Foreword:
A New Economic Landscape

During the first six decades of the 20th century, our nation's economic growth was powered by steel, coal, and manufacturing.

Ohio excelled in this industrial economy. Located in the heart of the country--crisscrossed by railroads, rivers, and highways--spacious and rich in raw materials--our state teemed with industry and commerce.

Good jobs were plentiful. Strong, hard-working Ohioans earned high wages. Our state enjoyed a competitive edge.

But today, the industrial economy that shaped 20th century Ohio has been eclipsed by a new economy that is global, digital, and knowledge-based.

The rules are changing in this new economy. Ohio's businesses must now operate on a world-wide scale and produce at an ever-increasing rate. Success will be the result of knowledge and imagination.

Furthermore, our state must now engage in what Miami University President James C. Garland calls "a new kind of struggle and economic cold war among states for a share of the global information and technology based markets."[1]

Ohio is positioning itself to succeed in those new markets through substantial investments in research, technological innovation, technology transfer, and workforce development. The capacity of our colleges and universities to produce researchers, innovators, entrepreneurs, and skilled technical workers will play a major role in the success of these investments.

But the minds and imaginations of tomorrow's skilled workers are being shaped in our K-12 schools. In the words of Norman Augustine, chair of the national Business Roundtable's Education Task Force: "More and more, we see that competition in the international marketplace is in reality a battle of the classrooms."[2]

To win this "battle," we must prepare our K-12 students for 21st century work and citizenship. ***Continued investment in technologically enriched teaching and learning for our students is a critical part of Ohio's winning strategy.***

1. Workforce Development: The Critical Challenge

The "new economy" has been defined in a variety of ways, but its essence can be expressed by three characteristics:

Global.
Goods, services, labor, innovation, and money move freely across national borders and geographical distances.

Digital.
Digital information technologies improve speed, efficiency, and cost-effectiveness in the development, production, marketing, sales, and delivery of goods and services.

Knowledge-Based.
Thinking, learning, and innovating are principal activities for creating wealth.

The U.S. businesses and industries that led the way in these three areas—competing in global markets, using digital technologies strategically, and applying knowledge in new ways—were major contributors to the long period of economic prosperity that spanned much of the 1990s. They also transformed the economies of the states and regions surrounding them, creating a new wave of job opportunities for citizens.

The next wave of economic opportunity is rapidly building.

Emerging Economic Centers

Some states—most notably California, Texas, New York, Illinois, and Massachussetts—are certain to continue prospering in the economy that their R&D institutions and businesses helped create.[3]

But with the explosive growth of information technology and new opportunities in areas such as biotechnology, advanced materials, and nanotechnology, several additional states and regions are now positioning themselves to become our nation's newest centers of high tech industry.

Ohio in Competition

Ohio is in serious technological competition for leadership in the new economy. To attract 21st century businesses and the high-wage, high-skill jobs they will create, we are strengthening our capabilities for research and development. We are forging dynamic partnerships between higher education, industry, and government. And we are creating innovative strategies for commercializing new technologies.

But achieving a competitive edge will depend upon our people.

To succeed in becoming one of our nation's future centers of economic growth, Ohio needs a workforce with the right mix of 21st century knowledge and skills:

- A strong community of knowledge generators--from biochemists to computer scientists to civil engineers.
- A steady supply of skilled technical workers--from computer programmers to automotive technicians.
- Business leaders and managers who can leverage knowledge and navigate the rapidly emerging opportunities of a new economy.
- Service providers who can instantly access, shape, and apply information and knowledge to meet a variety of customer needs.
- Health care professionals who base decisions on the most current knowledge.
- Manufacturers who take advantage of the most sophisticated tools and techniques.
- Educators who can prepare developing minds for unknown challenges.
- Community leaders who infuse politics, culture, and society with new ideas and positive solutions.

Building such a workforce is our state's most critical economic challenge.

Some of Ohio's Investments in Nurturing High Tech Industries

Ohio is positioning itself for success in the global, digital, knowledge-based economy.

Some recent initiatives for creating new opportunities to attract 21st century businesses and create high wage, high-skill jobs include:

- Recent legislation will help recruit top researchers and encourage commercialization by allowing university researchers to share in the success of their innovations.
- With the goal of expanding Ohio's research base, facilitating technology transfer, and stimulating the creation of research parks and technology incubators, Ohio's legislature has increased the state's Technology Action Fund from $3 to $30 million.
- New business tax credits for research and development and a training have been signed into law.
- Governor Bob Taft is leading the way toward a regional strategy for nurturing the high-tech industries of the future by working with the Council of Great Lakes' Governors to form the Great Lakes Biomedicine/Biotechnology Consortium.

Ohio also is working to meet the skill demands of high tech industries by:

- Tripling funding for its Jobs Challenge initiative to enable two-year colleges to provide customized non-degree training to employers.
- Working to raise the number of high school students preparing for technology-based careers. Governor Taft's goal is 35,000 students in Tech Prep programs by 2003.
- Developing a comprehensive workforce strategy with guidance from a 57-member Workforce Policy Board that includes several representatives from the business community.[4]

Source: Governor Bob Taft, *The Year in Review*, 1999

Ohio's Key Long-Term Strategy

In the new economy, which is shifting toward high-skill, high-wage jobs, Ohio needs a comprehensive approach to workforce development that encompasses both short- and long-term strategies.

