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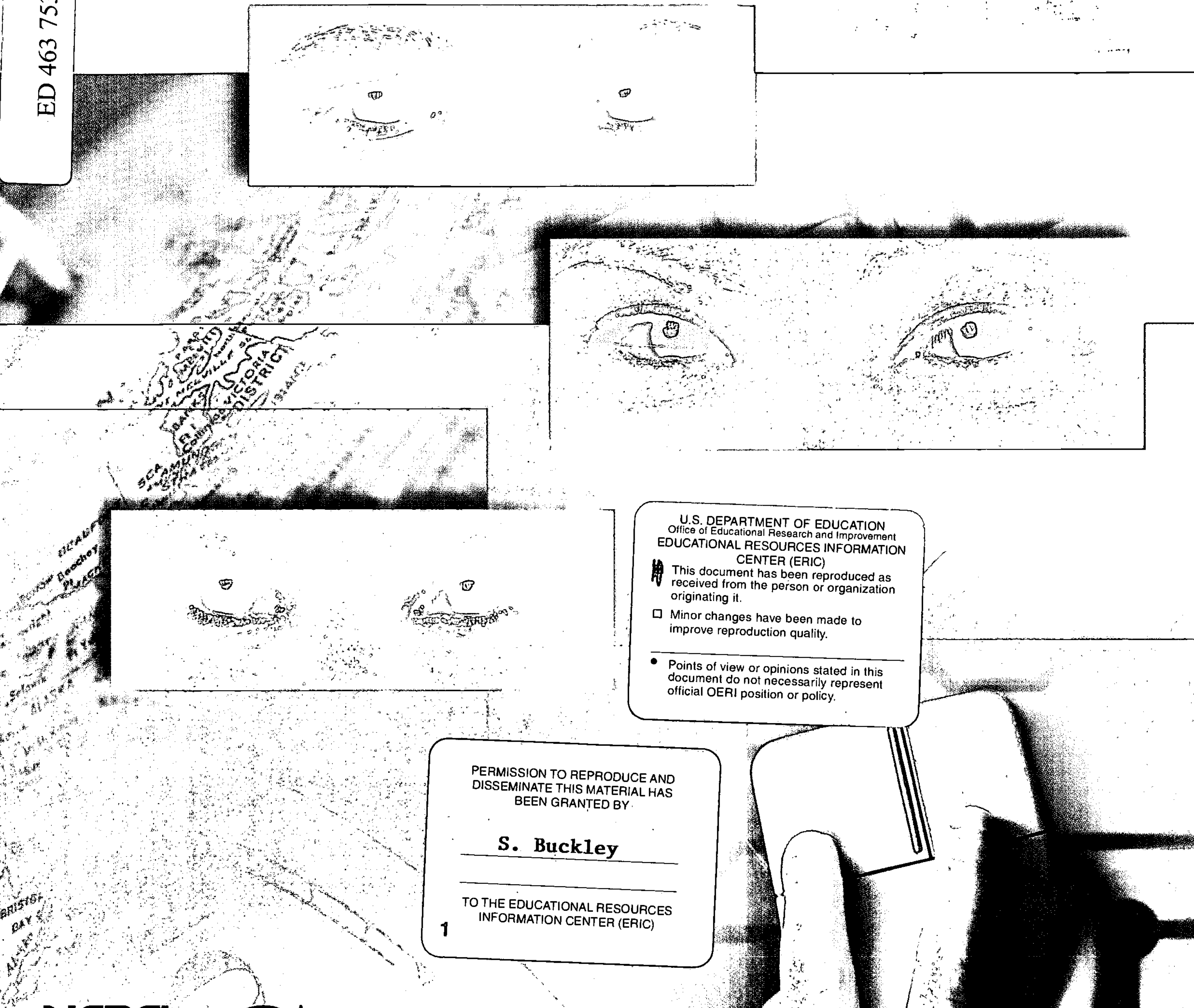
ABSTRACT

The North Central Regional Educational Laboratory's (NCREL) "enGauge" is a Web-based framework that describes six essential conditions, or system-wide factors critical to the effective use of technology for student learning. In addition to the framework, the "enGauge" Web site includes an online survey instrument that allows districts and schools to conduct online assessments of system-wide educational technology effectiveness. This publication describes a set of 21st century skills that will be increasingly important to students entering the work force. These skills are not at odds with traditional educational skills, but are, in fact, extensions of those skills, adapted to new technologies and new work environments. The educational system will be challenged to encourage the development of these 21st century skills in relevant and meaningful ways. The publication consists of five main sections, following an introduction. The first section, "Digital-Age Literacy," discusses basic, scientific and technological literacies; visual and information literacies; and cultural literacy and global awareness. The second section, "Inventive Thinking," focuses on adaptability/ability to manage complexity; curiosity, creativity, and risk-taking; and higher-order thinking and sound reasoning. Section three, "Effective Communication," deals with teaming, collaboration, and interpersonal skills; personal and social responsibility; and interactive communication. The fourth section, "High Productivity," discusses the ability to prioritize, plan, and manage for results; effective use of real-world tools; and relevant, high-quality products. Section five, "Information Technology," identifies possible social effects with regard to information technology. Two other sections provide a brief summary and references. (Contains 43 references.) (AEF)



NCREL's

enGauge

21st Century Skills

Digital Literacies for a Digital Age

About enGauge

NCREL's *enGauge* is a Web-based framework that describes six essential conditions, or system wide factors critical to the effective use of technology for student learning. In addition to the framework, the *enGauge* Web site includes an online survey instrument that allows districts and schools to conduct online assessments of system wide educational technology effectiveness.

For more information on *enGauge,* please visit the Web site:

http://www.ncrel.org/engauge/

enGauge was codeveloped by NCREL, NCRTEC, and the Metiri Group.

