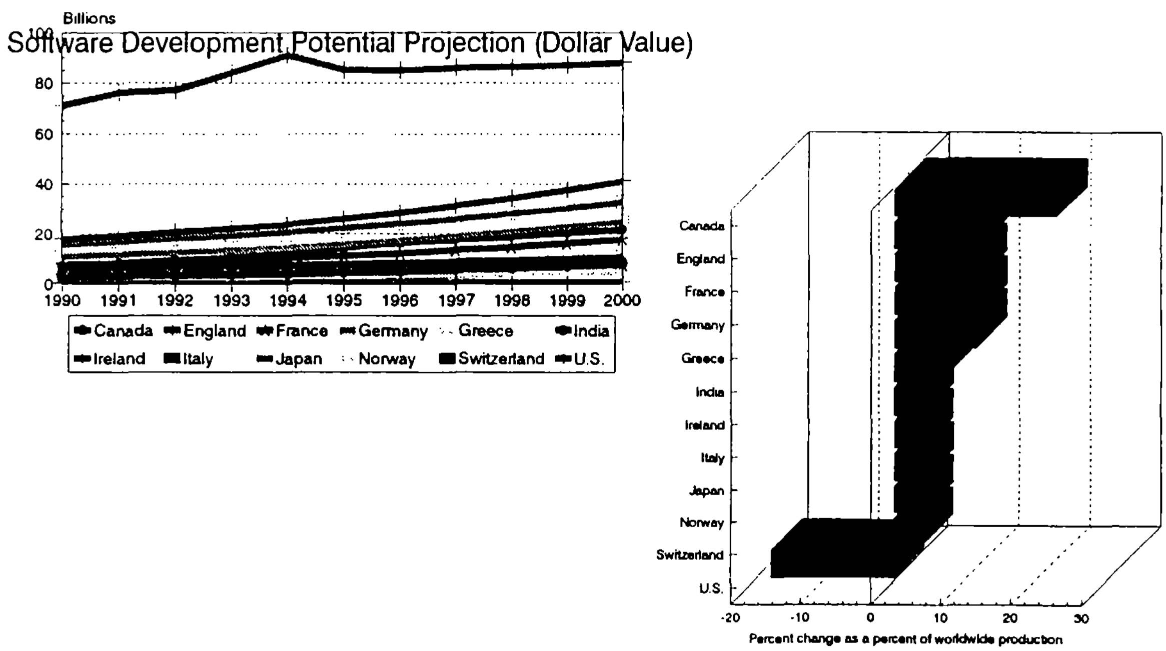
Worldwide Benchmark Report 1997

SEI Results (% of those responding)



Howard Rubin: Figure 13

Projected change in software output 1996 to 2000



Howard Rubin: Figure 14

Recruiting Underrepresented Groups

Building the 21st Century Information Technology Work Force:
Underrepresented Groups in the Information Technology Workforce

OVERVIEW OF ISSUE

The proliferation of digital technologies in the American economy has created robust demand for workers who can create, apply, and use information technology, with especially strong demand for skills in popular new programming languages and network related software. As a result, employers across the country report having difficulties recruiting and retaining adequate numbers of workers with the knowledge and skills in demand.

Women and some minorities are underrepresented in most technical fields, including those related to information technology. As a result, while many employers struggle to recruit adequate numbers of workers with computer-related skills, large pools of potential talent remain untapped. Another underutilized pool of skilled labor that could potentially be tapped for information technology occupations are mid-career and older technical professionals, such as engineers who were dislocated during defense and corporate downsizing. For many, however, this could require making a transition to an entirely new field of career endeavor.

SUMMARY OF RESEARCH

The labor market for information technology (IT) workers is expanding and shifting rapidly. New skills are constantly in demand, and IT occupations are evolving in new directions. New kinds of IT jobs are being created, and new job titles and job requirements are appearing on a regular basis. For example, a few years ago, "webmasters" were few in number; now there are legions of them developing sites and keeping information up-to-date on the World Wide Web.

While IT jobs are changing rapidly, the statistical frameworks used to gather and analyze information about industries and occupations has not evolved very quickly. As such, this paper will refer to occupations--as representative examples of the IT workforce--for which there is a variety of longitudinal data available. These occupations include:

- electrical and electronic engineers
- computer systems analysts & scientists
- operation and systems researchers & analysts
- computer programmers
- computer operators
- data entry keyers.

While many workers use computers on the job, this paper refers to those occupations that are more intimately, directly, or frequently involved with the creation of information technologies rather than its application to a wide range of disciplines and enterprises.

Groups Underrepresented in the IT Workforce

The following presents the currently available statistical information on the representation of women, African-Americans, Hispanic-Americans, Older Workers, and Disabled Americans in the overall information technology workforce in the categories listed above.

Data on Women's Representation in the IT Workforce:[1]

OCCUPATIONS	Total Employed	Gender (as % of total) Male	Female
Electrical and Electronic Engineers	603,000	92%	8%
Computer Systems Analysts & Scientists	1,091,000	72%	28%
Operation and Systems Researchers and Analysts	207,000	57%	43%
Computer Programmers	558,000	69%	31%
Computer Operators	398,000	40%	60%
Data Entry Keyers	690,000	16%	85%
All IT Occupations	3,547,000	56%	41%
All Occupations		54%	46%

While women represent a significant portion of the IT work force as defined above, when the largely administrative support positions of Data Entry Keyers and Computer Operators are removed, women represent only 25 percent of the professional IT workforce. Although significantly underrepresented in computer scientist and programmer positions, the lack of women in computer-related engineering fields is the most stark gender-gap in the industry. It is encouraging, on the other hand, that women are very well represented in the field of Operation & Systems Research.

[1] Source: *1996 Current Population Survey*, Bureau of Labor Statistics, Office of Employment Projections.

Data on Racial/Ethnic Minorities' Representation in the IT Workforce:

OCCUPATIONS	Total Employed	Race/Ethnicity (as % of total) White	Black	Hispanic	Other
Electrical and Electronic Engineers	603,000	86.1%	4.3%	3.9%	0.6%
Computer Systems Analysts & Scientists	1,091,000	81.9%	7.1%	2.5%	0.4%
Operation and Systems Researchers & Analysts	207,000	86.6%	8.0%	3.5%	1.4%
Computer Programmers	558,000	83.8%	5.4%	4.6%	0.4%
Computer Operators	398,000	83.6%	13.4%	8.1%	0.6%
Data Entry Keyers	690,000	77.9%	17.1%	11.0%	0.8%
All IT Occupations	3,547,000	82.6%	9.1%	5.4%	0.6%
All Occupations		85.1%	10.7%	9.2%	0.7%

As with women, African Americans seem to do fairly well as a percentage of the overall IT workforce as defined above,[2] until Operators and Keyers are removed. Then the population falls to 6 percent of the professional IT workforce. (African Americans are , however, more strongly represented as Computer Scientists and Operations & Systems Researchers).

Hispanics are significantly underrepresented by either definition, at 5.4 percent of the total IT workforce, or 3.4 percent of the IT professionals.

Although the Bureau of Labor Statistics data above does not break out population to show the representation of Asians or American Indians in the IT workforce, we can see some trends from data collected through the National Science Foundation:[3]

OCCUPATIONS	Asian	American Indian
Science & Engineering Labor Force	8.9%	0.2%
Resident Population of U.S.	3.2%	0.7%

This data is less representative of the entire IT Workforce, as it shows only Science and Engineering workers broadly, but the trends appear to hold true across Information Technology as well. Asians are generally somewhat overrepresented in these fields, and American Indians are quite underrepresented.

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[2] Source: *1996 Current Population Survey*, Bureau of Labor Statistics, Office of Employment Projections.

[3] Source: *National Survey of College Graduates: 1993*, National Science Foundation, Appendix table 1-5 as quoted in *Women, Minorities, and Persons with Disabilities in Science & Engineering: 1996*, National Science Foundation, (NSF 96-311).

Data on Older Workers' Representation in the IT Workforce:

OCCUPATIONS	Total Employed	Age (as % of total) 16-19	20-24	25-34	35-44	45-54	55-64	65-74
Electrical and Electronic Engineers	603,000	0.1%	3.3%	32.4%	34.1%	20.3%	8.6%	1.0%
Computer Systems Analysts & Scientists	1,091,000	0.3%	5.1%	35.0%	34.4%	20.2%	4.5%	0.3%
Op & Systems Researchers & Analysts	207,000	0.0%	3.1%	33.6%	30.3%	25.3%	6.0%	1.8%
Computer Programmers	558,000	0.9%	7.3%	42.7%	29.1%	15.9%	3.8%	0.2%
Computer Operators	398,000	2.9%	12.4%	27.9%	29.5%	16.7%	8.4%	2.1%
Data Entry Keyers	690,000	5.1%	17.6%	28.0%	26.3%	15.7%	5.9%	1.2%
All IT Occupations	3,547,000	1.6%	8.3%	33.5%	31.2%	18.6%	5.9%	0.9%
All Occupations		5.1%	9.6%	25.3%	27.7%	20.1%	9.3%	2.4%

Workers generally seem to be evenly represented in the IT workforce until they reach the 45-54 age range, and even workers in this range do well in all professional IT positions with the exception of Computer Programmer (no doubt a fast growing segment of the job market). Once workers reach 55, however, there is a considerable drop in the numbers holding Computer Science, Systems, and once again Programming jobs. The trend no doubt worsens approaching retirement age and beyond.

Data on People with Disabilities' Representation in the IT Workforce:

Once again, the data available on the representation of persons with disabilities in the IT workforce can be found through the National Science Foundation.

OCCUPATIONS	Persons w/ Disabilities	Persons w/out Disabilities
Science & Engineering Labor Force	5.8%	94.2%
Resident Population of U.S.	20.0%	80.0%

Persons with disabilities are clearly underrepresented in the fields of Science & Engineering, representing one-quarter of what they represent in the overall population.

Groups Underrepresented in the IT Educational Pipeline[4]

One indication that underrepresentation of women and some racial minorities is unlikely to change in the near future is their relative underrepresentation in the computer and information sciences education pipeline. Women – who comprise 51 percent of the population and earn more than half of all bachelor-level degrees awarded – earn only 22 percent of the bachelor-level computer and information science degrees awarded by U.S. academic institutions. In computer engineering, women earned only 13 percent of the bachelor's degrees awarded by U.S. academic institutions in 1996, and they earn bachelor's degrees in electrical engineering at similar rates. Women do participate at greater levels in bachelor-level business information systems programs that focus on management information systems and data processing.

Degree/Certificates Awarded	Men in All IT Programs	Men in College	Men in Population	Women in All IT Programs	Women in College	Women in Population
Less than Two Yrs. Program	50.10%		48.88%	49.90%		51.12%
Associate's Degrees	75.71%	40.46%	48.88%	24.29%	59.54%	51.12%
Bachelor's Degrees	78.22%	45.35%	48.88%	21.78%	54.65%	51.12%
Master's Degrees	78.95%	44.92%	48.88%	21.05%	55.08%	51.12%
Doctoral Degrees	86.02%	60.56%	48.88%	13.98%	39.44%	51.12%

More disturbing is the trend line: the share of all computer science degrees awarded to women in the United States has fallen steadily from a peak of 35.8 percent in 1984, to 27.5 percent in 1994 (the lowest level since 1979), with only a slight rebound to 28.4 percent in 1996. This trend, coupled with the continued downturn in the number of computer science degrees awarded overall, has cut the number of women receiving bachelor's degrees in computer science by more than half, from a high of 15,126 in 1986 to 6,954 in 1996. In 1996, men were three times more likely to choose computer science as a field of study than women.

African-Americans, Native Americans and Hispanics are also underrepresented in computer science education, though the share of degrees in this fields received by each of these groups has climbed substantially since 1977. These groups also are underrepresented in higher education generally.

[4] Source of Charts in this Section: U.S. Department of Education, Integrated Post Secondary Education Data System, '94-'95 Compilations Survey, ftp://nces.ed.gov/data/postsec/ipeds/completions

Degree/Certificates Awarded	Whites, Non-Hispanic, in IT Programs	Whites, Non-Hispanic, in College	Whites, Non-Hispanic, in Population
Less than Two Yrs. Program	52.03%		73.93%
Associate's Degrees	69.60%	77.70%	73.93%
Bachelor's Degrees	63.60%	78.73%	73.93%
Master's Degrees	43.53%	73.63%	73.93%
Doctoral Degrees	39.42%	62.61%	73.93%

Degree/Certificates Awarded	Blacks, Non-Hispanic in IT Programs	Blacks, Non-Hispanic, in College	Blacks, Non-Hispanic, in Population
Less than Two Yrs. Program	13.66%		11.98%
Associate's Degrees	10.04%	8.73%	11.98%
Bachelor's Degrees	7.64%	7.52%	11.98%
Master's Degrees	3.02%	6.08%	11.98%
Doctoral Degrees	1.04%	3.75%	11.98%

Degree/Certificates Awarded	American Indians in IT Programs	American Indians in College	American Indians in Population
Less than Two Yrs. Program	1.17%		0.73%
Associate's Degrees	0.85%	1.02%	0.73%
Bachelor's Degrees	0.37%	0.57%	0.73%
Master's Degrees	0.14%	0.41%	0.73%
Doctoral Degrees	0.07%	0.29%	0.73%

Degree/Certificates Awarded	Hispanics in IT Programs	Hispanics in College	Hispanics in Population
Less than Two Yrs. Program	14.19%		10.10%
Associate's Degrees	9.46%	6.67%	10.10%
Bachelor's Degrees	5.83%	4.67%	10.10%
Master's Degrees	2.13%	3.25%	10.10%
Doctoral Degrees	1.02%	2.21%	10.10%

Comparing the number of bachelor's, master's, and doctoral degrees granted in 1994 to students of each race and ethnic group to their share of the U.S. population of 22-30 year olds, the percentage earned by Asians (5.5 percent) and Whites (5.2 percent) is significantly higher than Native Americans (2.9 percent), African Americans (2.4) percent, and Hispanics (1.4 percent). However, Asians, African Americans, and Hispanics who earn bachelor's degrees chose computer science as a field of study at higher rates than White and Native American students.

An Expanded Pool of Talent[5]

Increasing the representation of women and minorities in the technical workforce may require reaching out to individuals originally trained in other disciplines. Many people who work in skilled IT jobs come from educational backgrounds other than computer science and engineering, including business, social science, physical science, electrical engineering, and mathematics degree holders. In fact, many people working in IT jobs have some college but no formal degree, and others have entered jobs such as computer programming with no post-secondary education at all.

Women, minorities, and disabled persons, some of whom are unemployed or underemployed compose a very large pool of people with technical and other education backgrounds, with the potential to enter successfully IT occupations if appropriate transition assistance was available and affordable.