Our most important long-term strategy is creating a K-16 educational system that prepares all Ohio students for success in a new economy and a rapidly changing world.

Beginning in the early grades, Ohio students need to think, learn, and work in ways that reflect the challenges they will face as adults in the new economy:

- They need good textbooks. But they also need to witness ideas circling the globe at the speed of light, the complexities of a global community, and the achievements of their future competitors—students in other nations.
- They need to gain the basic skills that provide a foundation for all learning. But they also need to experience the use of 21st century methods and tools for finding information, solving problems, and communicating.
- They need to acquire a body of knowledge. But they also need to develop minds that can put existing knowledge to work in a variety of contexts—and generate new knowledge, ideas, and solutions.

In short, building a future workforce that will give our state a competitive edge in the new economy means creating global, digital, knowledge-based schools for all Ohio students.

Ohio SchoolNet

Ohio has already laid the foundation for global, digital, knowledge-based schools through the work of Ohio SchoolNet.

Since Ohio SchoolNet was established in 1994, our state has made significant progress in creating a basic physical infrastructure for educational technology.

The majority of our classrooms have been wired for the Internet. A high percentage of our K-4 classrooms have been equipped with at least one multimedia computer, and fifth-grade classrooms are beginning to be funded. Districts also have used local funding—and in some cases, funding from the business community—to purchase technology for their schools.

With the physical infrastructure for educational technology well-established, it is time for Ohio to begin the transition to global, digital, knowledge-based schools.

SchoolNet's Accomplishments

Launched in 1994 by Governor George V. Voinovich and the Ohio General Assembly, Ohio SchoolNet represented a commitment to wire all of Ohio's public school classrooms for voice, video, and data, as well to provide computers to every classroom in the 25 percent of districts with the lowest-wealth.

Following the original $95 million investment, the legislature established SchoolNet Plus in 1995 to provide $400 million in funding for the purchase of multi-media computers for the state's K-4 public school classrooms.

As a result of these investments:

- 88 percent of Ohio's schools now have access to the Internet.
- 78 percent have Internet access from one or more classrooms
- Ohio's overall ratio of one multimedia computer for every seven students was ranked third in the nation in 1998.[5]

Ohio Schools in Transition

As we count the costs of installing computers and Internet connections in our schools, it is natural to begin looking for immediate improvements in student learning.

But delays are almost inevitable when new technologies are introduced.

In fact, various groups, including researchers with the Apple Classroom of Tomorrow (ACOT) study,[6] the CEO Forum,[7] and the Milken Exchange on Educational Technology,[8] have outlined distinct stages of progress.

During the initial stages, learning environments and teaching and learning practices remain relatively unchanged. Then a transition begins. Teachers start developing their technology skills and integrate technology into existing practices. They become more confident with their technology use.

Finally, comes a transformation stage in which technology is used for teaching, learning, and interacting in ways that have never before been tried. It is in this final stage of transformation that schools become global, digital, knowledge-based learning environments.

Only in the transformation stage will students engage in new work and learning habits and teachers exhibit new roles and practices.

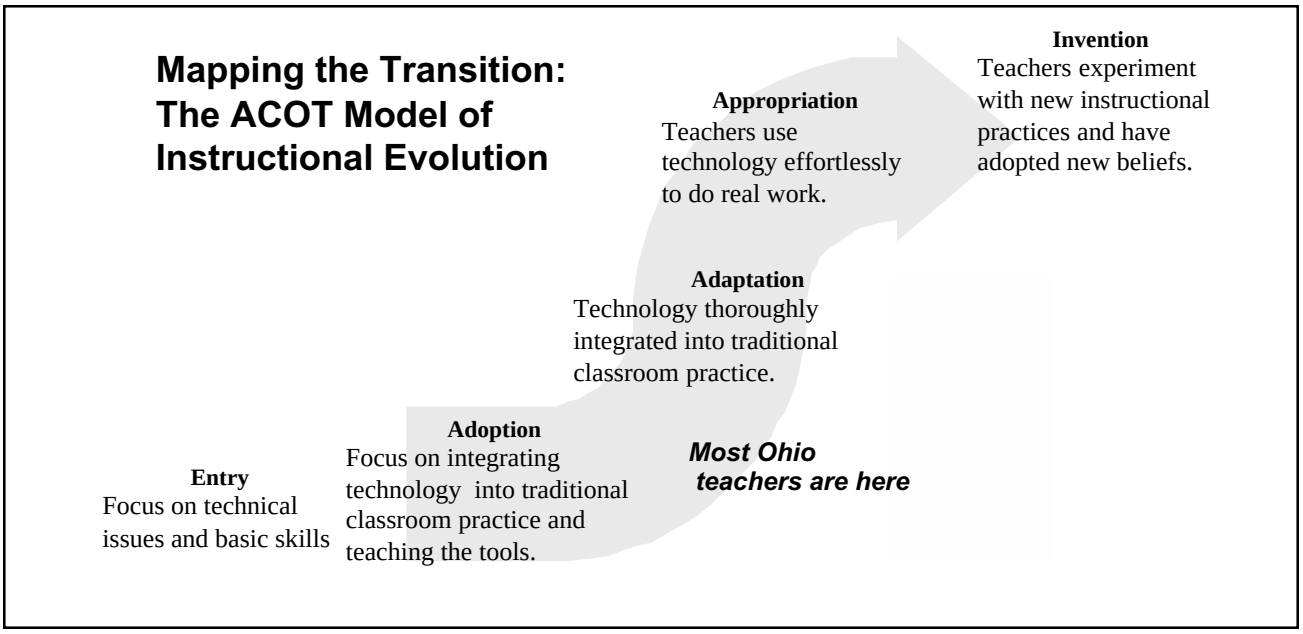
Educational technology initiatives in most Ohio schools are now in transition--the middle period of integration and adaptation.