The 21st Century Skills portion of *enGauge* reprinted in this brochure was written for NCREL by Cheryl Lemke, Metiri Group.

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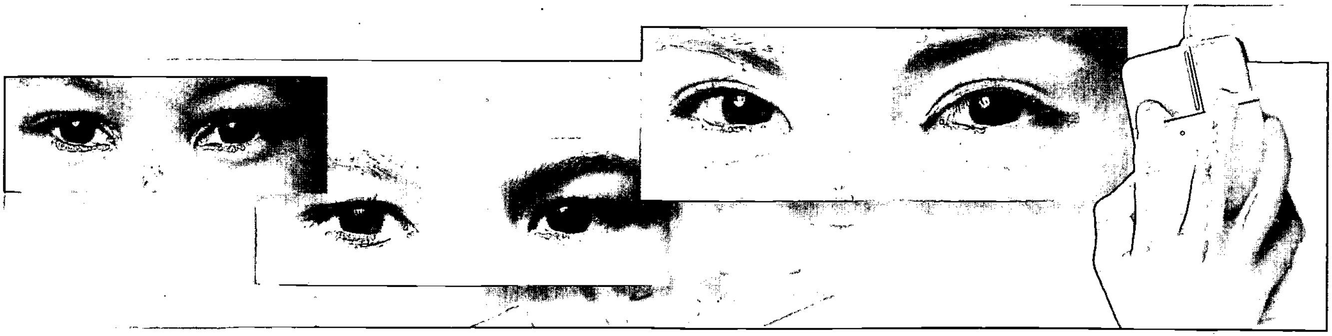
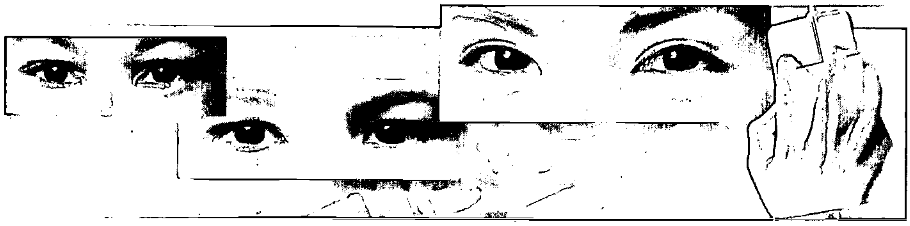
NCREL's **enGauge**
21st Century Skills

Digital Literacies for a Digital Age

Contents



Introduction



Executive Summary

We know that technologies change almost daily. We also know that, in order to succeed in this new "digital age," the nation's workforce must be fluent in the skills and languages of those ever-changing technologies. It follows, then, that education—and how technology is used in education—must change to keep up or, ideally, stay one step ahead.

This publication describes a set of "21st Century Skills" that will be increasingly important to students entering the workforce. These skills are not at odds with traditional educational skills, but are in fact extensions of those skills, adapted to new technologies and new work environments. The educational system will be challenged to encourage the development of these 21st century skills in relevant and meaningful ways.

Even as researchers begin to accumulate evidence of the effects of a particular technology on educational practice, technology itself is changing and, in some cases, becoming obsolete. NCREL's *enGauge* framework describes general, system wide factors that are thought to be critical to the effective use of technology in education regardless of the specific hardware, software, or communications infrastructures of the day. Ideally, effective system wide use of technology in education will assist students in acquiring traditional academic content knowledge that is powerfully leveraged by the 21st Century Skills outlined in this brochure

Growing Up Digital

"Students are natives to cyberspace, where the rest of us are immigrants."

—Douglas Ruskoff, Playing the Future, 1996

Today's children are "growing up digital." Their view of the world is quite different from that of adults. They are growing up with unprecedented access to information, people, and ideas across highly interactive media. In his book *Growing Up Digital*, Don Tapscott (1998) suggests that it is precisely this real-time, webbed interactivity that has spurred societal changes in ways prior technologies did not.

Since 1994, when the Internet rose from obscurity to popularity due to the World Wide Web, over 116 million Americans (44%) have logged on. Americans now use the Internet for business transactions, shopping, entertainment, information searches, communication, and, to some extent, learning. In January 2001, the Web-based Education Congressional Committee reported, "The World Wide Web is bringing rapid and radical change into our lives—from the wonderfully beneficial to the terrifying difficult" (Kerry & Isakson, 2001).

Digital-Age Economy

"The biggest unknown for the individual in a knowledge-based economy is how to have a career in a system where there are not careers. What used to be true only in declining industries–that skills suddenly become valueless–is now true everywhere."

—Lester Thurow, The Atlantic Monthly, June 1999

Technology and telecommunications have already caused significant shifts in the way the government and private sector conduct business. Technology has contributed almost one-half of the nation's long-term economic growth since World War II according to a 1999 report by the U.S. Department of Commerce. More than 19 million new jobs were created during the last decade–a rate of growth more than twice that of the previous decade. The U.S. Department of Labor (1999) reports, "High-technology industries account for one million of these new jobs. E-commerce generated $300 billion in revenues last year approaching the size of the automobile industry."

The 21st Century Workforce Commission (2000) predicted that by 2006, nearly one-half of all U.S. workers will be employed in industries that produce or intensively use information technology products and services. There will be a premium on American workers who are able to read and understand complex materials, think analytically, and use technology efficiently.

A Digital Divide

The U.S. Department of Commerce report *Falling Through the Net* (1999), released in October 2000, reports the following:

- U.S. households with Internet access soared to a record high of 41.5 percent in August 2000.
- More than 116.5 million Americans were online at some location as of August 2000.
- This rapid uptake of technology use is occurring among most groups of Americans regardless of income, education, race or ethnicity, location, age, or gender.