		Highest Level of Education					
OCCUPATIONS	Total Employed	No Diploma	HS or Equiv.	Some Coll.	Assoc.	BA	MA
Electrical and Electronic Engineers	603,000	0.3%	6.6%	9.5%	10.4%	48.1%	20.9%
Computer Systems Analysts & Scientists	1,091,000	0.3%	6.2%	14.7%	9.0%	47.6%	18.7%
Op & Systems Researchers & Analysts	207,000	0.1%	13.6%	16.5%	9.1%	42.2%	14.7%
Computer Programmers	558,000	1.4%	8.7%	20.9%	9.6%	45.2%	13.0%
Computer Operators	398,000	4.6%	34.2%	31.9%	11.2%	15.3%	2.4%
Data Entry Keyers	690,000	4.7%	40.9%	31.8%	10.7%	10.3%	1.4%
All IT Occupations	3,547,000	1.8%	17.0%	20.2%	9.9%	36.1%	12.7%

Another potential pool of talent for filling IT jobs is comprised of mid-career and older, (over the age of 40), technical professionals, including many with computer-related education and experience who are not now part of the IT workforce. This includes mid-career IT professionals laid-off during defense and corporate downsizing, as well as individuals with advanced training

[5] Source of Chart in this Section: *1996 Current Population Survey*, Bureau of Labor Statistics, Office of Employment Projections.

in other fields of science and technology who may be underemployed, unemployed, or working out-of-field. There is considerable debate over why these individuals are not being absorbed into the new technology workforce. Among the most common explanations are opinions that the compensation and security expectations held by mid-career individuals may be higher than those held by new college graduates or those who have been in the workforce for just a few years. This argument can be countered by the observation that these older, often highly trained workers can bring a level of knowledge and experience to the workplace that younger employees have yet to acquire. The debate is by no means simple or straightforward and challenges many widely-held beliefs regarding the flexibility, work ethic, age biases, and technical competence of workers in different age groups.

BARRIERS

Barriers that Cut Across All Groups Underrepresented in the IT Workforce:

All groups underrepresented in the IT workforce face many of the same barriers to entry. These include:

Image of the Profession. The IT field is surrounded by a mystic that can be hard to penetrate. It is often perceived to be the domain of the highly educated and technical elite. The field's technical terminology and jargon may be incomprehensible to the uninformed. And, the field is perceived to be populated by the much maligned "geek" or "nerd," an image many young people and minorities seek to avoid.

Lack of Encouragement. Women and minorities may experience less encouragement to enter technical education and careers due to a lack of role models in the technical professions in school, at home, or in the community. Teachers may operate with a subtle bias toward encouraging boys and white students into more advanced mathematics and science studies. Also, women and minority groups often demonstrate different learning styles which may not be accommodated in the high-school level gatekeeping mathematics and science courses, providing further difficulties for these groups in acquiring the basic knowledge and skills required to pursue post-secondary technical education. Encouragement may also be lacking in the home; based on the family's work history and parental aspirations for children, technical careers may not be considered an option.

Lack of Opportunity and Access. In groups with few economic means, there may be an absence of widespread computer literacy in the population, and inadequate resources to invest in computer-related education or equipment both at home or in schools. Even in more resource rich communities, the number of computers available to students in school may be less than optimal, teachers may lack computer skills, and the use of information technology may be poorly integrated into the curricula.

Lack of Appropriate Skills. Attaining the right portfolio of skills to enter IT careers may be troublesome for all. Employers often recruit for a highly specific set of skills--often based on particularly IT technologies, programming languages, applications, etc.--which may be difficult for individuals to assemble. The problem is compounded by rapid technological change in the field, and the pace at which the education and training infrastructure, occupational data, and skill standards can respond and serve as up-to-date guides and education providers.

Broader Socio-Economic Context. Some schools are located in high-tech regions, such as Fairfax, Virginia, Silicon Valley, Austin, Texas, or Boston which may confer general advantages to students in those areas with respect to access to IT educational resources. Many other students, in rural areas for instance, may be situated in regions in which the local government may not even have Internet access. Similarly, school districts with active magnet school programs might provide greater encouragement to students to enter IT fields than school districts with fewer magnet schools.

Barriers Unique to Individual Groups Underrepresented in the IT Workforce.
In addition to barriers to participation in the IT workforce that cut across underrepresented groups, each underrepresented group--women, minorities, mid-career and older professionals, persons from other fields moving into IT, and persons with disabilities--faces unique challenges in entering the IT workforce.

Women

Women leave high school about as well prepared as men to enter post-secondary technical education programs. For example, the average mathematics scores of male and female 9- and 13-year olds did not differ in 1992, and the difference in scores for 17-year-old males and females is small. Gender differences in average science achievement test scores have diminished, but males score higher at each level.

There are few role models and mentors for women in science and engineering – in school, in post-secondary education, in the workforce, and among high-tech business owners and executives. For example, at research and doctoral-level academic institutions, among the science and engineering fields, women's faculty presence ranges from less than 6 percent in engineering and 8 percent in the physical sciences, to over 20 percent in the biological sciences. Women may be less likely to be encouraged in science and engineering education as men; educators in technical fields often demonstrate subtle biases in favor of males.

Women have fewer and less developed networks than men in both school and in the business community. This may contribute to women's difficulty in penetrating a glass ceiling to senior-level corporate positions. And, although the IT industry grew out of a male dominated culture, opportunities may be growing for women in rapidly changing fields where there is no long-term base of experience from which to draw senior level personnel.

Finally, several observers have noted a very subtle form of discrimination in the high-intensity IT environment as some IT employers perceive women job candidates as potentially less dedicated to the job due to their obligations to children and family. This includes a perception that women are less available for the overtime, night, and weekend work required in a highly competitive environment.

Racial/Ethnic Minorities

There are a number of barriers that inhibit racial and ethnic minorities in pursuing technical education and careers. While racism does not appear to be a strong barrier to employment in the IT industry, insufficient access and opportunities in the education pipeline may prevent racial and ethnic minorities from entering technical education programs and, later on, technical careers.

In K-12, though differences have narrowed, non-Hispanic white youth continue to score much higher than black or Hispanic youth on standardized tests of mathematics and science achievement. Racial and some ethnic minorities suffer a disproportionate impact from poor schools at the K-12 level, for example in the inner cities. Black and Hispanic students are less likely than white students to have access to a computer at home. Racial and ethnic minorities may experience less encouragement to enter technical education and careers due to a lack of role models in the technical professions in school, at home, and in the community. This limits exposure to information technology and IT careers, mentors, and others, as well as opportunities for educational and career positioning. Encouragement may also be lacking in the home; based on the family's work history and parental aspirations for children, technical careers may not be considered an option. Also, employers look for leadership skills cultivated through extracurricular activities that have been curtailed in many financially pressed inner city schools.

In higher education, there may be a lack of linkages--R&D, internship opportunities, and recruitment--between the IT industry and Historically Black Colleges and Universities, Predominantly Hispanic Colleges and Universities, and Native American schools. This reduces opportunities for technical training, real-world IT experience, exposure to the industry, and for springboarding into jobs through the industry-academia partnership pipeline. Also, lack of recruitment at these schools reduces the "market" pull choosing the focus of their education.

For some minorities there may be a cultural tradition that encourages students to pursue other educational directions. For example, Native Americans often choose to study in the fields of education, medicine, law, and social sciences in response to long standing issues, needs, and problems in their communities.

Racial and ethnic minorities still encounter racism and stereotyping in higher education, the recruitment process, and in the workplace.

Older Workers

Some IT professions are weighted toward younger worker populations. For example, in 1996, 80 percent of computer programmers and 75 percent of computer systems analysts and scientists were 44 years of age or younger. According to the National Survey of College Graduates, the number of computer science graduates employed in skilled IT professions declines substantially as time from college graduation passes.

6 (years) 57%
8 57%
10 47%
12 42%
14 37%
16 34%
18 29 %
20 19%

Even if older IT professionals possess skills in demand or could obtain them quickly and easily, employers often perceive them as costing more to the corporation than younger workers. New graduates or those out of school for just a few years have lower salary expectations, accrue lower benefits costs due to having few or no dependents, and are considered more available for overtime, night, and week-end work due to the lack of childcare and other family responsibilities.

Employers may view young technical employees with a few years of experience as the best buy for the human resource dollar. At this stage of one's career, the technical education is recent and a few years of experience makes an individual more productive. In addition, the young employee with a few years of experience has not reached the higher salary levels. Newly-minted graduates with the latest skills or those who can be quickly trained, though less productive than the more experienced employee, are also attractive to the employer.

As IT professionals mature, they may become less attractive to employers. They have moved up the salary scale, family obligations grow, medical insurance costs increase, and the educational background is getting old in a fast-moving technical field.

The IT industry is a young one; for example its paragon, Silicon Valley, is well-known for its youth consciousness. Young managers may look to hire individuals like themselves, demonstrating a subtle bias against older workers, or they may feel uncomfortable supervising employees older than they are.

In some parts of the country, and some parts of the IT industry, worker mobility is high, with many IT workers hopping from company to company. Many IT companies are start-ups and many of them fail, leaving their employees to find new jobs. This high-level of mobility and employment uncertainty is uncomfortable to many older works who have financial and family obligations, and who may be accustomed to higher levels of job security. Job security is also important for racial and ethnic minorities; for example, Native Americans traditionally place a high priority on the well-being of their children and their elderly.

Nontraditional Entrants to the IT Workforce

There are many individuals in the United States who are technically trained in non-IT related disciplines. Some are underemployed, some are working outside of the discipline for which they are trained, and some are even unemployed. For example, many technically-trained individuals were laid-off during the defense and corporate downsizing of the 1980s and 90s. Some of these individuals are potential candidates for IT jobs.

While these individuals may acquire IT skills that are in demand, many employers seek individuals with several years of experience in particular programming languages and/or their application. These experience requirements would serve as a barrier to those wishing to switch careers.

Also, many mid-career professionals laid-off during defense and corporate downsizing have experienced financial and emotional hardships. These individuals--who had committed themselves to years of education to attain an advanced technical degree, who worked hard, progressed in their careers, and demonstrated significant loyalty to their employers--found themselves unemployed or underemployed struggling to fulfill their financial and family obligations. For individuals who have worked and studied hard, this experience takes a heavy psychological toll. Because these are well-educated individuals, they are expected to find their own way back into comparable employment with little or no assistance. In reality, they may need career and psychological counseling, help in identifying retraining and employment opportunities, and help tapping into professional and employment networks.

Also, employers often recruit on the basis of narrow skill sets and may overlook the value of the other technical skills and experience these workers possess. Mid-career professionals who left the IT field and seek to reenter it will find that technological change is rapid and their skills, once cutting edge, are out-of-date.

People With Disabilities

According to the President's Committee on the Employment of People with Disabilities, over 54 million Americans identify themselves as having a disability, over 26 million have severe disabilities, and over 65% are currently unemployed. Indeed, this group represents a substantial pool of candidates for the IT Industry -- an industry that will finally value their intellectual capabilities above all other factors. When seeking employment, however, people with disabilities more often than not face the "Glass Door", rather than the "Glass Ceiling". People with disabilities often have lower levels of education, and until recently were directed away from career opportunities in the IT occupations. In addition, many people with disabilities are challenged by work disincentives created by public assistance programs and choose not to jeopardize their life sustaining benefits.

Although advances in technology have opened virtually all employment areas to people with physical and mental disabilities, many corporate cultures still carry barriers created by myths, stereotypes and fears about people with disabilities in the workplace and falsely perceive that accommodations are too expensive. The latter perception is not well grounded, according to a report by Peter David Blank, Senior Fellow at the Annenberg Washington Program, entitled "Transcending Compliance: Follow-up Report on Sears, Roebuck & Co." (Iowa City, Iowa, 1996). The report supported Dr. Blank's 1994 Sears Report and set forth new findings that the average workplace accommodation for an individual with a disability at Sears was $45.00. This was less than half the $121 average cost for an accommodation at Sears from 1978 to 1992. Employers should be made aware that the average accommodation is not expensive, and including individuals with disabilities into a competitive workplace makes good economic sense for business. This report also discussed how employers and employees can use the ADA to provide a framework for effective dispute avoidance and resolution.

Similarly, the advent of telecommuting can offer tremendous freedom and benefit for people with disabilities. It allows the employee to work from the home -- an environment that has been converted into a highly productive and comfortable space. But here again, employer perceptions are the barrier. Many employers are still uncomfortable about employees working at home -- disabled or not. Managers believe that employees who work off-site may not work required hours, or even as hard as those who are under supervision in a traditional workplace. Until all employers are committed to managing, communicating, and increasing group productivity through the use of technology, the desire for substantial supervisory oversight will continue to keep telecommuting from reaching its potential to serve both the employer and the disabled.

EXAMPLES OF PARTNERSHIPS & ORGANIZATIONS THAT ADDRESS UNDERREPRESENTED GROUPS

New Media Centers is the home page of a not-for-profit organization that is working with higher education institutions to integrate multi-media technologies into their teaching and operations. Among their plans are to include more HBCU and HACU institutions in the project and to branch out into non-traditional training.
url: http:// www.newmediacenters.org

Diversity Careers Online in an online job service and magazine focused on increasing diversity in the workplace, especially the IT industry.
url: http:// www.diversitycareers.org

Women

MentorNet ...is a national electronic industrial mentoring program for women undergraduate and graduate students in science and engineering which would link, for one year at a time, any interested student with a volunteer mentor from industry via e-mail. Through the mentoring process experienced professionals acquaint students with career opportunities, offer guidance and advice based on experience, and provide support, encouragement, and access to professional networks. The program is run through the Women in Engineering Programs & Advocates Network (WEPAN), a collaboration including the Association of Women in Science (AWIS), the Society of Women Engineers (SWE), the University of California-Berkeley, Carnegie-Mellon University, Dartmouth College, and San Jose State University.
url: http:// www.advancingwomen.com/wk_mentornet.html

Project Edge ...is a mentoring project that targets young women at key educational transition points, along with pre-college teachers, counselors and university faculty. The project also provides training for teachers, counselors, and college professors in gender equity techniques for the classroom, and in developing peer-coaching systems to monitor reform. Overall goal is to encourage and support the interest in and the retention of more young women in science, engineering, and mathematics by increasing the frequency, consistency, and coherence of positive experiences and messages about participation in these fields.
url: http:// wall2.rit.edu/edge

Telementoring Young Women in Science, Engineering, and Computing Project ...has created a national Internet-based mentoring program which links high school girls with female professionals in technical and scientific fields. Central to the project's goals is the belief that ongoing electronic communication with successful women engineers and scientists can provide girls with validation and advice rarely found in traditional educational settings. The project has developed a range of on-line environments where young women can safely discuss strategies for overcoming obstacles and fears, and gain access to sound career advice and expert domain knowledge. The program is hosted by the Education Development Center's (EDC) Center for Children & Technology (NY, NY) and is funded by the National Science Foundation's Directorate of Education and Human Resources.
url: http:// www.edc.org/CCT/telementoring

Computing Research Association's (CRA) Distributed Mentor Project ...brings together for a summer of research undergraduate females in computer science and computer engineering (CS&E) and female professors at research institutions. The intent of the mentor program is to increase the number of women entering graduate school in CS&E. Because of the limited number of female researchers in CS&E who can serve as role models and mentors, undergraduates are brought directly to the professors' institutions.
Also at CRA: Women's Database Project, other activities by the Committee on the Status of Women in Computer Science and Engineering
url: http:// www.cra.org/Activities/craw

Role Model Project for Girls ...is a CD-ROM and supporting website created to share the notion that girls can grow up to be almost anything, in a wide variety of professional careers. Through first-person video stories of women in almost 200 professions, the project will give girls an idea of the breadth of their choices, encourage them to explore ideas that they may not have thought possible before, and offer ideas about how they can achieve their goals. The program is sponsored by WomenWork!, in collaboration with the Association for Computing's Committee on Women in Computing (ACM-W).
url: http:// www.womenswork.org/girls

National Science Foundation Program for Women and Girls in Science, Engineering and Mathematics ...focuses on encouraging the design of innovative activities to improve the recruitment and retention of women and girls in science, engineering and mathematics education and careers; encouraging the implementation of existing models or research in new settings or with new populations that will enhance the access of women and girls to improved science, engineering, and mathematics education or careers in these fields; and encouraging positive and

permanent changes in the academic, social, and/or scientific climate for more equitable inclusion of girls and women in science, engineering, and mathematics.
url: http:// www.ehr.nsf.gov/EHR/HRD/women

Association for Women in Science (AWIS) Mentoring Project ...facilitates networking between women scientists at all levels and in all career paths through its 76 local chapters. AWIS chapters also encourage the participation of girls and women in science by sponsoring educational activities in schools and communities. For the past 7 years, AWIS has established and improved community mentoring programs for undergraduate and graduate students with funding from Sloan and the National Science Foundation (NSF). Over half the AWIS chapters participated in the original Sloan project. A detailed final publication called Mentoring Means Future Scientists, which presents and analyzes the results of this mentoring program, was published.
url: http:// www.awis.org

National Science Foundation also encourages women through graduate research fellowships, with specific awards for women in engineering, and computer and information science which include significant stipends and cost-of-education allowances.