Technologies are in place. Many teachers have learned basic skills and taken steps to incorporate the new technologies into their teaching.

But most Ohio teachers are not yet using educational technology as a tool for interacting with their students in new ways, changing practices that are ineffective, and developing innovative, student-focused learning experiences.

We must accelerate our progress toward global, digital, knowledge-based Ohio schools that prepare all students for the new economy. We can do this by investing our efforts and resources in teacher learning, technology productivity, and knowledge generation.

The economic benefit of these steps will be the creation of the global, digital, knowledge-based schools needed in a new economy and a changing world.



2. Global, Digital, Knowledge-Based Schools: The Economic Advantages

When viewed from an economic perspective, continued investments in the technological enrichment of teaching and learning offers some distinct advantages:

A global perspective. Our schools will expose students to the global community, promote high standards, and help diminish the inequities and barriers that often keep low-income and under-represented groups out of the skilled workforce.

Students prepared for the digital world. Our schools will narrow the gap between real world expectations for technological proficiency and students' educational experiences.

Students prepared for knowledge work. Our schools will expand opportunities for developing the habits and abilities of critical thinking, problem-solving, communicating, and lifelong learning that are essential for performing knowledge work.

Developing a Global Perspective

To prepare students for success in the new economy, the K-12 educational community and itsstudents need to develop a global perspective.

Preparing Students for Global Organizations

Today's K-12 students will work in environments that require a global perspective:

- Many will work for companies that serve international markets. Their success will depend largely on their ability to anticipate and respond to the needs of customers in other nations.
- Many will work on projects with colleagues from around the world. Their success will depend largely on their ability to collaborate and to understand and appreciate other cultures.
- Many will have jobs that require meeting competing demands. Their success will depend largely on their ability to see the big picture, to look at problems from all angles.

Real opportunities to develop each of these abilities are more easily available in technologically enriched teaching and learning environments.

Meeting Global Standards

Discussions of educational improvement often center on developing standards to ensure that U.S. curricula are designed to produce students who can compete with their counterparts in a global economy. Many of our nation's governors and business leaders have long supported national standards.

When U.S. eighth- and twelfth-graders performed at or below the international averages on the Third International Mathematics and Science Study (TIMSS), the National Science Board strongly recommended that educational systems across the nation come to consensus on a common core of knowledge and skills in mathematics and science to be embedded consistently in classroom teaching and learning.[9]

The nationwide—even worldwide—sharing of ideas and information that is a necessary first step to this consensus process can be much more dynamic among technologically enriched teaching and learning environments.

Teachers with access to the Web can instantly download the standards proposed by the National Council of Teachers of Mathematics,[10] the American Association for the Advancement of Science,[11] the National Research Council and National Academy of Sciences,[12] and the National Educational Technology Standards.[13]

Taking advantage of the opportunity to read such resources and communicate with the best teachers and education systems in the world—perhaps even to watch demonstrations of best practices—will encourage more thinking about what standards represent "best in the world."

With this trype of perspective, Ohio schools will raise the bar. Rather than comparing their proficiency test results with those of similar school districts, educators with a global perspective would be examining best practices worldwide. Achieving an Effective rating on the annual district report card would be viewed as only the first step in achieving excellence. Our state's minimum performance standards would be replaced by world class benchmarks.

Closing the Digital Divide

Providing equitable opportunities to achieve also is essential in developing schools and students with a global perspective.

In 1995, Ohio's legislators advanced educational equity by providing every classroom in the state's lowest wealth districts with funding for computers.

In the years since that decision, the rest of the nation has become increasingly aware of a growing "digital divide."