The report clearly states that Internet access is "no longer a luxury." If the digital divide were defined strictly in terms of Internet access and computer ownership, current statistics would indicate that digital inclusion would be a realizable goal. But that chasm is deeper than just access—it also represents differences in the capacity to use these tools efficiently, effectively, and innovatively. Access is only the first step toward equity. True equity will require high levels of technology proficiency to ensure broader, meaningful, innovative uses of technology by all segments of the population.

Technology and Learning

Technology itself is providing new insights into the working of the human mind. *How People Learn* (Bransford, 1999) is groundbreaking in its convergence of brain research, cognitive learning theory, and technology. The book discusses medical breakthroughs in computer imaging of the brain that allow scientists to understand more fully how people think and learn. The book lists five ways technology adds value to learning:

1. Real-world contexts for learning
2. Connections to outside experts
3. Visualization and analysis tools
4. Scaffolds for problem solving
5. Opportunities for feedback, reflection, and revision

Practitioners agree with those findings. The U.S. Department of Education's fall 2000 conference, "Technology in Schools: Measuring the Impact and Shaping the Future," was a working conference for classroom teachers, educational administrators, researchers, and policy leaders. The breadth and depth of the conference program contributed to the participants' conclusions, including the following:

- Breakthroughs in technology have advanced what is known about how children think and learn.
- Research shows that, under the right conditions, technology advances children's academic achievement.
- Technology's tremendous influence on society has changed what children need to know and be able to do to be successful today.
- Emerging technologies can and should be used to more accurately assess what and why children are or are not learning (U.S. Department of Education, 2001).

Technology not only changes *how* people learn, it affects *what* they need to learn as well. This sentiment is evident in the Secretary's Commission on Achieving Necessary Skills' (SCANS) recommendations for 2000. These recommendations build upon the principles set forth in the 1991 SCANS report *What Work Requires of Schools*. In their latest report, the commission links the economy, the schools, and the need for continued renewal of workers' skills in three recommendations:

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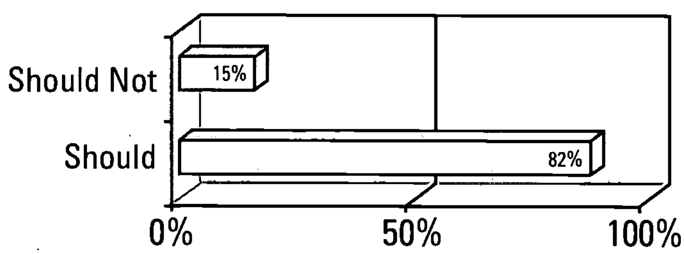
- The qualities of high-performance that today characterize our most competitive companies must become the standard for the vast majority of employers, public and private, large and small, local and global.
- The nation's schools must be transformed into high-performance organizations.
- All Americans should be entitled to multiple opportunities to learn the SCANS know-how well enough to earn a decent living.

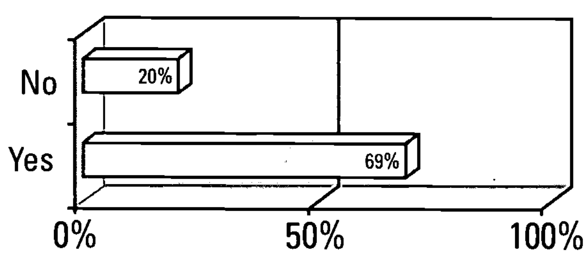
SCANS' primary message to schools is to "look beyond the schoolhouse to the roles students will play when they leave to become workers, parents, and citizens" (Secretary's Commission on Achieving the Necessary Skills, 2000).

The public recognizes that fact. A 2000 poll by Phi Delta Kappa and Gallup reports that 69 percent of the public believes that technology improves learning, with 82 percent recommending that more dollars should be spent on school technology.

32nd Annual PDK/Gallup Poll
Should Schools Invest More in Technology?



32nd Annual PDK/Gallup Poll
Has Technology Improved Instruction?

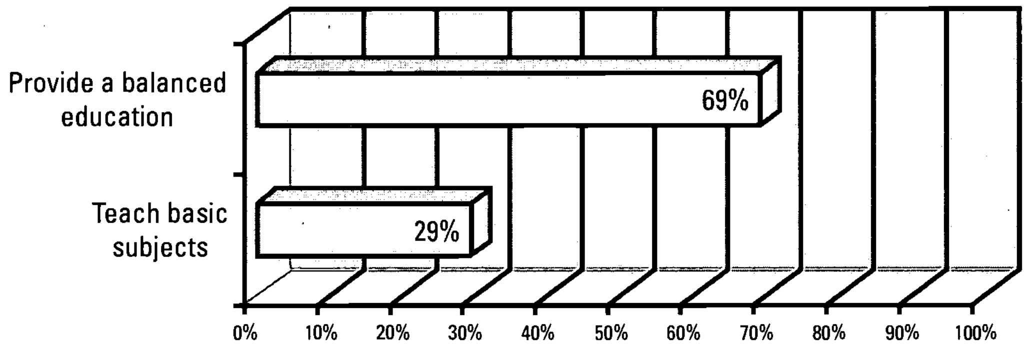


Source: Phi Delta Kappa/Gallup, (2000, September).
Policy implications of the 32nd annual Phi Delta Kappa/Gallup poll. Phi Delta Kappan, 82(9), 51-55.

Just as compelling was the survey's finding that the public expects students to receive a balanced education. "Policymakers should prepare for the negative public reaction...if school improvement efforts focus on the basics to the exclusion of other subjects" (Phi Delta Kappa/Gallup, 2000).

32nd Annual PDK/Gallup Poll

Primary Purpose of the Public Schools



Skills for the 21st Century

The driving force for the 21st century is the intellectual capital of citizens. Political, social, and economic advances in the United States during this millennium will be possible only if the intellectual potential of American youth is developed now. It should be no surprise that what students learn—as well as how they learn it and how often they must refresh these skills sets—is changing.