Racial/Ethnic Minorities

Hispanic Americans

Promotion and Awareness of Careers in Engineering and Science (PACES) Program ...is a student-oriented activity sponsored by the Society of Mexican American Engineers and Scientists. PACES is a nationwide program implemented by student chapters on various university sites throughout the United States. In the PACES Program, MAES student members work directly with Mexican American and Hispanic youths in high schools and junior high schools to: serve as role models and mentors; instill an interest in engineering and science in the students contacted; continually remind students of the privileges of a higher education; increase the number of Mexican American and other Hispanic youth preparing for engineering and science related fields.
url: http:// www.tamu.edu/maes.paces.index.html

African Americans

National Black Data Processing Associates ...is a national group of African-American IT professionals. The organization sponsors an annual programming contest for high-school students
url: http:// www.bdpa.org

Black Geeks On-Line ...is a online community dedicated to increasing computer literacy and internet access among African Americans by sharing information and resources (new media developments, job announcements, etc.) and by providing opportunities for African Americans to network with one another across the country and around the world. http://www.blackgeeks.org

The Executive Leadership Council ...is an organization of African Americans in senior positions in corporate America. Their educational foundation's technology transfer project is aimed at helping HBCUs improve their IT capabilities
url: http:// www.elcinfo.com

Ballou High School Novell Program... is a program operated by Washington, D.C.'s Foundation for Education Innovation (FEI). With the cooperation of several corporate sponsors, FEI trains inner city high school juniors and seniors as Novell technicians. Contact: Archie B. Prioleau, Executive Director at prioleau@cais.com

Native Americans

American Indian Science and Engineering Society
url: http://www.bioc2.uthscsa.edu/aisesnet.html

Older Workers

Senior Staff 2000 Effort ... is a federal database of 7,000 downsized, retired and other over-50 IS professionals with COBOL and other mainframe skills.

Massachusetts Computer Software Council, Fellowship Program for Older/Transitioning Workers ... provides a bridge for highly skilled professionals, transitioning from other industries, to find careers in the software industry. The program includes a five-month on-site company project experience and holds weekly seminars to keep the Fellows current on issues unique to the software industry. Classes start approximately every two months.
url: http://www.swcouncil.org/fellows.html

People With Disabilities

HEATH Resource Center of the American Council on Education ...operates the national clearinghouse on post-secondary education for individuals with disabilities. Support from the U.S. Department of Education enables the Center to serve as an information exchange on educational support services; policies and procedures; adaptations; and opportunities at American campuses, vocational-technical schools, adult education programs, independent learning centers, and other postsecondary training opportunities. This information assists people with disabilities in developing their full potential through postsecondary education and training.

url: *http://www.acenet.edu/programs/HEATH/home.html*

Disabilities Action Team of the Potomac Knowledgeway Project ...is a group working in the Greater Washington area to promote and encourage use of the internet as an information channel for and about disabilities to: increase public awareness of disability rights and issues; share current information about disabilities, treatment and coping; and, break down barriers in communication for people with disabilities.
url: http://www.knowledgeway.org/programs/ateams/abilities-ateam.html

SUGGESTIONS FOR SOLVING PROBLEMS

- Information technology jobs are expanding and shifting rapidly in response to the rapid advancement and diffusion of information technology. New skills are constantly in demand, and IT occupations evolving in new directions. Better and more timely information is needed on occupational developments and the skills employers require to meet their IT needs.

- The pipeline for technical education and technical careers begins in the early years. If underrepresented groups are not engaged and succeed in mathematics and science in the early years of K-8, they are less likely to pursue more advanced technical studies. Math and science programs should be designed to accommodate the learning styles of girls and minorities, and to make these subjects more relevant to their lives. This includes revising curricula to increase minority participation in the gatekeeping courses of algebra, geometry, chemistry, and physics. In addition teachers and guidance counselors should be provided with better information and training to help them guide underrepresented groups into the IT education and career pipeline.

- Women and minority groups would benefit from having great numbers of IT mentors and role models from which to draw inspiration and guidance. This is especially true for communities in which technical professionals of any kind are scarce.

- Women may have different learning styles than men that may make their participation in technical education programs more difficult. The establishment of "learning communities" of women peers in educational environments may help women help each other in learning and overcoming barriers to learning and working in male dominated technical fields.

- Companies should explore recruiting options through the technical professional societies comprised of racial and ethnic minorities (such as the American Indian Science and Engineering Society, the Hispanic Society of Hispanic Professional Engineers, and the National Society of Black Engineers). Companies could also place job ads in newspapers and journals that serve racial and ethnic minority communities.

- Companies should be encouraged to establish partnerships with and recruit from Historically Black Colleges and Universities, predominantly Hispanic Colleges and Universities, and Native American junior and community colleges based on Indian reservations. This would give students from underrepresented groups opportunities for exposure to information technology and IT jobs, for internships, and research. Greater levels of recruitment at these schools would provide incentives for students to pursue technical education. Companies could also form partnerships with racial and ethnic minority student societies at colleges and universities.

- In response to rapid technological change in the IT field, greater emphasis on professional development of the technical worker throughout their career would help ensure that employees' skills continue to be up-to-date as they move into mid-career and beyond.

- Given trouble employers have recruiting employees with the skills in demand, employers may consider boosting their investments in workforce training generally, and specifically, efforts aimed at recruiting, training, and retraining underrepresented group members.

- Government should exercise continuing vigilance and take appropriate action where evidence exists of discrimination in university technical programs.

- Industry should form economic development and training partnerships with Native American communities, inner-city community development organizations, and other such organizations who are able to assist in career identification, training, and mentoring of underrepresented group members.

- Steps should be taken to ensure that underrepresented groups have access to adequate information about the IT labor market, skills needed, and potential employers. This could include help in packaging one's portfolio of skills to best demonstrate their value to a potential employer.

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Responsiveness of Industry and Higher Education to Each Other's Needs

Building the 21st Century Information Technology Work Force: Improving the Responsiveness Between Industry and Higher Education

Introduction:

During the last decade, at a time when high paying job opportunities in the information technology field have been growing, concerns have arisen about a mismatch between skills needed by the private sector and the quality and quantity of skills produced by the higher education system. Even as the wages for a typical computer programmer approaches $70,000 (with wages growing rapidly and at higher levels in some niches),[i] students entering higher education are choosing fields of study which are not necessarily as in high demand or as lucrative as the information technology field. The disparity between high and medium wage employment opportunities and the number of students entering these fields suggests a serious disconnect between industry, education and the academic and professional aspirations of young Americans.

The Task Force on Higher Education and Industry Responsiveness addressed three questions:

1) How responsive are higher education and industry to one another in effectively addressing the challenges in training sufficient numbers of qualified information technology professionals?
2) What are models of "best practice" that can guide schools and industry desiring to work together more effectively?
3) What policy changes can facilitate greater responsiveness between industry and higher education?

The ideas presented here reflect the individual experiences and opinions of task force members and, where data was available for analysis, the Task Force's interpretation of that data.

Part 1 - Assessing the Responsiveness of Higher Education and Industry to Each Other's Needs

Higher Education's Response to Industry: Some Programs are More Responsive than Others

Higher education's response to industry's needs in Information Technology (IT) cannot be neatly summarized in a single standard because higher education itself is a diverse body of organizations and programs. When talking about an institution's ability to respond to any outside stimuli, private institutions are different from public institutions. Two-year colleges vary from their four-year cousins and continuing or adult education has little in common with graduate programs.

This is significant because private institutions, two-year colleges, and non-degree programs have some advantages in terms of responsiveness. In general, private colleges and universities are better able to modify their existing curriculum and create new programs. Both are key factors in keeping up with the rapid pace of technology and the resultant changing needs of industry in recruiting and training a work force. The public sector tends to lag behind in part due to the often-lengthy procedures necessary to create new programs, and funding limitations for new programs. While these issues exist in the private sector as well, private institutions exhibit greater flexibility in adapting to a changing education marketplace. A further hindrance to public institutions' ability to respond is the turnover problem; public institutions tend to have a higher turnover rate because the state has difficulty competing in the salary arena with the private sector. As a result, state institutions find it harder to keep skillful, creative people - the type of individuals who are most likely to create new programs.

Focusing on the difficulties of public institutions is less enlightening than looking at why community colleges and adult education programs seem to be more successful in responding to industry's needs. First, there is a major cultural difference between the traditional "academy" and the community college. Academicians often pride themselves in avoiding mundane, practical problems and focusing on theoretical research. Community colleges and private training programs are less caught up in theory, and more grounded in solving practical problems experienced daily in the marketplace. When industry speaks of "Ivory Towers of Learning" in discussing IT, the reference is more often to four-year and graduate level programs, and it is not meant as a compliment.

Such issues as practical training, re-training or re-engineering of the current work force, and dealing with short term industry needs are emphasized more in two-year programs, certificate programs and continuing education programs. In addition, these programs also tend to be more flexible and able to 'think outside the box' in adjusting to job market demand and looking ahead. For example, the colleges of Foothill and DeAnza have a long-time partnership with Hewlett Packard. Personnel from Hewlett-Packard sit on Foothill and De Anza advisory boards, helping guide the development and upgrade of the colleges' technical programs. H-P helps recruit part-time faculty from among its employees, and the colleges offer on-site programs exclusively for H-P workers to upgrade technical skills and provide new skills.

At times, industry voices a concern that the short-term, skills-intensive programs may not provide enough emphasis on foundational theory and effective problem-solving needed to success in a rapidly changing business environment. If IT professional do not possess these skills, in addition to the application of practical knowledge, their skills become out of date in five to seven years and their careers becomes stalled. In the view of some industry leaders, the only place IT workers are learning effective problem-solving is "on-the-job."

At the other extreme, a common complaint about four-year schools, and particularly graduate programs is that they are disconnected from the "real world." That is to say, most four-year and graduate programs are biased towards theory and away from practical problems. In some cases, they are turning out too many graduates in the disciplines that do not prepare students for the reality of the job market. One human resources director bitterly complained about the inordinate number of liberal arts majors applying for IT jobs for which they are not prepared. It is not uncommon for "academics" at universities to have the attitude that it's not their job to worry about students getting jobs. Resource decisions are not made according to real job opportunities, but only according to how many students apply to the program.

It is not fair to paint an overly bleak picture of higher education's response to the Age of Technology. Certainly the work being done by many two-year and adult education programs does target industry needs. There are new programs directed towards IT, business outreach efforts, a strong emphasis on brief (one-year and less) certificate and non-credit classes that can be created quickly. In a recent report, the League for Innovation in Community Colleges coined the term "entrepreneurial colleges," a term designed to capture its entrepreneurial spirit, market-oriented drive, and responsiveness to external organization.[ii] Furthermore, there are new programs being created on the four-year level. George Mason University is close to graduating its first class in its new Masters of Technology Management program, developed with significant input and sponsorship from companies in the booming IT sector in Northern Virginia. Four major public institutions of higher education in Maryland also unveiled an initiative to double the number of computer technology degrees it awards during the next ten years. State funding was approved, although there has been some concern expressed that the initiative does not do enough to link the four-year institutions with community colleges and private training programs.

This brings up the question of higher education reaching out to industry to support these initiatives, either through funding or technological support. At this time, these efforts are still in their infancy, with some colleges and universities trying a micro approach, and some trying a macro approach. Some colleges and universities are taking the direct route by approaching individual businesses. In general, these efforts tend to be more successful when the higher education institution can bring a program with a clear benefit - for example, a masters degree in Information Management -- to the table.

On the industry-wide scale, some academic institutions are trying to mine the potentially very profitable field of professional and trade associations. Alliances with these groups, representing as they do large portions of industries, have the potential of creating win-win situations for both higher education and industry by providing colleges with large numbers of potential financial and technical contacts, while at the same time providing the association with an invaluable service to its members -- access to the raw materials they need to advance in IT.

Industry's Response to Higher Education: Skills Needed, but at what Price?

While higher education may sometimes seem unable to respond quickly enough to industry's demands, there is the perception by some in education that the business sector is often unwilling to literally put its money where its mouth is. Industry has a clear message for higher education when it comes to information technology - "we're interested in skills, not just credentials. These skills must be practical, emphasize effectiveness and provide enough theory to help the IT worker continue to learn. We want students who are prepared to meet the demands of the job from Day One. We want graduates with applied degrees, not liberal arts majors. We want programs that show a clear benefit to us in IT."

However, industry does not always back up that message with action. One academician puts it this way: "industry says, `You guys are wonderful, give us more students.' Higher education responds, `How would you like to give us money?' Then industry gets quiet." On the other hand, it is not hard to understand industry's reticence in getting involved with some academic institutions. Industries and individual businesses have been slow to respond to higher education, even when higher education reaches out, because of the perception that change happens so slowly in the academic sector. As one academician has put it, colleges bring a lot of baggage to the table when they ask for help from industry. To put it another way, industry is leery of potentially wasting its time and money in creating a 286 PC when a state-of-the-art notebook computer is what is needed.

Industry-Provided Training Resources

Estimates are that cumulative spending for training by companies is over $210 billion annually.[iii] There are also many examples of IT businesses starting to reach out to the academic community to offer financial and technical support. In a 1994 interview with Educom Review, Microsoft chairman Bill Gates said, "I think all of us in the information technology industry realize it's in our best interest to continue to support higher education."[iv] In October of this year, the Oracle Corporation announced its intent to undertake a $50 million effort to address the IT skills issue by "helping universities recruit and educate greater numbers of technically-competent graduates and match them with companies in need of their skills." The Oracle Academic Initiative (OAI) will provide academic institutions worldwide with software, support services, curriculum content, testing capabilities and staff development resources to further develop technology education programs." [v]

In June 1997, Microsoft announced its Skills 2000 Initiative which will address the IT skills issue in a three tiered strategy. Tier 1 involves recruiting; and Tier 2 involves offering reduced-price one-day training workshops to update skills of current IT workers in the use of Microsoft networking software. Tier 3 would double the funding of the roughly 300 high schools, colleges and universities that are members of Microsoft's Authorized Academic Training Program (AATP). This additional funding would help students earn Microsoft certifications and better prepare students for work in IT industries.[vi]

In a more direct example of a corporation taking training into its own hands, Syntel, Inc. a Michigan based applications outsourcing and Year 2000 compliance firm, is launching its Technical and Professional Development (TPD) Program in metropolitan Detroit to establish a supply of well-trained junior software programmers. The TPD program is an eight-week "technology boot camp, which will provide comprehensive computer training to people interested in becoming software programmers. An intensive screening process chose 18 participants from 80 applicants. The second class will include 12-14 students. [vii]

In these examples, large IT companies with significant resources are investing directly in education to address specific skill needs that affect their businesses. These efforts do not necessarily increase the overall pool of qualified IT workers, nor do they benefit smaller, start-up IT businesses that are seeking workers.