According to the U.S. Department of Commerce, high-income households in the U.S. are twenty times as likely to be connected to the Internet as households at the lowest income level are. Black and Hispanic households are about two-fifths as likely to have home Internet access as white households, and those in rural areas lag behind those in urban areas." [14]

If this trend continues, we will eventually live in what Don Tapscott calls a society of "information haves and have-nots, knowers and know-nots, doers and do-nots."[15]

The consequences of the digital divide will be severe for the "have-nots." According to Patricia Dung, Science Director of the Los Angeles Educational Partnership, "lack of access to technology can result in both lower academic achievement and lower job expectations. It can be the gatekeeper of the future."[16]

Eliminating Inequities in Instruction

Nationally, Black and Hispanic students in low-wealth schools are in the greatest danger of becoming tomorrow's "information have-nots." They have less access to educational technology than do students in wealthy communities.

Furthermore, their experiences with technology are of a lower quality than are those of students in wealthy communities, according to Harold Weglinsky of the Policy Information Center, Education Testing Service.[17]

In his analysis of how technology impacted student performance on the National Assessment of Educational Progress (NAEP), Wenglinsky observed lower performance among eighth-graders who used computers primarily for drill and practice and higher performance among those who used computers for simulation and application.

He also found that black and Hispanic eighth-graders were significantly less likely than their white counterparts to use computers for the more sophisticated functions of simulation and application but were more likely to employ computers for drill and practice.

Averting a Shortage of High Tech Workers

To compete globally, many of Ohio's high tech companies must now depend upon foreign workers who obtain visas under the H-1B non-immigrant category of U.S. immigration law.

But as evidenced by the current world wide shortage of information technology workers, this strategy has limited value.

In the long term, it is also risky.

As more nations begin to compete in the new economy, they will create more high-wage job opportunities to offer to their skilled workers, including those who pursue advanced study in the United States. As more U.S.-educated workers carry technical expertise back to their native countries, higher education in those countries will improve—further diminishing the role of our universities as sources of high tech knowledge workers.

With these potential risks to the future competitiveness of Ohio's high- tech industries, Ohio must do more to develop the technical skills of students in its low-wealth schools. They are a largely untapped resource with great promise.

Serving Disadvantaged Communities

In addition to preparing disadvantaged students for workplace technology and knowledge work, technology in low-wealth schools also will help remove some of the other disadvantages that can impede their success—such as the low educational levels and unemployment of their parents.

According to the U.S. Department of Commerce, "groups that are less likely to have Internet access at home or work (such as certain minorities, those with lower incomes, those with lower education levels, and the unemployed) tend to access the Internet at schools and public libraries. These same groups also tend to engage in online activities that can result in their economic advancement, such as taking educational courses, engaging in school research, or conducting job searches." [18]

Expanding Options

Providing low-wealth schools with what Andrew Blau calls "the basic tools of opportunity, of wealth creation, of political engagement"[19] not only will help close the digital divide, it will also help solve some of the other problems facing students in low-wealth schools.

Engaging Under-Motivated Students

According to a 1997 study by the Corporation for Public Broadcasting, 82 percent of teachers surveyed believed that multimedia computer activities lead to increased student motivation and enthusiasm for learning.

The same benefits were attributed to online activities by 76 percent.[20]

Other studies have provided some affirmation for this belief:

- According to the U.S. Department of Education, "technology-rich schools report higher attendance rates and lower dropout rates than in the past." [21]
- A report on data collected between 1990 and 1994 by the Software Publishers Association cites several studies that link technology-rich environments to consistent improvements in "student attitudes toward learning and student self-concept."[22]
- A 1996 review by RAND of numerous studies also linked educational technology to improved motivation.[23]

Mitigating Impacts of Teacher Shortages.

According to the National Center for Education Statistics, our nation's schools will need to hire approximately 2.4 million teachers over the next 11 years because of teacher attrition and retirement and increased student enrollment.[24]

Low-wealth schools, already struggling to recruit and keep good teachers, are certain to be the most severely affected.

Although computers should not be considered a replacement for good teachers in low-wealth schools, they can help mitigate the effects of teacher shortages. For example, John Goodlad's suggestion to enlist highly educated, experienced teachers to lead teams of new teachers[25] could be more effectively employed if teams were linked electronically.

Expanding Access to Opportunities

Schools in our low-wealth districts are working toward better teachers and learning opportunities for their students. Increasing the graduation rate and college participation is critical.

Technologically enriched learning environments in our low-wealth schools would provide opportunities for students to:

- Gain access to advanced courses through distance learning.
- Spend some time interacting with telementors who could guide their learning.
- Attend virtual summer school or Saturday sessions to receive extra help.

Preparing Students for a Digital World

Our students are entering a digital economy in which nearly all but the lowest paying jobs will require at least a basic foundation of knowledge and skill in using sophisticated information technology. In addition, a large percentage of jobs will require significantly more than basic technology skills, and some of the most promising, highly paid jobs will require technology expertise.