The urgency to build the capacity of American workers to meet the needs of the 21st century is readily apparent in the number of high-profile groups publishing reports as "calls for action." For example, in January 2001 the National Skill Standards Board (NSSB) approved and published for public commentary the *Manufacturing Skills Standards Council Skill Standards: A Blueprint for Workforce Excellence.*

The *enGauge* list of 21st-century skills presented in this publication is intended to provide the public, business, industry, and education with a common understanding of and language for discussing the skills needed by students and workers in this emerging Digital Age. The *enGauge* project is based on the premise that preK-12 schools should incorporate 21st-century skills and proficiencies into school curricula within the context of academic standards.

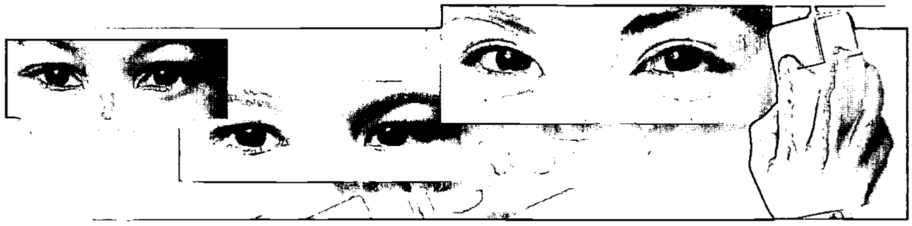
Methodology

The *enGauge* 21st-century skills are based on literature reviews, analysis of nationally recognized skill sets, input from educators, data from educator surveys, and reactions from constituent groups. Eight nationally recognized skill sets were analyzed to inform the identification of the enGauge 21st-century skills:

- *National Education Technology Standards,* 1998, International Society for Technology in Education.
- *What Work Requires of School,* 1991, Secretary's Commission on Achieving Necessary Skills, U.S. Department of Labor.
- *Standards for Technological Literacy,* Content for the Study of Technology, 2000, International Technology Education Association, www.iteawww.org.
- *FIT: Being Fluent With Information Technology,* 1999, Committee on Information Technology Literacy, National Research Council.
- *Information Literacy Standards for Student Learning,* 1998, American Association of School Librarians (AASL), Association of Educational Communications Technology (AECT), and American Library Media Association (ALA).
- *A Nation of Opportunity: Building America's 21st Century Workforce,* 2000, 21st Century Workforce Commission, U.S. Congress.
- *Growing Up Digital: The Rise of the Net Generation,* 1998, Don Tapscott.
- *Preparing Students for the 21st Century,* 1996, American Association of School Administrators.

In addition, data was gathered from educators at state-level conference sessions in ten states, educator surveys, and focus groups in Chicago and Washington, D.C. Initial drafts of the *enGauge* 21st-century skills were then reviewed by experts in the field prior to publication.

Digital-Age Literacy



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Basic, Scientific, and Technological Literacies

The term "literacy" originally focused on the ability to read and write. In recent years, the term has also been used to describe competence in a field of knowledge. Due to the breadth of concepts addressed in current literature on literacy, the plural term "literacies" is used here.

The definitions of the literacies in this Digital Age are highly politicized given the power shifts due to technology's influence on the economy and society (Kaplan, 1995). Just as a digital divide exists based on access to technology and connectivity, so will a digital divide develop based on levels of basic, technological, cultural, scientific, mathematical, visual, and information literacies. As in the past, one key to closing these divides will be found in the transformation of public education into a high-technology, high-performance learning organization—one that provides avenues to high literacy achievement for all students.

As society changes, the skills that citizens need to negotiate the complexities of life also change. In the early 1900s, a person who had acquired simple reading, writing, and calculating skills was considered literate. Only in recent years has the public education system expected all students to learn to read critically, write persuasively, think and reason logically, and solve complex problems in mathematics and science (Bransford, 1999).

Basic Literacy: Language proficiency (reading, writing, listening, and speaking) using conventional and technology-based media (Education Development Center, 2001).

Functional or basic literacy—the ability to read, write, listen, and speak—has become more important than ever in this Digital Age. The definition of basic literacy has dramatically shifted with the times (Lindamood, n.d.). Whereas in the early 1900s it was defined as the ability to write one's name, later it was expanded to mean the decoding of text, and in the 1930s to include reading and expressing oneself through writing.

In today's age of hypertext, images and icons, charts and graphs, and statistical data, basic literacy includes the ability to read and understand complex documents that include images and information in an expanding array of technologies (Rafferty, 1990). While reading, writing, listening, and speaking is paramount, today's student must be able to decipher meaning and express ideas through a range of media.

Scientific Literacy: Knowledge of science, scientific thinking, mathematics, and the relationships between science, mathematics, and technology (Nelson, 1999).

The *New York Times* (2001, January 18) recently reported an astounding scientific breakthrough. Scientists developed a method to capture light and then release it at will. Technological advances such as this are occurring at ever increasing rates. In the past decade alone, scientists have mapped the genome, discovered how to clone animals, and sent probes past the outer edges of the solar system. The body of scientific knowledge is continually expanding as scientific breakthroughs occur and scientific hypothesis and theories are developed and tested.

The *Third International Mathematics and Science Study* (TIMSS) reports that between fourth grade and eighth grade, the scientific and mathematical accomplishments of American students fall from near the top to around the middle compared to more than 40 other countries (Boston College, Lynch School of Education, & International Association for the Evaluation of Educational Achievement, 1995).

Several national groups (e.g., the National Research Council, American Association for the Advancement of Science, and National Council of Teachers of Mathematics) have recently revolutionized thinking about science and mathematics education by setting standards that emphasize scientific inquiry, scientific process, problem-based learning, and the integration of science and mathematics (Linn et al., 2000). This area also includes numeracy, or quantitative literacy, and the use of mathematics to investigate, explore, estimate, systematize, and visualize phenomena across the curriculum.