In its January 1997 report titled "Spanning the Chasm," the Business-Higher Education Forum summarized the current state of higher education/industry responsiveness in the following manner:

> "Today, a chasm separates the academic and corporate worlds. Corporate leaders are convinced that university employees -- including administrators and faculty members -- do not understand the requirements of the private sector and the need for students to be better prepared for the demands of a changing global economy. Academic leaders are equally

> sure that corporation have little respect for the campus and that U.S. universities are in fact world class. Recently employed alumni value their college experiences but report that they had too little direction and guidance in choosing and preparing for a career."[viii]

Does a "chasm" truly exist? The Task Force concluded that, yes, in many places, chasms separate higher education from industry. But in a growing number of instances, strong bridges are being built and the results are stronger that might be imagined.

Part 2 - Examples of Higher Education's Best Practices in Developing IT Relationships with Industry

Higher education's best practices in developing IT relationships with industry are generally in the area of dovetailing theory and application, i.e., in creating programs that give students practical experience.

Specialized masters programs:
This is best accomplished by partnering with industry to create new, industry-specific programs, like a masters in Computer Science or a masters in Technology Management, that meet specific needs.

Business/Academic Advisory Boards:
Having industry IT experts on university advisory boards is an effective tool in strengthening the ties between the academy and industry. At one established university computer science program, each degree program has established a "program improvement audit committee," including representatives from industry, to provide input on the effectiveness and relevance of the program. In and of itself, this program can not overcome academic resistance to addressing practical problems at the university level. However, the process of receiving industry input is a key element if change is to occur. This is also another area where "community" colleges seem to have an advantage. Community college presidents typically sit on more local boards and, since they are out in the community more, they are more responsive and connected to local needs.

Membership Organizations to Facilitate Innovation:
Organizationally, there is an association of two-year institutions that already focuses on working with industry in innovative programming -- the League for Innovation in the Community College. Traditional institutions of higher education also are members of national and regional associations; however, as far as the Task Force is aware, these organizations are not focusing on encouraging more market-responsiveness among technology programs.

Regional Business/Educational Partnerships:
There have been instances in which major research universities have effectively responded to industry needs. In one state, research universities are working together with community colleges and private industry councils to turn out more graduates with degrees relevant to IT. In Omaha, Nebraska, the business community has worked with the Applied Information Management Institute to facilitate applied technology training among the four-year, community colleges, and training centers in the city. Creighton University has responded by establishing a subsidiary

technology certificate training program that meets a market demand for intensive, certificate training in COBOL to address the year 2000 problem.

At least two major university programs established that have created new institutes focused on IT. These programs have been able to go around the standard academic delivery systems, cut through red tape, obtain corporate backing and focus on specific training -- in short, they do the types of things on a large scale that private, two-year colleges and continuing education programs do on a small scale.

In terms of specific best practices programs, giving students practical, programming experience so they can tackle everyday problems is a high priority for industry. But simply having programming experience is not enough. Industry needs people with problem solving skills and who can interface with the rest of the company. In other words, if you want to create bicycle riders, have them ride bicycles, not analyze the theory of bicycles. One particularly convenient way of "riding bicycles" is to give students the chance to take off their training wheels by working with campus network systems - applying the skills of interfacing with the campus community, analysis and problem solving, and the essential programming work. Another area previously mentioned involves colleges and universities partnering with industry groups for their mutual benefit. One academician has summarized this type of relationship by saying, "colleges have the time, industry has the money."

Internships:
Internships are another best practice often mentioned in discussions of how higher education can better respond to the IT industry. These internships can be for either pay or college credit and are most effective when carried out on-site, as opposed to on-campus.

Distance Education:
Distance education is another means of delivering education and training with a special focus on IT work skills. Students and their employers, both current and potential, are demanding that education and training become more convenient. With the age of the average undergraduate student nationwide now 25, it is clear that the average student no longer is someone with unlimited time. They are often parents, usually working parents. Not only is distance learning more convenient and time efficient, it can provide the "just in time" skills upgrading that IT workers need on an on-going basis in order to stay professionally relevant and for their companies to remain competitive. These students must have the ability to learn anywhere and at anytime -- at home and on the job -- without having to fight traffic, and waste time, commuting to and from campus. Distance education, whether by Internet, closed circuit television, videotapes, local cable programming, PBS or notebook computers, is the means by which students can have access to the world from wherever they may be.

A multitude of educational institutions have already established distance learning alternatives for some or all of their course offerings. The Western Governors University is being developed as an on-line university to serve several western states. California declined to join the Western Governors University program, and instead, is developing the California Virtual University, a system that integrates California's public and private colleges and universities and community colleges into an integrated system of distance and on-line learning.

Part 3 - What Can be Done to Make Higher Education and Industry More Responsive to Each Other?

Improving the responsiveness of higher education and the IT industry is likely to function best when all parties are fully engaged, including the government.

Suggestions for Government: Financial Aid and Support for Secondary Schools

In higher education, the term "financial aid" typically refers to students. In terms of the government providing IT support for higher education and industry, a key component to financial aid for students needs to be addressed -- the importance of Information Technology itself to the college student.

Financial Aid Formulas Must Recognize Technology:
Currently, federal student aid recognizes computing technology as a "cost of attendance" if the school designates a computer as an essential educational tool, such as textbooks. At several schools, owning a laptop computer is required for enrollment, and at all schools, computing technology is a vital academic tool. College and universities should consider reassessing the importance of technology to today's learning environment, and where appropriate, require the use of computing technology, at least for students in computer sciences and engineering. This would enable federal student aid to encompass computing technology at all schools.

Allocation of Resources: Tax Incentives for Industry/Education Partnerships:
The task force believes that government should consider tax incentives to increase the attractiveness of industry donations of hardware and software to institutions of higher education. Government should also consider more direct fiscal measures, such as providing funds for IT training in welfare-to-work programs.

Secondary School Reform: Expand the Pool of Technology-Capable Students:
Curriculum issues in secondary schools, particularly in math and science, is another area in which governmental attention could be helpful. The task force believes that the core education in areas like science and math needs to be upgraded and that governments at all levels should be engaged in addressing the problem.

Industry Initiatives: Fund and Support

Industry should expand its funding and technical support for IT programs in higher education. Having said that, it is also important to realize that there must be a plan involved; simply "throwing money at higher education" is not going to work. As a starting point, industry should make a clear distinction between funds that it expects to show a return to the bottom line and funds that are strictly philanthropic in nature. Some guidelines for this support are follow:

Balanced funding:
Industry should fund IT training for students at two-year schools, not just four-year universities.

Partnerships to Address Specific Training Needs:
At the community-college and private training level, industry needs to continue developing partnerships to address industry-specific and regional training needs.

Better Articulation of Industry Needs:
To better reform course offerings, both at the community college level, and more at the university level, the business community needs to articulate broader industry needs more effectively. Regional alliances and professional associations will help individual companies focus on long-term needs that are relevant across industry, rather than proprietary in nature. This type of coordination will be quite difficult and run counter to the competitive and proprietary forces at work in the IT industry; thus industry organizations have an important coordinating role to play.

Sharing Product Information with Schools:
To help colleges and universities provide more relevant, up-to-date training, up-to-date product information must be made available to institutions of higher education while still protecting intellectual property rights. A national on-line clearinghouse should be established, with appropriate oversight mechanisms, with the purpose of making available to computer science educators up-to-date product information about key products and languages used in private industry. Such a clearinghouse must attend to antitrust concerns (i.e., sharing of proprietary and competitive information among competitors) while at the same time promoting awareness within universities of industry needs.

Corporate Donations of Hardware and Software:
Finally, businesses can help colleges and universities stay current through investing in updating and upgrading higher education's hardware and software needs, and providing relevant training to teaching staff.

Strong Company Policies to Facilitate Collaboration:
In developing these collaborative relationships, companies should set clear expectations and make accommodations for their employees that are asked to provide training and coordinate activities with the institutions of higher education. If company leaders do not set specific goals for the collaboration, shift workloads and create positive incentives for designated employees, the employees will question the seriousness of the initiative. In this scenario, the initiative will probably die from neglect if it is forced to compete with priorities more urgent to the company's core business.

Higher Education Initiatives: Speed and Flexibility Foremost

Higher education could improve its responsiveness to the IT industry by demonstrating more speed and flexibility in curriculum developments and review. Addressing the need for flexibility in higher education, Microsoft founder and chairman Bill Gates said "we think it's crucial that colleges and universities continually evaluate their programs against the needs of industry, particularly the fast-changing industries, like ours. To help that process, we meet continually with university deans and others from computer science and engineering departments around the country."[ix]

Higher education institutions could benefit from adopting the principles of "continuous improvement." This requires the ability to change, and to solicit feedback from its customers, both individuals and industry. Where necessary, policy level changes outside of the university will need to be made to allow continuous improvement to be adopted.

Revising Curricula more Quickly:
The task force suggests that colleges and universities make efforts to improve responsiveness to industry input and develop methods to integrate quickly industry input into course offerings. For example, state higher education oversight boards could give individual campuses streamlined authority to create and update course offerings in response to industry input. Not only should schools be given greater flexibility in updating curricula, incentives should be created to encourage re-engineering of existing curricula.

Flexible Delivery Methods:
Colleges and universities must be flexible to meet the needs of student/workers who are unable to spend substantial portions of their days on campus. That means offering more courses over the Internet and via alternative delivery methods.

Collaboration Among Higher Education Sectors:
The task force suggests that universities, community colleges, and technology training schools seek to develop matriculation and articulation alliances that will make certificates and associate degrees more portable to the four-year college and university. Talented and experienced professionals that want to attain a bachelors degree should not have to relearn what they already know. For example, working with the Virginia Technology Council and Virginia's Center for Innovative Technology, Virginia Tech's Division of Continuing Education will soon introduce three flexible new certificate programs which may be taken for credit and a degree or for non-credit as a credentialing tools. These courses are developed around fifteen hour modules which may be delivered via Virginia's ATM network, over the Internet, or on site. Some industry members suggest also including secondary schools in these "articulation alliances" so that technology skills obtained at the high school level will count toward certification requirements at the community college and four-year college level.

Local and National Industry Input:
Of course, higher education cannot make these changes in a vacuum. Every college, university and community college should seek to establish a local alliance to gain meaningful input on how to make course offerings more relevant and up-to-date. Higher education must also work closely with industry through national organizations such as (but not limited to) the League for Innovation and the Information Technology Association of America.

Attitude Shift:
Some sectors of higher education need an attitude shift. They must acknowledge that "real world" problems are worthy of intellectual effort and avoid the attitude that "the problems of industry have already been solved in theory in the classroom -- so why bother taking it out in the

world?" To accomplish this shift, industry and universities must engage in ongoing dialogue to so that university departments have a better sense of the sorts of skills graduates must have in today's IT workforce.

Working Together: Areas of Cooperation

The task force suggests that industry and higher education explore cooperative arrangements in the following areas to address contemporary challenges in the IT workforce:

Outreach to high school students:
A good starting place is in the high schools. Both parties need to get the word about the astounding professional opportunities available in information and technology out to students, teachers and guidance counselors. Too often, there is too little knowledge of the opportunities in IT on the secondary school level. High school-targeted information programs are a good start on the local level. However, macro efforts, involving national-level organizations, will ultimately be needed to successfully address industry's demand for individuals trained in Information Technology. There is a need for higher education and industry to work together to coordinate the development of curriculum and certification programs. As colleges and universities gain greater understanding of industry needs, all parties can work towards setting up meaningful universal certification programs standards in IT.

Modernizing Technology at the Higher Education Institution
Under current conditions, it is surprisingly difficult for industry to donate reconditioned computing hardware to colleges that are in desperate need for up-to-date technology. First, the equipment itself has to be relatively new for colleges to be interested in it at all. Second, equipment often needs to be reconditioned, which can be quite expensive and time-consuming for any company to accomplish. The task force suggests that higher education institutions and industry should work together to encourage establishment of third-party non-profit organizations that can provide needed reconditioning of donated equipment. Such organizations could provide an answer for the need to ease the donation of useful computing technology for higher education institutions.

Coordination of Hardware and Software Donations:
Typically, there is very little coordination within industry of donations of hardware and software to institutions of higher education. Thus, the higher education institution is left to make the best with what has been donated. A more aggressive policy that coordinates donations of hardware and software would be a better use of industry resources and more efficient for the educational institutions, as well. This coordination could be carried out by the same non-profit organizations formed to receive hardware donations and provide equipment reconditioning.

Clearinghouse:
In summary, the task force believes that what is needed is an examination of IT curricula and the development of strategies to bring the needs of the work force and colleges into closer alignment. One way to expedite this would be the creation of a national Information Technology curriculum clearinghouse where individual industries and businesses can provide information about IT

products and innovations -- the basic parameters that individual colleges and universities can use to build relevant curriculum.

Final Remarks:

In the opening note from the report "Spanning the Chasm," J. Dennis O'Connor said, "while different actions will be effective in various situations, cooperative efforts by business and higher education leaders will help ensure that new employees enter the work force prepared to meet the challenges of today's changing world."[x]

The task force shares the optimistic vision articulated by O'Connor. The workforce challenges in information technology is not the singular fault of either education or industry, nor is there likely to be a "silver bullet solution." The solution does not even rest in the cumulative effect of the action items suggested here. However, the task force that constructive steps to address IT workforce issues lies in harnessing the strengths of industry, higher education, and all levels of government.

In the end, a larger more qualified pool of technology-literate workers will benefit companies in the IT sector, while also providing a new stimulus to higher education as it reassesses some of its practices. Most importantly, efforts to better educate Americans to participate in the information economy of the future will immensely benefit all workers—both those who choose fields in information technology and those who undertake different careers.

Task Force on Higher Education/Industry Responsiveness

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[i] Business Week, July 21, 1997
[ii] "Workforce, Economic and Community Development, The Changing Landscape of the Entrepreneurial Community College, (Grubb et. Al), League for Innovation in the Community College, 1997
[iii] ITAA, Public Policy Report, 1997
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[vi] Microsoft Corporation, Press Release, May 3, 1997

[vii] Syntel, Inc., Press Release, April 2, 1997
[viii] "Spanning the Chasm: Corporate and Academic Cooperation to Improve Work-Force Preparation." Business-Higher Education Forum, in affiliation with the American Council on Education
[ix] Educe Review, Volume 29, # 1, Jan/Feb. 1994
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Implement Rigorous K-12 Mathematics and Science Education:
Solution To America's New Deficit

Issues Identified by the Task Force on Basic Mathematics and Science Competencies
National Information Technology Workforce Convocation (12-13 January 1998)

EXECUTIVE SUMMARY

A thorough grounding in the principles of mathematics and science are essential to individuals who aim to contribute as a skilled workforce in the interconnected fields represented by Information Technology (IT). This common sense observation is well supported even from a cursory look at the results of a survey conducted by this Task Force. The Task Force examined the challenge of strengthening mathematics and science skills for potential IT workforce entrants. What level of achievement is necessary for varying job categories within the IT industry? Is there a minimum level of mathematics and science competency necessary for every worker in the IT industry?