Jobs of the Future

Many of the new professional and skilled jobs have been created in industries that produce information technologies or use them in innovative ways. In fact, the U.S. Department of Commerce estimates that in five years, almost half of all workers will be employed in industries that produce or intensively use information technology.[26] The remaining half will require varying degrees of proficiency with information technology, but less than 20 percent of all jobs will be low-skill (and those will be mostly low-paying).[27]

IT Industries

IT-producing industries—which employ a large core of computer scientists, computer engineers, systems analysts, and computer programmers—currently pay the highest salaries. The average annual wage for workers in IT-producing industries was $58,000 in 1998—or 85 percent higher than the $31,400 average wage for all private workers.[28]

According to the U.S. Department of Commerce, IT-producing industries accounted for only 8.3 percent of the economy's total output in 2000. But they contributed nearly a third of real U.S. economic growth between 1995 and 1999 by enabling the transformation of industries that the U.S. Department of Commerce refers to as IT-using.[29]

IT-Producing Industries: A Key Economic Engine

The IT-producing industries are high-tech enterprises that supply hardware, software, and networking products and services. Several sources indicate that employment growth in the IT industries is outpacing average employment growth:

- According to the U.S. Department of Commerce, employment in the IT industry grew almost 28 percent from 1994 to 1998, and employment in IT occupations increased by 22 percent over the same period. By contrast, over those same years, total U.S. nonfarm employment rose by about 11 percent.[30]
- According to a report by the Information Technology Association of America (ITAA), employers are expected to create a demand for roughly 1.6 million IT workers just in the year 2000.[31]
- The Bureau of Labor Statistics (BLS) projects that IT-producing industries will employ almost six million workers

IT Job Growth in for Ohio

In the 10-year period between 1996 and 2006, Ohio's projected job growth in the computer and data processing services industries is expected to increase by 88 percent (from 43,000 jobs in 1996 to 81,000.[33] Rising demands for skilled IT workers in all industries include:

Computer engineers	+103%
Computer systems analysts	+94%
Database administrators	+73%
Computer support specialists	+74%
Data processing equipment repairers	+42%
Computer programmers	+19%

Source: Ohio Bureau of Employment Services

IT-using industries—those that are among the top fifteen industries in relation to either IT investment per employee or the percentage of their total equipment stock that is IT equipment—are a vital part of the employment picture. According to the U.S. Department of Commerce, the IT-using industries:

- Accounted for between 40 and 50 percent of annual employment growth between 1992 and 1997.
- Employed almost 43 million workers in 1997 and paid an average wage that was 12.6 percent higher than the average for all industries ($33,500).
- Will constitute 44 percent of the nation's private workforce and employ 51 million workers by 2006.[34]

Ohio will experience significant job growth in some of the 15 occupations that require intensive use of information technology. Finance, insurance, and real estate occupations will grow by 33 percent. Health occupations will account for approximately one in seven new jobs for Ohioans with the largest growth (22 percent) among health technicians.[35]

Industries Considered Major Users of IT Equipment

- Telecommunications
- Security and commodity brokers
- Radio and TV broadcasting
- Business services
- Other services, not elsewhere classified
- Health services
- Motion pictures
- Holding and investment offices
- Legal services
- Wholesale trade
- Insurance carriers
- Real estate
- Instruments and related products
- Insurance agents and brokers
- Depository institutions
- Nondepository institutions
- Pipelines, except natural gas
- Petroleum and coal products
- Chemicals and allied products
- Electronic equipment

Source: U.S. Department of Commerce[36]

Ohio's Progress in High-Tech

Ohio's high-tech payroll for 1999 was $6.5 billion for 5,900 high-tech establishments. It's technology industry paid an average wage of $46,800, or 55 percent more than the average private sector wage.

Nationally, Ohio ranks:

- 5th in industrial electronics manufacturing employment with 14,200 jobs
- 8th in communications equipment manufacturing employment with 8,600 jobs
- 9th in data processing and information services employment with 14,200 jobs
- 10th in computers and office equipment manufacturing with 8,600 jobs

Source: American Electronics Association[37]

Other High-Tech Jobs

It would be inaccurate to say that the remaining 51 percent of jobs remain outside of the digital, knowledge-based economy. Many future jobs that are classified as "non-IT" according to the U.S. Department of Commerce's definition will be highly technical in nature. Such jobs include:

- Highly trained scientists and engineers in specialized non-IT areas, such as environmental engineering, aerospace, and biotechnology.
- Technicians and technologists who install, diagnose, operate, and repair equipment in areas ranging from aircraft maintenance to manufacturing to auto repair.
- Systems analysts and computer programmers employed by large retail and restaurant chains, airlines, universities, and government agencies to design and maintain corporate information systems and networks.

In addition, the rise in e-commerce--expected to represent an annual dollar value of between $634 billion and $2.8 trillion by 2003[38]--is likely to increase skill requirements for many of the low-skill sales and customer service jobs of today and make business ownership a possibility for more young people.

Growth in telecommuting and virtual work groups—viable alternatives for those who are sufficiently comfortable with technology—could alleviate a significant portion of today's child care problems, as well as allowing workers to "relocate" to new jobs without uprooting their families.

Business Basics

Since most industries have become centered on information, even many skilled jobs that are not considered "high-tech" will require more technology proficiency than the average worker has today.

Workers who are striving to advance in any business setting will be expected at some time to do several of the following:

- Create documents, presentations, spreadsheets, and databases using desktop software applications.
- Use e-mail systems to communicate internally and with customers and suppliers.
- Use electronic systems to enter and access data used for accounting, budgeting, scheduling, project management, inventory control, and other corporate functions.
- Access job-specific information through libraries of product information that have been placed on intranets.
- Upgrade their skills through customized computer-based training courses or commercially available tutorial software.