It is important for today's students to learn to do science and mathematics as field and research scientists do—with the advantages of modern technologies. Students need to leave school literate in the language and functionality of the sciences and mathematics of the Digital Age.

Technological Literacy: Competence in the use of computers, networks, and applications.

Technology has become pervasive in American society. While mainframe technologies were introduced over 50 years ago, it has been less than 20 years since personal computers were designed, and less than seven since the World Wide Web and widespread public use of the Internet began. The accelerating rate at which technology is evolving makes it difficult to stay current.

Standards and guidelines have been developed for K-12 students' technological literacy. The International Society for Technology in Education (ISTE) includes a "Basic Operations and Concepts" section that clearly states that students must be proficient in the use of technology (ISTE, 1998). The Secretary's Commission on Achieving Necessary Skills published a report in 1991 that listed five competencies for K-12 students, one of which was to "work with a variety of technologies." More recently, the American Association of School Administrators included "skill in the use of computers and other technologies" as an essential skill for students in the 21st century (Uchida, Cetron, & McKenzie, 1996).

In the present marketplace, technological literacy is an essential component of job readiness. It is important that students become competent in the use of technology and associated applications. More importantly, they must be able to apply their skills to practical situations. Thus, students should learn technological skills in the context of learning and solving problems related to academic content and academic standards.

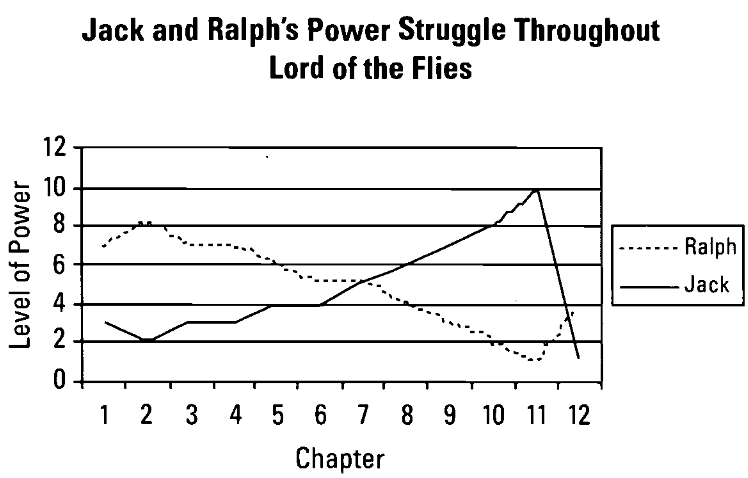
Technological literacy is a dynamic skill that involves continual effort. Students must be able to build on what they already know as they learn new languages, adapt to new systems, and weigh the benefits and applications of technological development. Technological literacy necessarily changes over time as technologies emerge and become readily available to citizens.

Visual and Information Literacies

Visual Literacy: The ability to decipher, interpret, and express ideas using images, graphics, icons, charts, graphs, and video.

The graphic user interface of the World Wide Web and the convergence of voice, video, and data into a common digital format have increased the use of visual imagery dramatically. Through advances such as digital cameras, graphics packages, streaming video, and common standards for imagery, visual imagery is increasingly used to communicate ideas. Experts in many fields are using visualization tools to represent data in ways never before possible. From three-dimensional representations of data to geographical information systems to representation icons, a picture is truly worth a thousand words. Students need good visualization skills to be able to decipher, interpret, detect patterns, and communicate using imagery.

Computer-based visualization and analysis tools have fundamentally changed the nature of inquiry in mathematics and science. Scientists use these powerful modeling tools to detect patterns and understand data using colors, time-sequenced series, three-dimensional rotations in real-time, and graphical representation of complex correlations. Such visualizations are equally as effective in language arts, the social sciences, the arts, and physical education. For example, Senge (2000) describes students in a K-12 classroom that graphed the power struggle of two characters (Jack and Ralph) throughout the *Lord of the Flies* (see below). Such graphs represent the students' understanding and interpretation of evidence and events in the book.



Excerpt from students' work with supporting evidence for the above chart:

Chapter 1: On the boys' first day on the island, Ralph is appointed chief. He gets this power due to his attractive physical appearance and the fact that he is in possession of the conch. Jack is given lead of his choir/hunters and has incredible confidence in himself.

Chapter 3: Ralph is still recognized as chief by Jack, but the hunters begin to rebel against Ralph's idea of a signal fire. He argues that hunting for meat is more important.

Source: Senge, P. (2000) Schools that learn.
New York: Doubleday/Dell Publishing Group, Inc.

A primary cause of underachievement in mathematics is an inability to visualize and verbalize the underlying concepts. Supporting the perception that mathematics is calculation, individuals memorize facts instead of thinking inventively, reasoning creatively, and solving problems by manipulating numbers and data sets (Lindamood, n.d.).

Visualization tools enable students to build interactive models to test theories in real time, using graphics to display results. This method helps many students make sense out of complex subjects by exploring the relationships between component parts and visually representing the interplay of ideas. The software packages *Inspiration, STELLA,* and *SemNet* are three excellent examples of such tools.

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Information Literacy: The competence to find, evaluate, and make use of information appropriately.

In their 1998 publication *Information Literacy Standards for Student Learning,* the American Association of School Librarians and the Association for Educational Communications and Technology called information literacy "a keystone of lifelong learning." The publication also lists 12 key standards under the umbrella areas of information literacy, independent learning, and social responsibility. Information literacy includes accessing information efficiently and effectively, evaluating information critically and competently, and using information accurately and creatively.