The Third International Mathematics and Science Study (TIMSS), which compared the U.S. with up to 40 other nations in curriculum, teaching, and student performance at the fourth, eighth, and twelfth grade levels, has focused increased attention on the lackluster mathematics performance of U.S. students, particularly in the middle school years. The U.S. was the only country in TIMSS whose students dropped from above average performance in mathematics at the fourth grade to below average performance in mathematics at the eighth grade. And, U.S. students exhibited the smallest achievement gain in mathematics from grades four to eight of any TIMSS nation.

These results call into question our practices in mathematics education: why is achievement lagging for our middle school students? In fact, this lost potential in learning has consequences far beyond the middle school years. Even by the twelfth-grade, U.S. students do not catch up in mathematics achievement. The twelfth-grade TIMSS results will not be released until February 24, 1998, but the Second International Mathematics Study (SIMS) found that U.S. twelfth graders scored in the bottom half of all nations in all mathematics subject areas tested.

In science, U.S. fourth graders and eighth graders scored above the international average on TIMSS. In fact, U.S. fourth graders are near the very top in science achievement in the world.

Albeit anecdotal, the following observations appears to be consistent from a preliminary scan of K-12 teachers responding to a survey conducted by the Task Force:

Very few teachers have access to instructional technology in the classroom. (Q #7-10)
Elementary and middle school mathematics were identified as highly important. (Q #13)
Reading comprehension, problem solving and analytical skills were highlighted. (Q #15)
Mathematics was the focus for IT related professions. (Q #16-17)

To seriously address the shortcomings of U.S. mathematics and science education and to address concerns raised by teachers, the task force raises the following issues:

Teacher Qualifications: From middle school to high school, teachers should be required to have earned at least a bachelor's degree in mathematics or science to qualify as a mathematics or science teacher. In states where middle school mathematics and science teachers can teach on a K-8 license, a middle school licensure should significantly upgrade the requirements of preparation for teachers in these subject areas. Elementary school teachers should demonstrate subject matter competency in math and science.

Credentialing: Schools of Education must change their credentialing process in order to better prepare teachers for the classroom.

Increased Salaries for Qualified Mathematics and Science Instructors: To attract, encourage, recruit and retain qualified candidates in the K-12 teaching profession it is essential to increase starting salaries for qualified teachers.

Professional Development for Mathematics and Science Teachers in the Workforce: University based and other professional development partnerships must be encouraged to equip current teachers with the content knowledge and pedagogical skills they need to teach challenging mathematics.

Rigorous Curricular Standards: To implement the proposed competencies, elected officials, parents, educators and business leaders must insist on rigorous curricular standards in mathematics and science.

Project-Based Learning: Approaches linked to application in business or industry are necessary.

Carefully-targeted Corporate and Business Donations: Corporate and business contributions for community activities may best serve the children by structuring gifts for public K-12 education in a manner that focuses on priority reforms. It is also important for business to help parents, students, and teachers understand why mathematics and science are relevant for a wide range of career opportunities.

In summary, educators, industry leaders and elected leaders need to understand that poor quality mathematics and science preparation does have an immediate and negative impact. They should use lessons learned from the IT workforce challenge as a welcome impetus to create the type of serious curricular, instructional and structural reforms in mathematics and science education that are long overdue.

Implement Rigorous K-12 Mathematics and Science Education:
Solution To America's New Deficit

Issues Identified by the Task Force on Basic Mathematics and Science Competencies National Information Technology Workforce Convocation (12-13 January 1998)

How Well are U.S. Students Performing in Math and Science?

According to the 1996 National Assessment of Educational Progress (NAEP), the percentage of 12th graders performing at or above the basic level in mathematics increased from 58 percent in 1990 to 69 percent in 1996. However, only 16% of America's 12th graders performed at a proficient or advanced level in mathematics in 1996. These 12th graders are facing a rapidly changing job market where information is the major driving force, and the demands for mathematics and science competencies needed to participate successfully in the IT job market are continually increasing.

From the Third International Mathematics and Science Study (TIMSS) we know that American eighth graders rate on equivalents levels with students from England and Germany while behind students from Japan, France, and Canada. In science, U.S. eighth graders were significantly outperformed by students from Singapore, the Czech Republic, Japan and Korea. Even though the . average score for U.S. eighth graders is behind these competitor nations, the total school-age population in the U.S. far exceeds these other nations. Therefore, in aggregate numbers, the U.S. is still able to produce a large pool of graduates with excellent qualifications in mathematics and science. However, our economic engine is also exponentially larger than many competitor nations, and the demand for qualified entrants in the IT workforce is almost overwhelming in its scale.

From the data collected by Information Technology Association of America (ITAA) in the report *Help Wanted: The IT Workforce Gap at the Dawn of a New Century* (February 1997) and reflected by the personal experiences of task force members, there are far too few students exiting U.S. high schools that have the requisite skills and aptitudes to fill the increased demand for IT workers.

Definition of IT Worker

Since this report is aimed at policy-makers, educators, IT professionals, business leaders and the public, we believe it is important to define Information Technology. The ITAA defined "information technology" as the "study, design, development, implementation, support or management of computer-based information systems, particularly software applications and computer hardware." The Task Force used the following definitions drawn the U.S. Department of Commerce report: "America's New Deficit: The Shortage of Information Technology Workers."

Computer Scientists: Computer scientists generally design computers and conduct research to improve their design, use, development and adapt principles for applying computers to new uses. They are distinguished from other computer professionals by the higher level of theoretical expertise and innovation they apply to complex programs and the creation of application of new technology.

Computer Engineers: Computer engineers work with the hardware and software aspects of systems design and development.

Systems Analysts: Systems analysts use their knowledge and skills in a problem solving capacity, implementing the means for computer technology to meet the individual needs of an organization.

Computer Programmers: Computer programmers write and maintain the detailed instructions, called "programs" or "software," that list in logical order the steps that computers must executive to perform their functions."

Areas of Increased Demand for IT Workers

According to the ITAA report, the increased demand for IT workers is spread across a wide array of job categories, each representing a differing level of mathematics and science expertise and preparation. Survey respondents did not provide a specific number of positions open in each category, but did identify the following job categories in urgent need of personnel: (1) Network operating systems, (2) Operating systems, (3) RDBMS, (4) Networking and (5) Languages/applications (source: ComputerWorld Survey).

Matching Mathematics and Science Competencies with Job Categories

The task force explored the challenge of strengthening mathematics and science skills for potential IT workforce entrants. What level of achievement is necessary for varying job categories in the IT industry? Is there a minimum level of mathematics and science competency necessary for every worker in the IT industry, for example, a network manager or programmer? Should even more challenging mathematics or science competencies be required for study in a specific field, such as computer science or systems analysis?

A thorough grounding in the principles of mathematics and science is essential to individuals who aim to contribute as a skilled workforce in the multitude of interconnected fields representing IT. This common sense observation is well supported even from a cursory look at the results of a survey conducted by the Chair of this Task Force. Sample copies of the survey are included here and may be reviewed on the web (www.vcsun.org/~smetzenb/teacher.html). The overwhelming response to this survey prevents us from providing the complete analysis at this time (follow-up will be released). Albeit anecdotal, the following observations appears to be consistent from a preliminary scan of responses from K-12 teachers:

Very few teachers have access to instructional technology in the classroom. (Q #7-10)
Elementary and middle school mathematics were identified as highly important. (Q #13)
Reading comprehension, problem solving and analytical skills were highlighted. (Q #15)
Mathematics was the focus for IT related professions. (Q #16-17)

From discussion with high school teachers who are well versed in IT and possess university degrees (in engineering, computer science, physics and mathematics) a partial list of skills and related areas were identified as helpful to those high school students preparing for the IT workforce. Teachers highly recommended integration of project-based learning while repeatedly emphasizing need for understanding of the "basics" in mathematics and physical sciences as a critical pre-requisite for students who may wish to be a part of the IT workforce that can weather with success the rapid pace of technological innovation. Thus, for each skill-related area below, we include a brief description of the academic foundation necessary.

Project-based Pre-engineering shop (e.g.: applications of robotics):
Geometry, simple machines and mechanics, lego designs; chemistry of materials; energy

Computer Programming Languages:
Number theory, set theory, matrices, logic, Boolean algebra, algorithms

Internetworking Technologies:
Algebra, calculus, rate of flow problems, topology; computer communications; optics

Analog/digital electronics:
Trigonometry; electricity, magnetism, heat transfer

Database, Spreadsheet Programs; Multimedia Web-applications:
Statistics; multiple algebraic variables; classification of information; programming

Computer-Assisted Design:
Topology, spatial relationships, visual thinking; circuits

These and other detailed description of skill standards for information technology for post-secondary candidates are contained in the NSF funded report *Building a Foundation for Tomorrow* authored by NWCET (Northwest Center for Emerging Technologies).

How Much More Mathematics Achievement is Needed to fill the Preparation Gap?

According to the 1996 National Assessment of Educational Progress (NAEP), only 24 % of America's 8th graders and 16% of America's 12th graders performed at a proficient or advanced level in mathematics in 1996. Without significant and focused curricular and instructional reform, it is difficult to imagine students improving in mathematics and science performance to the degree needed to meet increased demand for IT workers.

TIMSS Mathematics and Science Curriculum Analysis

A Splintered Vision offers an in-depth analysis of U.S. science and mathematics education from the Third International Mathematics and Science study (TIMSS). It clearly echoes the concerns of the Task Force about the confusion and lack of focus in U.S. education. The following are quotations from the executive summary:

"Our curricula, textbooks and teaching all are 'a mile wide and an inch deep.' This pre-occupation with breadth rather than depth, with quantity rather than quality, probably affects how well U.S. students perform in relation to their counterparts in other countries. In today's technologically oriented global society, where knowledge of mathematics and science is important for workers, citizens and individuals alike, an important question is: What can be done to bring about a more coherent vision and thereby improve mathematics and science education. The United States needs powerful mathematics and science education because they provide a strong basis for our democracy by helping create a literate and informed citizenry. (It) helps each individual to grow, develop, reach his or her individual potential and become more autonomous and empowered; (it) provides a sound basis for continuing national prosperity in a competitive, information-driven, technological and changing international arena."

COMPETENCIES

With the possibility of a million new jobs created in the area of information technology by 2005, the desired level of competencies are rapidly in flux. "Just a few years ago, Java was coffee, C was a passing grade and (the only) web masters (were spiders who) had eight legs. Today, experts in Java computing and C programming command a premium labor market, and an army of human web masters keeps information updated on the rapidly expanding World Wide Web." (*America's New Deficit: The Shortage of Information Technology Workers*, U.S. Department of Commerce, 1997). Information technology related jobs and their applications span the entire spectrum from aquiculture to zymurgy.

The level of competencies currently acquired by a public school graduate translate to statistics revealing that in 1994 only 1% of women and 3% of men earned bachelor's degrees in computer science. The numbers reflect a 42% decrease between 1986 and 1994. One reason for this decline may be found in the Carnegie Foundation survey indicating that 51% of mathematics teachers in public high schools did not take any course in mathematics during their years in college. Elementary and middle school teachers in the United States teach mathematics and science, legally, with non-content based, general credentials.

Project-based learning, particularly in areas of engineering, computer science and technology, is essential to understand the application of theory to practice. High school "hands-on" learning experiences provided by the Cisco Networking Academy are a prime example of the combination of academic rigor with real world application beginning at the ninth grade.

Case Study: Cisco Networking Academy

One particularly appropriate model for creating skilled IT workers is a program developed by Cisco Systems Inc., (San Jose, California) which spans high school and junior colleges. At all levels, students simultaneously proceed through a two-year rigorous academic and "hands-on" training program which makes them eligible to appear for an industry-certified qualifying examination. This program is in operation at several sites including the Thurgood Marshall Academic High School in San Francisco where students who succeed in the exam will be awarded a certificate from the Cisco Networking Academy. This certification shall enable graduates to compete for entry level positions in networking technologies.

In the view of this Task Force, it is futile to propose expected competencies, to address the demand for a skilled workforce, without articulating the **KEY** changes that must occur in order to implement the rigorous standards. Without such changes, we may be far from achieving proposed competencies in mathematics and science. In addition, there are several other subjects (geography, economics, etc.) which are equally important but outside the scope of this report. However, we wish to emphasize the need for advanced reading skills, verbal communication, writing and comprehension in English, as underlying and critically essential competencies.

Areas of Focus to Achieve Competencies

It is nearly impossible to provide suggestions, which, if adequately implemented, may solve all the problems of K-12 public education and approach the proposed level of competencies. However, in the view of this Task Force, the following **KEY** changes, if implemented, may provide solutions to a significant number of core problems and help stem the deficit of skilled workforce.

Teacher Qualifications: From middle school to high school, teachers should be required to have earned at least a bachelor's degree in mathematics or science to qualify as a mathematics or science teacher. In states where middle school mathematics and science teachers can teach on a K-8 license, a middle school licensure should significantly upgrade the requirements of preparation for teachers in these subject areas. For elementary school, all teachers, especially those who specialize in teaching of math or science for grades three through six, should demonstrate high levels of subject matter competence. Knowledge of content and expertise in subject matter must be an uncompromising pre-requisite for any teacher. Methods and process are important but second to content. For middle and high school, subject credentials granted by schools of education cannot be substituted in lieu of subject area degree.

Credentialing: Schools of education must change their credentialing process in order to better prepare teachers for the classroom. Collaborations with the mathematics and science departments are necessary for schools of education. The emphasis on methods and process should be replaced only with the essentials of pedagogy in a manner that college/university students may acquire those courses while pursuing their bachelor's or master's degree in a specific subject area. Classroom management, multicultural sensitivity and other social issues, essential as they are to being able to connect with students in an atmosphere conducive to learning, are best addressed during student teaching in a classroom with support from "mentor" teachers.

Increased Salaries for Qualified Mathematics and Science Instructors: To attract, encourage, recruit and retain qualified candidates in the K-12 teaching profession it is essential to increase starting salaries for qualified teachers ($30K bachelor's; $45K master's; $55K doctorate). Hiring teachers through direct correspondence with academic institutions and selective advertisement through academic societies are approaches that must be part of the recruitment process.

Professional Development for Mathematics and Science Teachers in the Workforce: University based and other professional development partnerships must be encouraged to improve the content base of in-service teachers. Effective classroom teachers who lack adequate training in content must be allowed release time to receive training in local colleges or universities to boost the knowledge of the subject matter they teach. School or school-district operated professional development measures must be restructured to provide meaningful useful assistance targeted to the needs of teachers.