These basic skills are largely lacking among today's job applicants—even those with college degrees.

To illustrate: twenty-five colleges and universities in Virginia and Maryland have piloted Tek.Xam, a five-hour computerized test used to determine the basic technology skills of job candidates with non-technical degrees. The pass rate has been about 30 percent.[39]

Early Preparation for Technology in the Workplace

The educational requirements of today's most promising and plentiful jobs vary. But whether a student ultimately chooses to pursue an advanced degree in computer science, a bachelor's degree in education, an associate's degree in graphic arts, or a certificate in auto repair, the same conclusion is valid:

Becoming a fluent user of information technology is now as basic as reading, writing, and mathematics.

An elementary school student who learns to use a keyboard or mouse with dexterity, a middle school student who becomes skilled with Internet search engines, and a high school student who successfully creates a Web page are all building a foundation of technical proficiency that will be widely useful whatever their career choices.

In addition, activities such as choosing the technological tools that will achieve desired results, using knowledge of one software application to learn others, and engaging in everyday troubleshooting require the use of "metacognition."

Described by the National Research Council as a process of monitoring one's own learning, metacognition involves employing strategies such as "predicting outcomes, planning ahead, apportioning one's time, explaining to one's self in order to improve understanding, noting failures to comprehend, and activating background knowledge."[40]

Using a software application to do work requires all of these metacognitive strategies.

So while the specific tools used in today's classrooms may be obsolete by the time students enter the workplace, routine use of computers in the classroom can develop metacognitive skills and strategies that will bring lifelong benefits.

Preparing Students for Knowledge Work

Most of today's students will be working in jobs that require them, to some degree, to become knowledge workers.

The primary work of some will be transforming knowledge into new forms by creating games, art, music, and other electronic content. For others—teachers, public relations and advertising workers, and journalists—it will be sharing knowledge. Some will convert knowledge into software or build it into product designs. Others will manage the knowledge of corporations or work groups.

Their workplaces, says Don Tapscott, will be settings where "motivated, self-learning, entrepreneurial workers empowered by and collaborating through new tools apply their knowledge and creativity to create value."[41]

Knowledge Work Competencies

The Secretary's Commission on Achieving Needed Skills (SCANS) outlined five essential workplace competencies tthat are needed for solid job performance.

According to SCANS, **effective workers can productively use:**

Resources- They know how to allocate time, money, materials, space, and staff.

Interpersonal skills- They can work on teams, teach others, serve customers, lead, negotiate, and work well with people from culturally diverse backgrounds.

Information- They can acquire and evaluate data, organize and maintain files, interpret and communicate, and use computers to process information.

Systems- They understand social, organizational, and technological systems; they can monitor and correct performance; and they can design or improve systems.

Technology- They can select equipment and maintain and troubleshoot equipment.

Source: *What Work Requires of Schools: A SCANS Report for America 2000.*[42]

The Role of Technology in Creating Knowledge-Based Schools

In classrooms that provide the "new tools" of knowledge work, teachers will have more options for creating learning experiences that reflect the challenges of knowledge work.

Creating a Knowledge Work Context

In knowledge-based schools, students work in contexts that resemble real world problems. Computer simulation tools help teachers create these contexts.

The benefits of simulation tools can be seen in a study of the NAEP results by the Educational Testing Service (1998). According to ETS, eighth graders whose teachers used computers mostly for 'simulations and applications' performed better than students whose teachers did not.[43]

Lewis Perelman also advocates the use of simulation tools. He cites research findings indicating that general concepts and knowledge learned in school do not transfer to everyday practice,[44] that life experience does not help in solving classroom problems,[45] and that knowledge gained in one school subject does not transfer to others.[46] Perelman says the answer lies in "bringing learning as close to the real context of practice as possible."[47]

Using simulation technologies and design software also creates instructional opportunities not otherwise available. Many problems in science, social studies, and the arts can be solved only through inquiry, experimentation, and performance—processes that often require too much time, space, and money to be feasible. However, technology makes these powerful ways of learning manageable.

Improving Communication and Collaboration

Collaboration—across the boundaries of disciplines, organizations, and nations—are becoming increasingly common in knowledge-based organizations.

Mary L. McNabb of the North Central Regional Educational Laboratory describes the potential for technology to create similar "collaborative communities" within the classroom. "With advances in telecommunications networks," says McNabb, "the 'classroom' may expand beyond the walls of the school building to cyberspace where telementoring relationships among learners and more knowledgeable others can develop and flourish."[48]

Such collaborative communities not only enrich the curriculum, they also improve students' communications skills.