Accessing information has become increasingly important as databases previously only accessible to library media specialists are now available to students directly. Browsing, searching, and navigating online have become essential skills for all students, as has recognition of the limitations of digital archives (some things remain unavailable electronically). Familiarity with natural inquiry, Boolean search strategies, and the organizational systems (cataloging, abstracting, indexing, rating) is also extremely important.

The digitizing of documents, imagery, video, and audio raises new issues of analysis and evaluation. Critical analysis of documents to determine purpose, bias, accuracy, and quality is more important than ever. Credibility of sources is also a critical issue given the ease with which computers can be used to edit or fabricate what have traditionally been viewed as factual records—both print documents as well as images. Ultimately, students need to understand the interrelationships between the library collections, proprietary databases, and other Internet documents to ensure appropriate, effective searching and accurate evaluation of sources.

Cultural Literacy and Global Awareness

Cultural Literacy: A recognition and appreciation of the diversity of peoples and cultures.

The globalization of commerce and trade has increased the need for cultural literacy. The Digital Age brings with it a connectedness across a globe that is rapidly becoming wired. The economy now has a global base, with the U.S. concerned about interactions, partnerships, and competition from around the world. With this globalization comes the necessity of knowing, understanding, and appreciating other cultures—including diverse ethnic and organizational cultures (Trilling & Hood, 1999).

The American Association of School Administrators (2000) reminds us, "Properly managed, diversity can enrich. Not properly managed, it can divide.

The key is education.... The world has become more interrelated as satellites, cyberspace, and jet travel bring people and nations closer together. Communication transcends political boundaries."

From another perspective, cultural literacy addresses the cultural formations established as norms in a technological society. Today, these cultural formations include virtual realities (e.g., MUDs and MOOs), World Wide Web browser environments, real-time chat rooms, e-mail lists, interactive television, and proprietary services such as Prodigy, America Online, and virtual schools. Students must be familiar with these environments if they are to thrive in a digital society (Kaplan, 1995). Yet, many of such cultures have yet to establish norms and protocols. The Children's Internet Protection Act (CIPA), which requires filtering on Internet connections by those schools and libraries receiving federal funds, represents one attempt to establish protocols.

Global Awareness: The understanding and recognition of the interrelationships among nation states, multinational corporations, and peoples across the globe.

"The Internet is a powerful new means of communication. It is global, it is fast, and it is growing rapidly. Reaching into the far corners of the earth, the Internet is making the world at once smaller and more connected, transmitting information at nearly real-time speed."

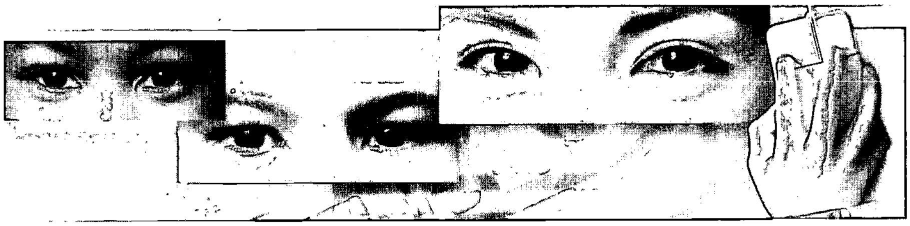
—Senator Bob Kerrey and Representative Johnny Isakson, Web-Based Education Congressional Commission, January 2001

Advances in technology have created entirely new growth industries, such as e-commerce, and enabled truly globally integrated firms. Lester Thurow (2000) observes, "We are experiencing what I think historians of the future will call the Third Industrial Revolution, a transition to a knowledge-based economy. We are witnessing big changes, a leapfrogging and interaction between technologies in six related areas: telecommunications, microelectronics, computers, new materials, robotics, and biotechnology. These factors taken collectively are in fact driving the global economy."

As e-commerce, e-communication, and advances in transportation bring the people of the world closer together, it is increasingly important for students to understand and appreciate diversity and other cultures. Jane Jacobs, author of *The Death and Life of Great American Cities,* observes, "The more variety, the more diversity, the more growing and living things in an ecosystem, the more resilient it is to misfortune" (cited in Harris, 1996).

Every student should have the opportunity to interact with people from other cultures. Whether across town or across the globe, the learning that takes place from both formal and informal dialogs serves as a bridge to openness and appreciation of diversity and other cultures.

Inventive Thinking



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"To be prepared for a future characterized by change, students must learn to think rationally and creatively, solve problems, manage and retrieve information, and communicate effectively. By mastering information problem-solving skills, students will be ready for an information-based society and a technological workplace."

—American Association of School Librarians, 2000, *Information Literacy: A Position Paper*

The Committee on Information Technology of the National Research Council (1999) defined intellectual capabilities as "one's ability to apply information technology in complex and sustained situations and to understand the consequences of doing so." These capabilities are "life skills" formulated in the context of Digital-Age technologies.

Adaptability/Ability to Manage Complexity

The interconnectedness of today's world brings with it unprecedented complexity. Globalization and the World Wide Web are inherently complex, accelerating the pace of change in today's world. Interaction in such an environment requires individuals to be able to plan, design, and manage in new ways—taking into account contingencies, anticipating changes, and understanding interdependencies within systems. In doing so, resource management (time, space, materials) is increasingly required to execute a plan successfully. Any such approach will often result in components of a system interacting in complex, unexpected ways. As projects are executed, it is also important to trace those interdependencies among information systems to look for, understand, and monitor cause and effect (Committee on Information Technology Literacy, 1999). As the variety of solutions become apparent, the tradeoffs, advantages, and disadvantages must be examined to determine the most appropriate solution. While the complexity of issues in today's global economy is self-evident, how this complexity is to be managed is not as obvious.

Curiosity, Creativity, and Risk-taking

Curiosity: Employing the "desire to know" as fuel for lifelong learning.