Particular emphasis is required for teacher training in curricular integration of technology. Installing wires and acquiring computers will not automatically improve student outcomes or solve the problem of content-poor curricula and systemic lack of rigor. Technology is only a tool and effective only in the hands of instructors who are core knowledge experts as well as proficient in use of technology. Dual characteristics are difficult to acquire. It requires training contributed by experts in content, multi-media, software, hardware and veteran teachers skilled in delivery and management in the classroom. Significant resources are required to make technology useful as a tool for the delivery of instruction.

Rigorous Curricular Standards: To implement the proposed competencies, elected officials, parents, educators and business leaders must insist on rigorous curricular standards in mathematics and science. TIMSS found that the U.S. expects less of its middle and junior high students in mathematics compared to high performing nations. U.S. students typically study arithmetic through seventh or eighth grade.

Beginning in fourth grade, students in top-performing countries practice arithmetic but are also introduced to algebra, geometry, probability, and other topics. Between grades four to eight, U.S. students need to progress to more advanced mathematics, including algebra and geometry.

To monitor expected competencies and proper implementation of the required curricula, a rigorous national assessment of reading and writing in English, mathematics and science is essential to test the preparedness of K-12 students.

Project-Based Learning: Project-based learning approaches linked to application in business or industry are necessary. Mentorships and internships are helpful. In an appendix to be printed later, we shall mention some model programs including CAMS in Dominguez Hills and the acclaimed Cisco Networking Academy, network technology training for students.

Carefully-targeted Corporate and Business Donations: Corporate and business contributions for community activities may best serve the children by structuring gifts for public K-12 education in a manner that focuses on:

(a) retaining qualified teachers (summer stipends; creating "chair" positions)
(b) supporting teachers who return to the university for professional development
(c) upgrading technology by installing wires, switches, hubs (no cash contributions)
(d) in kind hardware and software contributions for access to information technology
(e) supporting full-time on-site technology resource for curricular integration
(f) stipends for tutors in mathematics, science and technology literacy
(g) installing science, engineering, and computer laboratories for project-based learning
(h) funding academic guidance counselors and educational field-trips
(i) helping parents, students, and teachers to understand the relevance of mathematics and science to a wide range of career opportunities.

Case Study: Thomas Jefferson High School

An excellent example of a school that exemplifies some of the ideals identified by the Task Force is Thomas Jefferson High School for Science and Technology, a magnet school in Fairfax, Virginia. Established in 1985, Jefferson is the result of a partnership between businesses led by the Fairfax County Public School Education Foundation and the school system. This unique public school offers a comprehensive college preparatory program emphasizing science, mathematics and technology. Student selection is a competitive process based on aptitude, test scores, academic achievement, teacher recommendations, essays and self-reported interests and activities. Students entering the program are required to have at least 26 credits for graduation: including five in mathematics, four in science, two in technology, one in computer science and one elective in either mathematics, science, technology or computer science. The school has an active outreach program, training teachers, student tutoring in elementary schools, web building for businesses, and www video broadcasts, to name a few.

Summaries of needed curricular reforms in Science

Excellence in Physics
It is imperative that teaching of core physics must begin from the 8th or 9th grade. All students must have completed a four year graduation requirement in physics. These competencies will never be achieved if we continue the current practice of teaching physics mostly at the 12th grade. At present, less than 25% of graduating seniors take physics in high school and less than 20% of high school physics teachers possess a bachelor's degree in physics. The proposed competency guide and curricular outline may be based on Feynman lectures (I & II). It is assumed that students will have adequate foundation in mathematics in order to learn the topics over four years (9-12) of high school physics. Integration of physics with astronomy, cosmology, mathematics, chemistry, biology, medicine and geology is highly recommended. Excellent "hands-on" physics curricula are available from the American Association of Physics Teachers.

Excellence in Chemistry
Chemistry is the bridge between physical and biological sciences. From rocket fuel to Alzheimer's disease and everything in between, chemistry is at the core. It is, thus, imperative that teaching of chemistry must begin from middle school or 5th grade. Demonstrations of chemistry must be included in general science teaching from as early as 3rd grade. These competencies will never be achieved if we continue the current practice of teaching core chemistry mostly at the higher grades. At present, few graduating seniors take chemistry and fewer chemistry teachers possess a degree in chemistry. Rigorous mathematics is a must.

Excellence in Biology
Modern biology is dependent on biochemistry and biophysics for most of its research. Genetics and medicine, in addition, rely on mathematics and instrumentation physics. Development of bio-technology has its roots in molecular biology and recombinant DNA technology but increasingly depends on chemical engineering, as well. Thus the study of biology is an amalgam of physical sciences. It is for this reason the physical sciences must be taught ahead of biology. That is not the current practice, and it is for this reason that greater appreciation of modern biology is often hampered. Though biology is always a part of general science, the focus of high school biology should shift to genetics and molecular biology. A curricular outline may be broadly based on Cell and Molecular Biology by Bruce Alberts, et al.

Task Force Summary

Suggestions made in this report are not new, nor is the analysis of the deficiencies in mathematics and science education original or unique. However, the impact that these deficiencies have on the economy and on individuals is astounding: 191,000 unfilled jobs and over 2 million high school graduates unable to seize this opportunity because they have been poorly prepared, particularly in their mathematics skills. Educators, industry leaders and elected leaders need to understand that poor quality mathematics and science preparation does have an immediate and negative impact. Let this lesson from the increased demand for IT workers serve as an impetus to create the type of serious curricular, instructional and structural reforms in mathematics and science education that are overdue and necessary for continued U.S. economic growth.

Task Force on Basic Mathematics and Science Competencies
National Information Technology Workforce Convocation (12-13 January 1998)

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Skill Upgrading of the Current Workforce

Building the 21st Century Information Technology Workforce
Upgrading the IT Skills of the Current Workforce

OVERVIEW OF IT SKILL UPGRADING

The ITAA Help Wanted Study shows that robust growth in technology use in much of the economy, as documented by the ITAA Help Wanted study, has created a surge in the demand for workers with IT skills.. Increased demand for IT workers is reported by employers across the country, and, in fact, across the globe. It affects *not only the IT industry itself but also its customers, a wide range of employers.* The ITAA study and a number of localized studies are predicting an escalation of the problem over the next eight to ten years. The Convocation Task Force on Upgrading the IT Skills of the Current Work Force addressed helping the current U.S. workers (whether they are IT workers or not) be candidates for meeting the increased demand

Many employers seek IT-capable workers to implement technology they need to be competitive in their industries. The expanded demand for relevant IT skills is fueled by growth in technology use in industry and by home use. It is exacerbated by the proliferation of competitive IT companies producing new technologies at an unprecedented rate. Constant IT innovation makes technical skill ephemeral and continual training imperative for competitiveness. Whether one believes it's a shortage or a temporary inadequate matching of skill and wage requirements to open jobs, the continual churn in the IT industry causes problems for employers, workers and governments.

In response to the challenge, employers are engaging in a number of strategies. Some are very aggressive about training and promoting their own employees to generate the energy to respond to competitive requirements. Some are outsourcing all or part of their operations and some are struggling to operate with status quo because they can not respond.

Government leaders around the world, recognizing the need and the economic development potential of bringing high paying IT jobs to their economies, are building IT skills and business IT application expertise in their populations. A few local governments in the U.S. are doing the same, but there has not been a pervasive state-by-state nor national public or private effort.

Workers are not adequately aware of the advantages of working in this new, volatile complex industry or how to join it. The industry appears to move from one specific technology to another faster than it is building the skills to support the moves. Educators have just begun to be aggressive in helping employers and workers build skills. They are often not in a position to manage the rapid change or the expense of technology currency required to be fully effective.

The Task Force on Upgrading the IT Skills of the Current Work Force examined mechanisms to help current workers (whether they are IT workers or not) meet the IT skilled worker demand. Increased recruiting and training efforts are partial solutions to finding and reskilling workers for IT jobs. But, an effective way of upgrading skills of more of the work force is key to addressing the gap between skills needed and skills available. Employers, governments, workers, educators and unions have all created ways to handle the skill upgrading challenges. Key points they are addressing are career pathways, communication of skill requirements for positions, education and training sources, training delivery where and when and how the consumer needs it, responsiveness to the rapid pace of change and shortness of time in the workplace, new technology-based delivery mechanisms, and financing options. The solutions already explored by key stakeholders are described in the Appendix. The task force paper shows the extent of the IT training problem, challenges and issues, and the findings of the task force concerning the issues. It draws on the expertise of task force members and input from sources they use.

DEFINING THE TASK

To determine how to align the skills of the current work force with today's IT capability needs, it is important to see the variety of skills needed and who the candidates for skill upgrading are.

Jobs and Range of Skills

Some "IT jobs" have modest IT content which can make them commodity work and some have high IT skill requirements. Some jobs involving IT require high skill. Some IT jobs are high paying jobs today because the skill is scarce, but emergence of new technologies could easily decrease their desirability. Some jobs are lower paying but provide opportunity for growth to better jobs. However, how career paths operate is not well understood by workers, employers, or educators.

Finding: *Creating a career path and continually refreshing skills is the only way to ensure employment and good wage opportunities.* If employers want to recruit/retain workers they must be aggressive in ensuring they offer good assignments and growth opportunity. If a worker wants independence (controlling his own career), he must define a growth path and pursue it. *Defining what the IT jobs are, what skills they require, and how they form career paths is critical to deciding how to increase the number of current workers with relevant skills.*

The following describes the varieties of jobs and how they have evolved but not how they form career paths. The skills needed for them range in IT complexity and application knowledge.

Traditional IT Work

For many years, the IT arena consisted of a few companies producing software or hardware products and customer IT shops. When workload ebbed and flowed, data center and integration companies provided additional capacity. There was a gradual, manageable increase in demand for IT workers in this era. Universities began Computer Science degrees. Today, data management, decision support, and networking have contributed new IT shop jobs and the requirement for new skills.

Technology for Manufacturing

To meet Japanese competition, manufacturers became more and more interested in improving quality. Industry began to find ways to improve product quality by automating some of their processes and by putting people where decisions needed to be made according to Dr. David

Gulley of the University of Illinois at Chicago and the Chicago Manufacturing Center. Statistical process control was the first step. Manufacturers came to believe that it was important not to build production skills that technology can easily replace. Over time, *quality has become the driver of technology*. Although manufacturing technology eliminated many jobs, it created new ones both in production and in IT support. These new jobs required higher academic skills, technology skills and different skills than many of the old jobs. Companies have had a hard time finding workers for them.

Finding: *Continual skill upgrading is critical to implementing required technology updates and quality initiatives.*

Improvements in manufacturing continue with many revolutionary technology innovations in production and in supply chain OEM interactions through electronic data interchange (EDI). (EDI connects suppliers directly to their clients' IT systems.) Some companies are finding that they *must out source to people who have the technology or the skills when they don't have them in house* according to Don Treinen of the Alliance representing the AFL-CIO. Many of these changes have meant reskilling older administrative workers who had been handling mail, inputting orders, answering phones and so on but now have to do IT application support or help desk activities.

Finding: *For larger companies, skills have to be built in a consistent way in many parts of the country. To do this, a number of manufacturers are using networks of higher education institutions, frequently community colleges, to build and upgrade worker skills.*

Technology in Hard Goods

In the early 1980's, many manufacturers began to find ways to use computer technology in their products. At the same time, customers began to look for ways to be more competitive by applying operational technology or automation to support their users. From this, came the automated gas pump, technology-driven automotive transmissions, bank ATMs and other marvels of life today. These innovations usually require that IT professionals set up software or micro code in them during creation and that service people have programming skills to fix them. *They marry the need for technical skill with knowledge of the industry and its customers.*

Technology for Competitiveness in Other Industries

Organizations in many industries are using technology to be more efficient and effective and technology has become an important element of corporate strategies to remain competitive. In fact, Some industries have been *transformed with the introduction of technology*. An example is printing and publishing. The finance industry, too, has become not only nationwide but also global with technology. Companies in this industry can not compete today without IT products such as ATM, web banking and so on. Health care based on biotechnology and aerospace are other industries which are associated with pervasive, innovative uses of technology. *The technology skills needed in these industries are both industry-specific and high-demand IT skills.*

Finding: The Gartner Group says companies have many responses to IT-driven competitive pressures. Some companies press to use the most innovative solutions and develop IT competitive plans. *Their response to acquiring IT skill is to implement the most effective* *retention, reallocation and hiring practices.* They *change their HR practices to make their IT work places attractive.* They reexamine the effectiveness of benefits, salary scale, hiring options or perks, work arrangements, training, and all other employee practices. Diane Tunick of the Gartner Group Human Resources Area says that wages for *IT workers are highest where IT is the competitive difference.* Competitive organizations are found in the IT industry or in others such as finance. The next 30-35% of companies do not have wherewithal to deal with their IT needs in a very competitive talent market. *Their answer is to out source.* The last group do not see that the need is critical. They do not respond, often limited by their own beliefs and policies.

PCs Everywhere

Because the PC appealed to young, technically-inclined people and because the PC was not initially used for mission-critical work, *the new entrants into the IT profession frequently worked quickly, gained new skills on their own, did little system planning, acted very aggressively in solving problems, and were paid wages close to new hire wages. They dealt easily with the rapid changes in PC technology.* One of the characteristics of the introduction and proliferation of PCs in the organization is the commonplace lack of planning that accompanies the gradual implementation. *There is a need but also a reluctance to consider "the total cost of ownership."* Work place systems frequently have the compute power and application capability of what used to be rooms of computers managed by teams of people. Although PCs are certainly more user friendly, they are still complex. When they become networked, they are more complex. When they manage mission-critical data, they become downright complicated. Availability, upgrades, new users, new applications, new data forms, new communications needs are not free and must be implemented. There is a cost to that. Managing and implementing these services also has a cost. Keeping the IT and user skills current is imperative and it too has a cost.

Finding: *Upfront planning to include education and training ensures the best implementations, the best use of resources and the least required rework expense.* Lack of it is much more expensive in the long run.

Death of the Old Technology?

In the late 1980s and the early 1990s, there was much organizational restructuring and a *belief that computing would move totally to the desktop and away from the mainframe forever.* As a result, many *traditional IT professionals were released from employment* through retirement, severance packages and layoffs. Even after down sizing, *not all companies work efficiently,* especially in IT, according to Diane Tunick of the Gartner Group. Companies who have not looked at IT as a competitive edge or who have not addressed creating an effective structure in IT are still inefficient so they think they need more people than they do.

Restructuring is tapering off. *However, companies known for down sizing often have trouble recruiting industry-aware young people with current, competitive skills,* according to Paul Kostek, President-Elect of the IEEE.