Numerous studies have demonstrated the value of technology in improving student writing. According to a 1996 U.S. Department of Education report, students are more willing to edit their work when using word processors and more comfortable with critiquing and editing the work of others when it is exchanged over a computer network.[49]

Eight years of research on the effects of Maureen Scardamalia and Carl Bereiter's Computer Supported Intentional Learning Environment, a widely studied software application for sharing ideas in a collaborative setting, found that students who used the tool showed greater depth of understanding and reflection, as well as improved scores on standardized reading, language and vocabulary tests.[50]

Helping Students Learning How to Learn

In recent years, Jeffrey D. Rice, Associate to the Dean at the Ohio State University's Fisher College of Business, has seen a major shift in recruiting:

"Employers are no longer concentrating on one specific skill an employee brings to an organization," says Rice, "but rather that employee's ability to increase his or her knowledge and skills quickly in relation to advances in technology and market direction. Undoubtedly, adaptability and short learning curves are two of the knowledge economy's most critical literacies.[51]

Thomas G. Layton, originator of the nation's first distance learning high school, agrees. He reminds us that many of today's children will work in jobs that do not yet exist and even be required to unlearn some of what they are learning now.

When today's students enter the workforce, says Layton, they will need the ability to "gather knowledge, make use of it, let go of knowledge that is of little use, and then learn new and relevant things."[52]

A 1997 report to the President from the Panel on Educational Technology says that a shift to a "constructivist learning paradigm" has been tied to the nation's requirement for 21st century workers with "the capacity to readily acquire new knowledge, to solve new problems, and to employ creativity and critical thinking in the design of new approaches to existing problems." [53]

Thinking Skills for Workplace Success

According to the U.S. Department of Labor, the foundation for developing workplace competencies consists of basic skills, personal qualities, and thinking skills, including thinking creatively, making decisions, solving problems, visualizing, knowing how to learn, and reasoning.

- Creative thinking - generates new ideas
- Decision making - specifies goals and constraints, generates alternatives, considers risks, and evaluates and chooses best alternatives
- Problem solving - recognizes problems and devises and implements plan of action
- Visualizing - organizes and processes symbols
- Knowing how to learn - uses efficient learning techniques to acquire and apply new knowledge and skills
- Reasoning - discovers a rule or principle underlying the relationship between two or more objects and applies it when solving a problem

Source: *What Work Requires of Schools: A SCANS Report for America 2000.*[54]

The report says that technology can aid the shift to constructivist learning, which David Perkins of the Harvard Graduate School of Education has linked to "better retention, understanding, and active use of knowledge."[55]

One reason technology is so effective for active, independent learning is its ability to provide "cognitive scaffolds." In *How People Learn*, the National Research Council compares computers to training wheels on a bicycle.

"Computer scaffolding," says the NRC, "enables learners to do more advanced activities and to engage in more advanced thinking and problems solving than they could without such help."[56]

Few schools have gained extensive experience in using computer scaffolding, collaborative software environments, simulations, and other technology-enriched teaching and learning practices. Those that have, however, have demonstrated that technology can support improved student achievement.

In fact, authors of a study by RAND say that the challenging standards of the today's school reform agenda "may not be achievable without the use of technology" to support new practices. Examples of the practices outlined in the study include those that "tailor learning experiences more clearly to learner needs and abilities, provide students with access to resources and expertise outside the school, support more authentic assessment of a student's progress, and manage and guide the learning activities of the students."[57]

Much remains to be learned, and many other educational reforms need to occur before technology will make a real difference.

But in our new economy, lifelong learning is critical for career success, and technology is a vehicle for learning anytime, anywhere. To remain relevant, schools must be the best models for this revolution in learning.

3. The Transition to Global, Digital, Knowledge-Based Schools: The Next Step

Ohio has the technological capacity to create the types of teaching and learning environments that would help develop the global perspective, technological fluency, and adaptive, lifelong learning abilities needed in a new economy.

The time has come to begin taking full advantage of that capacity.

Because of the complexity and expense of creating the necessary physical infrastructure of network connections and computers, Ohio's investments and efforts during the "entry stage" of technology adoption had to be focused on the *tools* more than on the desired *educational improvements*.

Today, the tools are in place in most of Ohio's elementary schools. A large percentage of teachers have acquired the basic technical skills for using those tools. Many have adopted technology as a way to improve their success with traditional teaching methods, as well as to increase efficiency and motivate students.

It is time to shift our primary emphasis toward teaching and learning.

Ohio needs to accelerate its progress in creating the global, digital, knowledge-based schools that are needed to prepare all students for a new economy and a changing world.

We must provide equitable connectivity and access statewide and invest greater efforts and resources in teacher learning, technology productivity, and knowledge generation.

1. Provide equitable connectivity and access statewide.

Ohio's original plan for SchoolNet funding was to focus initially on placing technology in K-4 classrooms and in all classrooms in 25% of districts with the lowest wealth—then to add one grade per year.

SchoolNet funding has now been extended to fifth grade and many districts have used funding from local sources, federal grants, and business to provide at least basic equipment to their middle and high schools.

The ONEnet Ohio program is ensuring that we finish wiring and connecting our schools, and the Power Up for Technology program has begun providing needed electrical upgrades for nearly 30,000 Ohio schools.

Distance learning capabilities also are evolving—first through the Ohio SchoolNet Telecommunity, made possible by a $32 million commitment shared by nine major telephone companies and later through a new Interactive Video Distance Learning Pilot.