During the Industrial Age, students and workers were expected to follow explicit orders and procedures. Today, knowledgeable workers are expected to adjust and adapt to changing environments. Thus, they must maintain their curiosity and drive to stay current and informed. Inherent in lifelong learning is a curiosity about the world and how it works and a desire to learn continually.

At the same time that business and industry are redefining the type of worker they need, the science of learning is beginning to unlock the secrets of how people learn. Researchers now understand how the thinking of the expert differs from that of the novice, enabling educators to develop learning strategies that teach students to become expert learners. In fact, the very structure of the brain can be changed through intellectual pursuits. John Bransford (1999) explains, "There is a corresponding relationship between the amount of experience in a complex environment and the amount of structural change in the brain—in other words, learning organizes and reorganizes the brain." Curiosity fuels lifelong learning as it contributes to the quality of life and to the intellectual capital of the country.

Creativity: Using the imagination to develop new and original things.

Many of today's highly successful businesses succeed because they have a "digital nervous system" (Gates, 2000). All levels of the organization understand the company's mission and are wired into the information flow of the organization, enabling them to make sound decisions, creatively solve problems, and invent solutions with economic value.

Intellectual capital is an increasingly important national resource. The call from high-technology employers for a workforce that can think, learn, and create, together with the new science of learning based on brain research, suggests that students need to develop the self-confidence and motivation to engage independently in learning, exploring, and creatively thinking as a daily activity. This call was reflected in the list of skills and proficiencies released in the 1991 SCANS report and is even more important today.

Risk Taking: The willingness to place something valued in a position or situation where it could be exposed to damage or loss.

The very nature of learning requires risk taking. A small child would never learn to walk, talk, or socially interact without taking risks, experiencing successes and failures, and then monitoring and adjusting accordingly. Quantum leaps in learning, solving problems, inventing new products, and discovering new phenomenon require risk taking. In schools, risk taking includes a willingness to think deeply about a subject or problem and share that thinking with others to hear their perspectives, listen to their critiques, and then build on those experiences. Without risk taking there can be few quantum leaps in discoveries, inventions, and learning. In order to take risks that lead to intellectual growth, students must be in environments that they perceive to be safe places in which to share ideas, reflect on and discuss perspectives, and learn new things. Schools have an obligation to ensure that all students are placed in such environments.

Higher-Order Thinking and Sound Reasoning

Higher-Order Thinking: The process of creative problem solving that leads to sound, informed, thoughtful opinions, judgments, and conclusions.

For decades, researchers have been calling for higher-order thinking and sound reasoning in K-12 curricula. The 1991 SCANS report included thinking skills in the foundation competencies necessary for solid job performance. In this report, the authors define thinking skills as "thinking creatively, making decisions, solving problems, seeing things in the mind's eye, knowing how to learn, and reasoning." The International Society for Technology in Education in their 1998 release of the National Education Technology Standards (NETS) for students included critical thinking, informed decision making, and real-world problem solving through technology. The Committee on Information Technology Literacy (1999) included "intellectual capabilities" as being critical to technological fluency, citing "engagement in sustained reasoning" and "expecting the unexpected" as two of the eight key elements. All of these are critical aspects of higher-order thinking and sound reasoning.

Sound Reasoning: The capacity to think logically in order to find results or draw conclusions.

Sound reasoning begins with the careful definition and clarification of a problem. It then becomes an iterative process of learning more about the subject, refining, and then solving the problem. This process requires the ability to find, sort through, and evaluate information; check sources; maintain balance; cull extraneous materials; validate information sources; and resolve conflicting accounts of situations. Technological literacy is required to use electronic resources to accomplish this searching, sorting, culling, and organizing. The use of word processors, Web search engines, visualization and modeling tools, simulations, computer design tools, and other technologies might be used in this process to make sense of the information. Sound reasoning enables students to plan, design, execute, and evaluate a solution (Committee on Information Technology Literacy, 1999).

Effective Communication

3

Social and Personal Skills

Teaming, Collaboration, and Interpersonal Skills

Teaming: The ability to cooperate as a member of a highly successful group.

As telecommunications bring instantaneous, real-time communication to mainstream society, time has become a commodity. This reality has transformed the management of companies, taking real-time, high-stakes decision making out of the hands of executives and placing it in the hands of the people on the front lines. At the same time, the plethora of information has required specialization. The result is a high need for the teaming of specialists to accomplish complex tasks in ways that are efficient, effective, and timely.

According to both researchers and the business community, teaming and collaboration are essential to success in today's knowledge-based society. For example, the 1991 SCANS report lists the following skills in this area: participating in a team, teaching others new skills, serving clients/customers, exercising leadership, negotiating and working with diverse groups of people.

Collaboration and Interpersonal Skills: The ability to interact smoothly with others and to work together with one or more people to achieve a goal.

A survey of American workers reports that more than one-half of all workers lack the motivation to keep learning and improving on the job. Four in ten are not able to work cooperatively with their fellow workers, and fewer than 25 percent of workers in entry-level jobs have self-discipline in their work habits (Goleman, 1998).

In today's world of work, project responsibilities are often divided among a number of groups and individuals. Successful collaboration is dependent on the individual's and group's ability to devise a strategy to divide a task into pieces based on the strengths of the individuals, yet ensure that each has a clear sense of the entire project in order to understand the expectations for the component pieces.

Information technology can play a key role in the ease with which individuals and groups collaborate. E-mail, faxes, voice mail, audio- and videoconferencing, chat rooms, shared documents, and virtual workspaces can provide more timely, iterative collaborations. While collaborations of this nature allow rapid progress of work on shared documents and projects, they also require a greater attention to detail than is necessary in face-to-face interactions.

Personal and Social Responsibility

Personal Responsibility: Individual accountability for ethical, legal actions related to the use of technology and technology-related products.