Finding: For the most part, IT workers released during restructuring have *skills in large, mission-critical systems projects and older technologies.* These workers are paid wages reflecting their many years of experience and they expect to do careful, considered planning for technology implementations. *They often do not have current, marketable skills nor strong business skills nor a taste for risk but they are good candidates for skill upgrading.*

Outsourcing: All or Peaks

Outsourcing has a lot of flavors. Some organizations are *disbanding their own IT shops*, releasing the workers or giving them opportunities to join an external service provider then turning all operations over the service provider. Other organizations bring in IT workers to handle *peak problems or special projects.* Still others seek out IT service providers to *help them analyze their needs in new technology areas and implement the decisions* if they have no available skill to implement the decision. *External service providers* in the first two categories who hire IT professional to provide services to other businesses, *pay more than IT shops in general.* However, they do not pay for length of service or position in organizational hierarchy as many IT shops do, *but for critical technical skill, business skill, industry skill and flexibility.*

Finding: Don McLaurin of the Computer Consulting Group points out that *outsourcing is one of the new ways that work will be done and it appeals to young people. The young want the most exciting project with the most interesting technology possibilities and new challenges versus the potential for a gold watch.* They want to be employees to have benefits but they want flexible assignments and opportunity for new skills. It is an easy time today for consultants to recruit young, flexible people with high skills. Don also says the relationship between employer and employee is a societal change being first evidenced in the IT service arena. Mary McCain, Vice President for Policy and International Affairs at ASTD, agrees saying that *the new employer/employee relationship is an independent contractor relationship on a skills basis. They work together as long as there is benefit in it for both parties.* However, although a number of employers are prepared for this "societal change," *many workers who are good candidates for IT jobs have not developed the skills and personal resources to operate successfully in the new compact.*

Finding: According to Sean Rush, General Manager of IBM Global Education Industry, consulting and contracting companies are extremely aggressive about using claims of staff skills to obtain contracts. *Sometimes, these are skills of people whom they must hire or train rapidly to actually have on board.* IT assignments in this arena are project work which is intensive, often requires long hours and can last from a day to 10 or 15 years. There is a potential in these companies for employee burn out which could again negatively impact the supply of IT skills.

Software for Everyone

As the PC gained prominence, many user departments and small businesses found an affordable way to do computing in local offices and they began to be *aggressive consumers of packaged and custom PC application software.* Homes, too, were adopting the new platform and they also were seeking application software to handle their needs. These two factors generated a requirement for more programmers in the IT industry to produce this software. But it also expanded the need for IT workers in the IT shop to support the users, in the user departments to handle local technology, in small businesses, and in consumer sales/support companies. The change also drove the creation of *a new kind of IT person.*

Finding: The new breed is *the application-trained professional who learns IT as a second language* then becomes fluent in its uses for a specific arena such as finance, marketing, travel, advertising, etc.

At this point, *software is primarily created in the U.S.* The US has a 75% share of the packaged software market internationally according to Joyce Plotkin, Executive Director of the Massachusetts Software Council. Clusters of small software companies are in many parts of the country. They are *growing rapidly and need programmers with industry skill who are very flexible.* However, not all IT areas of the country have the Silicon Valley culture of risk taking. For example, there is a lot of software produced in *Massachusetts, Virginia and Illinois.* As David Gulley of the University of Illinois points out, Chicago is a more conservative, less risk-taking environment. People who start companies there expect to keep them in the family and pass them on to their kids. These companies *want skilled workers who will continually upgrade their skills and work long term for the company.*

The Year 2000

For the past 10 years, analysts have warned about problems with older technology which was programmed with only enough date data space to handle one century, the current one. As of the year 2000, these programs will understand the year 2000 to be 1900, 2001 to be 1901, and so on. *Organizations do not have a good inventory of their technology, especially the older technology,* according to Harris Miller, President of ITAA, so it is not clear what the problems may be or where they may occur. Problems could be in software, in hardware, or in services that no one remembers have a technology component and it may take years to straighten out these problems.

Computerworld says *that the IT workload to handle the challenge is estimated to take 30-40% of IT budgets through the year 2010 and maybe beyond.* Companies are using their own people to handle the work, outsourcing, or trying to ignore the problem. The Year 2000 problem is another factor increasing the need for workers with IT skills. *However, analysts report that the U.S. is prepared for only about 10-20% of the workload.* World wide preparation is minimal.

Now, the Internet

Use of the Internet has exploded over the last three years. With the pervasive use of the "net", people send information from office to office, from home to office, from home to home, from home/office to government, from customer to vendor, and so on. As the Internet moved from a university tool to a universal tool, it required more sophisticated mechanisms to support less skilled users. In fact, Joyce Plotkin, Executive Director of the Massachusetts Software Council, says that *the Internet is the most important factor in the increased need for software professionals so far.*

The Internet has also escalated the emerging IT user community requirements exponentially, and it has just begun to do so. Although estimates say that there are currently 82 million Internet users, most of them have not yet satisfied their needs for networked applications. Moreover, it is estimated that by 2001, there will be 268 million. This *growth* will not just be in numbers of users but also *in the applications they will need to support their use.* The Massachusetts Software Council reports that there are already 287 companies whose whole business is Internet-related IT service.

Finding: *To support the pervasive use of the Internet, a wide range of worker skills is needed.* Much of the IT skill needed to help Internet users is for low-paid IT workers to deal with the organizational services needed for basic web page programming. However, supporting wide area networks (WANs), competitively capable web sites and complex network applications requires much more skill than even a platform-specific IT job.

E-Business
New businesses join the Internet at the rate of 200 a month and this is expected to continue. Organizations are using Intranets, EDI, data mining and a wide variety of sophisticated IT. Customers, individuals or businesses find it *easier to trade with IT capable companies.* Often new networked businesses require new generic services as well as competitive-edge, operational services to be effective in this arena. E-business is not just for commercial enterprises. Many kinds of organizations have begun to use the Internet for key transactions such as online registration in higher education. *Strong IT skill is especially important when mission-critical work is on a network.* System IT professionals become key positions once again.

Internet access, e-commerce, intranets, data access: *companies are finding hard to be good at all this.* However, in many industries, they are becoming increasingly convinced that it is the competitive advantage. Even so, a number of them have a real inability to understand the downstream need for labor. E-business requires skills that are rare and in high demand such as network programming married with strong business application skill. Companies which would not leave anything to chance in other parts of the business make corporate wide IT decisions without understanding if they have access to the hard-to-acquire skills to implement.

Finding: To truly be competitive using the latest tools and to ensure access to the right skills at the right time, organizations need do the upfront planning looking *at where they'll be in three years, forecasting what technology and staffing will be available, who needs training, etc.* According to Sean Rush, *few organizations*, including higher education institutions which could help build the skills for the new environment, have *invested in planning and preparation for the coming tide.*

Where We Are
It is clear that the IT industry and its user community have grown over the last 10 years in ways they did not over the preceding 20+ years. *As previous IT workers left the profession, new IT workers emerged.* The net effect was that over several years *the growing demand for new IT workers and IT skilled application workers was not apparent.* With organizational restructuring slowing, the increasing use of technology in small businesses and the rapid expansion in the use of the Internet for commerce *during the last two years, the high growth in the demand for IT-skilled workers in IT professions and in other professions began to be visible.* Paul Kostek, President-Elect of IEEE, says that over the last few years their membership has remained stable indicating that the reported large loss of engineers to other professions is not borne out in IEEE data. In fact, after a period of unemployment we are in a period of major reemployment.

Some new IT-related jobs require skills that are easy to obtain and in plentiful supply while some are high-demand jobs for which few have the relevant skills. Wages for the former are relatively low and those employed are young while wages for the latter are currently escalating and often need the experienced. *With the pace of change and competitive pressures, employers with critical needs move quickly to scoop up workers already skilled in the latest technology.* This is *leading to higher salaries for a few and less employer-paid training for many.* Companies are hesitant to train when raiding is cheaper and technology changes so rapidly.

What is key technology has changed repeatedly over time. There have been large technology shifts such as the move from mainframe to desktop which occur about every 5 to 8 years. There are minor moves in technology use such as the move from HTML to Java programming. Skills to support major moves require planning and a great deal of time to implement. Minor technology shifts can be accommodated with a few classes. Few employers or workers have invested in tracking the long term industry moves and the resulting required skills.

Finding: *New workplace mechanisms are growing out of the changes in the industry.* New employer/employee relationships which have long been predicted are beginning to emerge. *IT workers need current technical skills, business skills, often industry skills, and flexibility to have work security and good wages.* The advice of the management consultant Tom Peters is one of the keys to the change. He said, "Be a brand, sell yourself." It is important for workers to *craft their careers around projects and demand good working conditions.*

Current Worker Candidates

The next factor to be examined is the pool of worker candidates for skill upgrading. Based on the job and the history (Background section), there are many sources of potential candidates.

<u>Workers in Formerly Strong IT Careers</u>

One category is the IT workers who left IT because of organizational restructuring. Although many of these workers who were unemployed and identified themselves as IT workers have returned to jobs according to the Gartner Group, studies show that some have switched to other lines of work and some are still unemployed. Others in this category would be IT workers who need current skills, particularly those in danger of being displaced if they faced further restructuring. To upgrade their skills it would be necessary to train them in new technology and currently requested business skills. This can be instigated by employers or workers.

<u>Workers in IT Careers That Could Be Enhanced</u>

Current IT workers supporting technology being marginalized or those who know they can fill higher paying jobs could upgrade their skills through employers or by their own initiative.

<u>Application Area Workers with Technology Aptitude</u>

A fast growing need is for IT workers who are very familiar with an application area. Often it easier to train a person with application skill in IT rather than the other way around.

<u>Recent Graduates from IT-Rich Programs</u>

Some universities and community colleges offer programs apart from computer science which heavily use IT. Mark Schaefermeyer of Virginia Tech says next year all entering freshmen must have a computer. Today, 80% of freshmen come with them. Schools like Maryland University with strong computer science areas encourage all departments to exploit technology. George

Mason University's history or business programs ask students to use technology to access core information on the Internet. Students in these programs can be encouraged to pursue IT careers.

Skilled Unemployed Workers
Unemployed workers who have strong skills in a particular business application area or IT aptitudes are good candidates for IT skill upgrading as seen in the Massachusetts Software Council Fellowship program.

Other Unemployed Workers
Low skilled unemployed workers are often not good candidates for quick IT skill upgrading because they need remediation at basic and platform skill levels that form the basis for higher skill level training. Once this is done, many of these people can become good IT workers. That includes some people on welfare, particularly those with a long work history prior to welfare.

Workers move to jobs which provide them the most income and/or the most satisfaction. Movement from one job category to another for the most flexible and most skilled will be based on the job potential and working conditions. After the prime jobs are taken, other IT workers will sort themselves into the remaining opportunities across the job category grid.

Definition
The U.S. Department of Commerce / ITAA Convocation Task Force on Skill Upgrading of the Current Work Force was charged with finding ways to help the current U.S. work force seize opportunities to meet the expanded demand for workers with IT skills.. Many of the jobs, such as those in the rapidly expanding software industry, are good positions with high wages. In fact, according to the American Electronics Association CyberNation study, high tech workers, a larger group of which IT workers are a part, earn 73% more than other private sector workers. For this discussion, the task force has defined its work as examining how with adequate IT skill building, potential candidates in the current work force can fill the jobs in IT arenas and in business areas heavily dependent on IT.

CHALLENGES, OPPORTUNITIES AND ADDITIONAL FINDINGS

Rapid Technology Shifts
One challenge to solving the skills problem is that the difference between *what is commodity work and what is a rare talent* is often only a matter of the shifts in the technology use. Systems and network skills were in demand in the early 1980s and lost favor later that decade only to return to high dominance when coupled with agility in the past year. A person with these skills as a base could be highly paid then surplused then with minimal skill upgrade be paid as much as many executives, stock options, perks and all.

With the frequent and difficult-to-predict changes in what technology method is dominant, creating a plan to continually, effectively upgrade IT skills in the current work force requires innovation, prediction and determination. Training for the product or even the technology du jour will not do the whole job.

Finding: *Educating for broad skills categories such as data base (or application programming or telecommunications) with short term upgrading for specific technology skills* such as relational data base or products such as Oracle's data base should be a productive paradigm. In addition, when the focal point skills change, they often change quickly for a large group of workers. When the base skills change, they usually change over a longer period of time.

Finding: *Matching the method of skill upgrading to the required speed of upgrading and the depth or reskilling needed* is new to education providers but must be addressed. Distributed or distance learning, says Lauren Brownstein of ITAA, can be an effective tool for upgrading skills quickly for a widespread audience. Mary McCain points out that learning with technology tools that accommodate the need for asynchronous work is critical to the challenges of skill building and upgrading today. However, there is *not enough known about how people learn well with technology and what it takes to make a particular mechanism effective* under various conditions. The costs versus benefits of various methods of skill building must also be understood

High Demand Skills

Today, ads for IT professionals insist that applicants already have certain high-demand product skills. Software companies which require immediate high-level skills in new data base or network technology to be competitive are paying very high wages and giving many perks for IT *workers who already possess the exact skills* needed. *Traditional IT shops are losing key people* they have trained in new technologies to these lures. They are also unable to find replacements for the salaries which they have paid in the past and which they can afford under current budgets. ***Finding:*** Some *workers are continually building skills to stay ahead of the need* because having high demand skills can provide a great deal of opportunity. However, like high-paid sports ability, over-the-hill skills can mean very short careers at the high wages/benefits for the worker. Other worker strategies have more long term potential.

Finding: Previously interested in only hiring applicants with key product skills, IT managers are now willing to hire workers who have worked in an area such as data base and then train the entrant on the specific tools their organization uses. But, they do this when they can find those candidates with great trepidation given their experience with losing people in whom they invest. *Employers need aggressive retention plans.*

Baseline Skills Required

Business leaders, governments and educators are pushing for more math skill for job market entrants as key to increasing available technology workers. This is because math is required for most college technology programs. However, *when IT workers were hired over the last three decades*, identifying IT skills was not a matter of only seeing who did well in math in school. Those who have *an aptitude for music, math, art, language* and some other areas have proved to have the system-wide *relationship and diagnostic skill* needed to work in IT.

Finding: To find candidates for skill upgrading, it is important to broaden the search to those with any background that has yielded effective IT workers in the past. In fact, since many people develop additional skills over time, *there should be a deliberate effort to more broadly assess* *other workers* to determine whether they have the aptitude and interest of IT work. This can produce a large number of successful IT workers when trained with the "boot camp" method.

Finding: These workers often have other skills that employers are seeking as well. The Gartner Group reports that there is a demand for IT workers to augment skills with business skills, industry knowledge and knowledge of sources of IT and/or business information. According to a recent Business Week article, *57% of required skills for the IT profession are business skills.* Joyce Plotkin says studies show that industry experience is harder to replace than IT skill and that *understanding the underlying business contributes to performance.*

Finding: To determine how to continually upgrade skills for IT work, it is useful to *define skills all workers need, skills all IT workers need, skills specific groups of IT workers need, and skills that are company-specific.* This helps trainers better align offerings and delivery to needs.

Categorizing the Jobs

IT job categories tracked by the U.S. Department of Labor need to reflect the jobs created in the IT arena and its user community plus the career paths for those jobs. This will help workers identify the opportunity better and provide key information for training providers and employers. There is some data collected on how the demand is distributed. For example, the Massachusetts Software Council surveyed workers who had worked at least ten years and then completed the MSC intensive training. Of these, 88% are in the software industry with at least 47K starting salary. The 88% broke down into 25% quality assurance (testing and programming), 20% software development, 16% customer service technicians (programming and debugging), 15% sales/marketing, 8% project management, 8% tech writer, 8% other including trainers.

Finding: *Category definition is a core activity to pursue further* . For each category, there is key information which must be determined: whether it is a growth area, whether employers indicate a shortage in the category, what key skills are required, and what primary strategy for filling these particular skill needs employers use. It would be useful to determine the *percentage of IT jobs which fall in each category*, what salaries average, and what effect training programs have.