However, some gaps in connectivity and access remain. Many schools still have an insufficient number of computers. Many of our middle schools and high schools have outdated computers that are incapable of running multimedia applications or accessing the Web. We must do better. The shift to skilled jobs has already begun, and every student attending Ohio schools today will be competing in the global, digital, knowledge-based economy.

We must continue improving our ratio of students to multimedia computers—particularly in our middle schools and high schools.

2. Invest in knowledge generation

Educational technology will always be part of a total educational reform package. Because its effects are not easily isolated and measured, it is difficult for even a single school building to attribute either failures or successes to the use of technology. From a statewide perspective—which must take into account myriad variations in the methods and environments surrounding the use of technological tools—it is even more difficult to determine whether technology is making any difference.

However, Ohio has expanded its knowledge base considerably.

This year's Annual Educational Technology Assessment (AETA)—conducted at the teacher, building, and district levels—has provided a wealth of data for targeting state and local investments. The high return rate for the surveys—90 percent of teachers, x buildings, and 90 percent of districts—means high confidence that the results are representative.[58]

Based on AETA results, research questions are being formulated to ensure a more in-depth picture of educational technology and its uses in Ohio schools.

Such inquiry is essential for planning and decision-making. But we must also begin to broaden our research perspective beyond looking at proficiency test performance and develop additional measures for evaluating the effects of technology.

Studies of technology usage have found some improvements in basic skills and standardized test scores.[59] More documentation of such results is needed. However, technologically enriched learning environments are more suited to developing competencies that are not accurately measured by proficiency tests--competencies such as complex problem-solving, critical thinking, collaboration, and creativity.

We must support the development and use of accurate measures based on these competencies and encourage Ohio teachers to use these measures. Only then will we be able to assess the quality of the technologies we use.

We owe our students who have already mastered the skills measured by the proficiency tests the best opportunities for developing more advanced competencies. We owe our students who are having difficulty mastering basic skills the benefits of the best tools for differentiating instruction.

3. Support teacher learning

Based on the results of SchoolNet's Annual Educational Technology Assessment (AETA), most Ohio teachers are using technology in a limited fashion.

Applications used most often with students are those that can be easily adapted to traditional instruction, such as word processing, commercially developed curriculum software, and content-specific drill and practice software.

Most of the 90,000 plus Ohio teachers who responded to the survey reported that in their classrooms,Web search engines are used once a month or less often. Few are using multimedia applications and equipment. Most science classes are not using probeware and simulations, and most mathematics classes are not using spreadsheets. A number of software applications are seldom or never used by the majority of teachers, and the demand for training in these applications is low.

The most powerful way to encourage more extensive adoption of technology and greater innovation in how it is used is through effective professional development.

AETA data suggest that teachers are not devoting sufficient time to professional development activities. Only 23 percent of AETA respondents have participated in more than 15 hours of technology training since Fall 1998, and 38 percent have participated in less than five hours.

Although Ohio teachers have many avenues for training available, enrollment patterns for the four levels of training offered by SchoolNet suggest that many teachers may be pursuing only basic skills training.

According to the ACOT study, as teachers sharpen their technical skills, they should begin seeking increasingly individualized professional development opportunities that will enable them to tie the use of technology to standards and to employ principles of constructivist, cooperative, and multidisciplinary teaching and learning.[60] This often means developing their own followup activities after they attend training, as well as pursuing study groups, mentoring arrangements, and long-term research and design projects within their own classrooms.

As Ohio's Local Professional Development Advisory Committee points out, quality professional development approaches such as these require system support and strong leadership.[61]

In short, creating the global, digital, knowledge-based schools needed in the new economy, Ohio schools must provide teachers with the time and resources needed to engage in ongoing, job-embedded, project-based learning focused on the innovative use of technology in teaching and learning.

4. Improve Technology Productivity

Marketing research by the computer industry, conducted during the early 1990s, indicates that less than 3 percent of the population was willing to experiment, take risks, and learn independently when presented with the opportunity to use computers. Less than 15 percent was willing to try new things or go out of their way to learn computer skills. Most are slow to change and will do so only under competitive or social pressure or after others have survived the risks and are reaping the benefits.[62]

Although computers are no longer considered new, teaching with computer simulations, designing online courses, and other innovative classroom uses of computers are still relatively unknown territory.

Training will help teachers enter and master this new territory, but additional motivation is needed.

According to the ACOT study, a major turning point in a teacher's use of educational technology is when he or she begins to use technology effortlessly to accomplish real work. In a sense, when teacher reach this point, technology becomes "invisible."[63]

The technology is hardly invisible when a teacher has to set up equipment, learn the intricacies of several software applications, deal with compatibility issues, find ways to allocate computers, and deal with computer crashes and network outages at crucial points in a lesson. Too many of such experiences discourage frequent use of technology.

Investments that will remove some of the effort of technology use for teachers include training administrators and teacher leaders in creating organizations and cultures that support new teaching methods and increasing the number of computer specialists and support staff working in schools.

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