Human Resources for IT

In the IT rich arena, knowledge workers are more important than capital equipment. Constant new entrants to a staff will not solve skill problems, but work places that are very unpleasant do not attract or retain workers. *Attracting IT workers is not all about money*; other things can make the difference, for example, employer strategies for in house IT training/promotion which moves current employees into IT positions and upgrades the skill and job scope of current IT workers.

Finding: It is important to *create an environment where people acquire and use new skills* and the *organization invests in people* in other ways such as *expanding an employee's job scope.* The Gartner Group suggests *human resources management (HR) geared to IT.* As a basis, companies *lay out plans including IT for 5 to 10 years then* look at what skills they will need, who the best candidates are and how those skills can be built. After considering *what work their own staff must handle*, for peak periods or expert work, external services should be considered.

Finding: Employers will have the best employees when employees are the most competitive. To be very competitive, employees need *information on where technology is going, where their own industry is headed with technology, what the characteristics of available jobs are, what skills are needed, and how the relevant skills can be obtained.* This data makes skill upgrading a shared responsibility of employers and workers according to Harris Miller of ITAA.

Finding: For the new type of HR practice, employers must closely *examine all their employee related policies to ensure they match the needs of their employees.* They might consider giving part timers benefits or examine all work to see who has to be on site or what expected activities are not really part of a given job. For example, one company in Boston has virtually no turnover because it deliberately hires disabled people and makes the work place very attractive to them.

Skill Building Systems/Options to Meet the Need

According to Debra Kolodny, labor/management consultant, the IT arena needs a *continual needs/gap assessment process not only within the company but also across the economy.*

Finding: Part of that process is the continual redefinition of IT jobs, the skills required for each, and the relationships among jobs that form career paths. An understanding of *what skills build on what other skills* will indicate what skills can be built in a two-year or a four-year degree program, what skills require some kind of certification, what skills can be handled by short formal training, and what skills should be provided on the job.

Employers are looking to have just the *right skill at just the right time.*

Finding: Defining the continuum of education/training will lay the foundation for *matching the speed of delivery sources to the speed of change.* Business needs should drive skills planning. However, people knowledgeable about skill building and delivery alternatives should decide what sources are most effective for delivering what skill in a particular time frame.

Finding: *Online access for training offers much potential for just in time training.* Colorado has one of the first higher education institutions to offer a *degree program entirely online to accommodate asynchronous learning for its employed customers.* Other higher education institutions are offering courses over the Internet. Many also use cable television for delivery.

To be sure that workers have the skill to use their products, vendors have developed *classroom and hands-on programs* to certify that a worker has successfully trained in them. Also a few employers have created certification for careers in their organizations. According to Sean Rush, for some professions, IBM has defined required skills, career paths and education as well as experience alternatives. Assessments allow candidates to become certified in those professions.

Finding: Certification is a good mechanism for workers and employers as well. Training programs that build skill in a specific area are available and effective. Employers and/or workers can select the training. When it results from both theoretical and applied (hands-on) learning, it proves to be a good predictor of actual job success. Certificates also *communicate what the worker can do* as well as *what skills an ad for employment specifically seeks.* Paul Kostek says that if a worker can learn one product through certification, he can learn the relatives easily.

Finding: According to Steve Hoffman, Vice President at Sylvan Learning, more *professional certification is necessary for effective skill upgrading in the industry* and it will happen.

There are *many sources of skill upgrading*. Employer-provided training includes skill planning, in house classes, mentoring, on the job training, corporate universities, and help functions. According to Linda Leffel of Virginia Tech, there are over 1200 *corporate universities* designed to build skills and provide credentials on the job. Unions offer career planning and education programs. Partnerships have brought richness to programs by supporting the interests of all. Vendors include training in their products. Community colleges and universities partner with employers to provide degree programs, certificate programs, and even outsourced skill building. *IT intensive skill building programs, "training factories,"* quickly *move career changers and new entrants into the IT* industry. (The Massachusetts Software Council trains application workers with IT aptitude for the industry. The ITAA partners with Old Dominion University in Norfolk, Virginia, to offer a programming "boot camp" to help with the Year 2000 problem.)

Finding: Private trainers, consultants, and higher education can be used effectively for training..

Private trainers such as Sylvan Learning pick up *vendor authorized training* and offer it *across the country in their network of providers*, but also often use their technology-based trainers to help employers solve their IT training problems as *adjunct staff*. Additionally, private education and training organizations, from those with training as their primary mission to those (like IBM, Motorola or the Massachusetts Software Council0 for whom skill building is one facet of their businesses, measure their effectiveness differently from other educational organizations.

Finding: *How well their students succeed and whether their work will be sought by employers is key driver of private systems. Other training functions must measure themselves in this manner.*
Finding: Because of the *slow pace of accreditation* in most states and the expense of changing technology, *higher education* finds it difficult to accommodate the continual need for new courses and alternate delivery. They *need a more responsive, flexible system* for adding courses and changing how programs are delivered. *Private trainers* offer many of the same services but more aggressively: a number of private trainers already have their programs on the Internet. .

Finding: *Technology* provides many new education alternatives and these must be better understood to accommodate the wide variety of needs in IT skill-building. Another kind of information needed in the process is *what it takes to build a particular type of skill, how people effectively learn the skill, and what mechanism used in what way will best deliver the skill.*

Financing
Skill upgrading can be expensive even with base skills in the same major technical category that the upgrading addresses. To design a long term skill system, it is important to *understand and plan for infrastructure costs* as well as *individual costs*. With a system of skill upgrading will come many *expenses which should ultimately be borne by the entity receiving the most benefit*. Employers will pay for training when they understand it is important to their business. It may or may not be the training that will give the worker the best long term opportunities. A union will pay for training when the training builds skill in occupations served by the union.

Finding: In the emerging economy where people get opportunities to develop their own skills, *workers must be able to drive for skills that are strong in the job market.* Each IT worker must be able to *decide what training they take and when. Low cost loans to the individual* which can be *used with IT private trainers* (which are often not state licensed) *as well as higher education* are one alternative for allowing workers to pay for training normally paid for by employers. To qualify for the loans, individuals must define career goals, understand the economic impact of the skill upgrading choice, and determine the most effective education/training alternative.

Short Term Actions
Based on the programs that have worked in the past listed in the Appendix, the task force sees that a number of actions that can help in the short term.

Finding: *Information on emerging new technology* and *key trends in applying the technology* in industry should be identified. This and *job market information* should be generally available. Some of this information is in IT, association, and business publications.

Finding: The following should be encouraged:

o An awareness campaign aimed at employers, IT companies, unions, education providers and workers. Articles, papers and the bully pulpit should be used to describe the situation.

o Training factories like the ITAA boot camp or the MSC Fellowship which train workers, usually not current IT workers, to program or provide some other IT service.

o Certification programs which certify skills (for an IT job or for supporting vendor products) and which have broad acceptance in the economy. They provide clearly defined skills and facilitate communications among employers, workers, and educators.

o Implementing new technology which reduces internal IT support requirements. Sometimes this moves a portion of the technical support into the user community.

o Augmenting training staff with private trainers or staff from technology-capable higher education institutions. This strategy can expedite staff skill building.

o More technology-driven education solutions such as offerings over the Internet for reaching more people with less resource and other technology mechanisms for collaborative learning or asynchronous training to accommodate schedules and consultation with experts/mentors.

Longer Term Actions
Long term the more difficult issues can be tackled. There are two key issues to address for long term success. The primary issue in the IT skill building arena is that the *legislative/regulatory pace in most jurisdictions is too slow for today's needs.* In addition, *policy makers in general do not have the IT knowledge they need to address the problems.* The second issue is that the economy needs a work force development system.

Finding: Updating policy makers on the IT skills issues and rethinking work force policy in light of the Information Age could expedite solving the problems.

Finding: A system must develop or be created to define careers, provide job market data and then educate/train for the opportunities. Changes in law/regulation may help the system. There will be new roles for employers, workers, unions and other institutions, aggressive service to students and employers by education institutions, and research to provide information to guide the system.

Finding: The task force recommends some key considerations which are listed below:

o A formal or informal group (of employers, unions, workers, educators, and government) should be created to guide the system. Workers and employers should be treated as clients.

o The process of renewal for an integrated system of skill building and job changing must be continuous to keep up with the pace of change in the industry.

o Continual research on IT work, effective skill building and the cost/benefits of skill upgrading will provide the data for the system.

o The system should ensure that career path documentation is created and given to workers with job market information. It is key to distinguish meaningful skills from "fad" skills.

o Providers should be encouraged to engage in client partnerships and delivery structures to ensure cost effective learning at just the right level at just the right time in just the right place.

o There should be encouragement for learning consortia which increase affordability for small business and improve the capability of the learning system.

o Delivery should be systematized to ensure speed, source, and content meet the needs.

o The cost of upscaling should be balanced against the value to the economy, to the employer, and to the worker. Financing each part should fall on the entity with the most payback.

o Aggressive planning across the system and by all the stakeholders can help to meet increased demand by preparing before it's a reality.

o To see how better support skill upgrading can be supported better, the following should be considered:

- Where do the unemployed get training? Do they have the opportunities the employed do?
- Would tax incentives for industry-wide consortia to address training expedite the system?
- How can we achieve more user control in the system?
- How will data on the system be made available to workers and employers?

Conclusion

Addressing the question of upgrading the IT skills of the current work force to more quickly expedite the effectiveness of a key new component of the economy has *no easy answers*. The stakeholders could all wait and let nature take its course. This paper has taken a more proactive approach. It has outlined the complexity of the IT industry and its customers then looked at what has helped as well as what is promising. At the Convocation, task force members who have a wide range of experiences in the aspects of the problem will use this paper as a basis for conversation and further solution development with attendees. Following the Convocation, the task force would like to see stakeholders, singly or in consortia, commission the required studies, take up their recommended roles and use the ensuing information from both to come together again each year for the next three years to check progress and renew the process.

APPENDIX

EXAMPLES OF EFFORTS TO TACKLE THE TASK

Government

The U.S. recently enacted two tax credits proposed by President Clinton that will provide financial resources to enable workers to obtain needed training and skill upgrading to move them into the areas of great demand, such as IT occupations. These include:

> Hope Scholarships- For students in the first two years of college, most taxpayers will be eligible for a tax credit equal to 100 percent of the first $1,000 of tuition and fees, and 50 percent of the second $1,000.
>
> Lifetime Learning Credit- For those beyond the first two years of college or taking classes part-time to upgrade their job skills, most families will receive a 20 percent tax credit for the first $5,000 of tuition and fees through 2002, and for the first $10,000 thereafter.

Governor Engler of Michigan reports that Michigan is *lashing up their community colleges with employers* to increase the skills of the education network and to provide upgrading that businesses can't do well alone. For a number of years, Wisconsin has provided entry and current worker skill building for industry, especially manufacturing, by encouraging *close-knit local relationships between business and its technical college system.* Individual colleges have thus built specialties in specific industries which attract students from around the world. For example, Fox Valley Technical College in Appleton has become know for architecture.

According to Dr. Janet Caldow of the Institute for Electronic Government, the governor of the Orissa province of India recently *visited the United States to find out how to build strong IT skills, what skills were most important to build, and how best to deploy them.* He commented that he expects his state to become "the Silicon Valley of India." Statistics show that the U.S. graduates 26,000 in computer science year while India graduates 50,000. The Minister of Education from Singapore on his U.S. visit examined IT applications with government and a number of U.S. companies to determine how Singapore could be the world leader in the application of technology. He feels his job is to know what the best use of technology is and find ways his function can help *ensure the competitiveness* of Singapore.
These are only two examples from a parade of world leaders coming to the U.S. (the international source of IT and of IT application expertise) to help their people and their companies move forward rapidly in this critical industry.

Employers/Business

Motorola is an example of a company which is beginning to *integrate training into jobs* to keep pace with the need for constant skill upgrading. Mentors within the team, help facilities and technology are ways they are addressing the challenge. IBM, too, has a capability called Desktop University which allows employees to train while they are using the tool the training covers.

Miller Brewing, P&G, Saturn, Ford and IBM have all begun developing *a seamless capability for skill assessment, career planning and plugging into skill upgrading.* Online technology, often Intranet, brings the services to employees in a company with locations all over the globe. A small manufacturing company, Menasha, in northern Wisconsin has set up a *skill-based management process.* As they define their plans they determine what skills they have today, what skills they need, what level of proficiency will be required, what the cost will be, and how it will be accomplished.

Mark Schaefermeyer of Virginia Tech reports that *retooling their operation* for distributed processing *made for fewer open positions* which were easier to fill. In some cases, the new technology made it easier to move some of the support work into the user community.

Unions Improving Skills

The building trades have long had a system of skill building that can serve as a model. According to Ken Edwards, Director of Research at IBEW, the IBEW provides information on skill needs, certification, available jobs and career paths. It also offers *not only initial certification but opportunities for upgrading.* The five-year initial program itself is also constantly upgraded with new skills such as telephone work since deregulation and electronic controls. It is *industry wide training and job information* according to Ken Edwards of the IBEW who says that *skill standards in other industries such as IT will help* with certification in those areas as well. In the IT Industry, CWA has also been a supporter of education and training programs and *collaborations which give workers new opportunities.*

When skilled workers are in short supply, the IBEW has supported *job sharing, teaming, and training.* It is also a supporter of certification but not licensing which is not reciprocal across government boundaries. Licensing can be expensive and time-consuming for workers. Labor unions report that 80% of collective bargaining contains the requirement for skill upgrading and education including certification programs.

Public/Private Partnership

In those parts of the U.S. where state and local government have created a climate of IT worker skill building and employer support, there has been a great deal of success in providing the high wage jobs that local economies seek. When INTEL built a new operation in New Mexico, the local work force did not have strong basic skills much less IT skills. Together New Mexico's government and educators worked with INTEL to change that. INTEL got a good work force and tax breaks in a low expense area and New Mexico got many *high quality jobs for formerly under employed workers.*

A number of countries such as Canada, Ireland, India, Taiwan, and China have created government partnerships with industry for building skills. There are *human resources councils*, business and higher education involvement, government funding, and *research efforts* to create the most effective action.

Consortia/Associations

MVAC, Michigan Virtual Automotive College, is *a learning consortium* of auto makers including Chrysler and Ford, the UAW and a number of local colleges. The arrangement is designed to *build education/training capacity which keeps up with the demand.* Mary McCain, Vice President for Policy and International Relations at the American Society for Training and Development says that it is a good first step for addressing *continuous skill upgrading* but it is still challenged to provide enough skill building fast enough.

IEEE is an association of engineers which provides its members with *information on what jobs require, the supply/demand for them, what new technology is coming,* and other things which it *encourages members to use to control their career paths.*

For some time, the auto makers and the UAW have had partnerships to provide automotive workers with *career planning support, job market information, placement assistance, as well as a number of education and training programs.* This has allowed automotive workers, especially in locations where multiple auto manufacturers are located, career longevity and more continuous employment. It has provided the companies with a stronger and stronger work force.
CWA, IBEW, Lucent Technologies, and AT&T have created the Alliance for Employee Growth and Development, Inc. (the Alliance) and the Employee Training Opportunity Program (ETOP). Both systems provide career planning, out placement assistance, and a range of education and training programs covering basic, platform, specialty skills and college tuition programs on a prepay basis. They provide *seamless opportunities to plan careers and build the skills to pursue them* in the telecommunications arena.

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