In a technological age, emerging technologies often present ethical dilemmas. The International Society for Technology in Education (1998) defines these standards as the understanding of the ethical and societal issues related to technology, and the responsible use of technology systems, information, and software. The Academy of Sciences also addresses "the technical basis for social concerns about privacy, intellectual property, ownership, security, weak/strong encryption, inferences about personal characteristics based on electronic behavior such as monitoring Web sites visited, 'netiquette,' 'spamming,' and free speech in the Internet world" (cited in Committee on Information Technology Literacy, 1999).

Dr. Ed Wenk, a professor at the University of Washington and former Science Advisor to the White House, often said to his students, "Just because we can do something (as a result of technology), doesn't mean we should." Professor Wenk (1985) conducted classes on the "social management of technology" in the schools of public affairs and civil engineering for exactly that reason. The Association of School Administrators agrees that technology can drive values and, for that reason, ethics and values must be developed to guide the application of science and technology in society (Uchida, Cetron, & McKenzie, 1996).

Social Responsibility: Individual and collective responsibility for managing the use of technology for the public good.

As information and communication technologies become more pervasive in society, citizens will need to manage the impact on their social, personal, professional, and civic lives. Y2K reminded all citizens of the fragility of the information technology system, and how dependent we have become on computers. Informed choices come from knowledgeable, insightful reflection on practices, policies, and public law.

One example is the Children's Internet Protection Act (CIPA), passed by Congress in 2000. In the interest of children's safety, the act requires all schools and libraries using federal funds for connectivity to use filters to block objectionable materials. While the basic premise of the need for Internet safety is generally agreed upon, this method of achieving it is extremely controversial. As a result, the judicial branch of the government will likely be called upon to decide how this regulation is enacted. CIPA exemplifies the need for citizens who live in a world of technological change to understand the fundamentals of technology in order to make informed decisions.

The American Association of School Librarians and Association for Educational Communications and Technology (1998) list three standards in the category of social responsibility. Students must be able to:

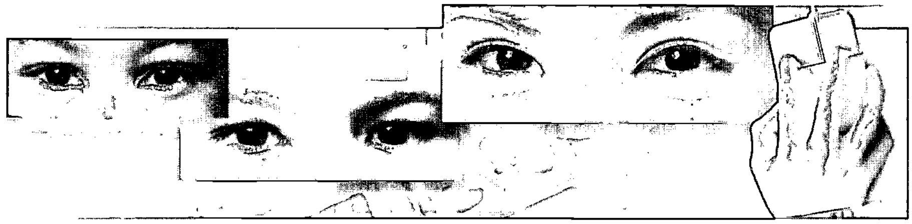
- Recognize the importance of information in a democratic society.
- Practice ethical behavior with regard to information and information technology.
- Participate effectively in groups to pursue and generate information.

Interactive Communication

Interactive communication is the ability to convey, exchange, transmit, access, and understand information. In today's wired, networked society it is imperative that students understand how to communicate using technology. These skills should include asynchronous and synchronous communication such as person-to-person e-mail interactions, e-mail lists, group interactions in virtual learning spaces, chat rooms, interactive videoconferencing, phone/audio interactions, and interactions through simulations and models. Such interactions require knowledge of etiquette often unique to that particular environment.

While information technologies do not change what is required for high-quality interactive communications, they do add new dimensions that need to be mastered so they become transparent. Otherwise they may interfere with rather than enhance the communication. Aspects of global communication include scheduling over time zones, cultural diversity, and language issues. Electronic communications also provide opportunities for enhanced communication through media (graphics, images, video, visuals, sound), provided the participant has mastered the effective use of such tools.

High Productivity



4

Quality, State-of-the-Art Results

Hank Levin (1999) observes, "When it is argued that the prime reason for high standards and high-stakes testing is to create a productive workforce for the economy, we should be cautious." His studies in the 1990s led him to conclude that how well students do on current tests in no way correlates to how productive they will be in the workforce. This fourth category, high productivity, is currently not a high-stakes focus of schools, yet it often determines whether a person succeeds or fails in the workforce.

Ability to Prioritize, Plan, and Manage for Results

The level of complexity often present in today's society requires workers—and students—to carefully plan and manage their work, and to anticipate contingencies. In addition, it requires concentration on the main goals of a project—an ability to keep an eye on the outcomes so as to guide and align all facets of the project toward that goal.

The 1991 SCANS report supports this concept by including "systems" as one of its five competencies. In that report, "systems" are defined as the understanding of complex, interrelationships and the ability to monitor and correct performance. The 1991 SCANS report also includes a fifth competency—technology—that emphasizes the application of technology to tasks and problem-solving activities to ensure results. In the "personal qualities" section of the foundation, SCANS lists self-management as a desired and necessary trait.

Effective Use of Real-World Tools

This skill set includes choosing appropriate tools for the task and applying them to real-world situations in ways that add significant value. Bill Gates (1999) describes this in his twelfth rule for business at the speed of thought, which is to "use digital tools to help customers solve problems for themselves."

In their Technology Productivity Tools, the International Society for Technology in Education (1998) suggests multiple reasons for students to use contemporary technology tools: collaboration, promotion of creativity, construction of models, preparation of publications, and other creative works. Doug Henton (2000) describes three types of knowledge important to today's economy: know-what, know-how, and know-who. He suggests that while everyone now has access to the know-what, "what really matters most in the new economy is know-how and know-who."

Relevant, High-Quality Products

Under the heading "technology problem-solving and decision making tools," the International Society for Technology in Education (1998) includes the use of technology for making informed decisions and problem solving in the real world. The Committee on Information Technology Literacy (1999) identified a tripartite approach to being fluent with technology. They insist that a combination of capabilities, concepts, and skills are critical—for without the practical aspect of the latter, the first two would remain conceptual, without taking shape to influence the real world.

Researchers are finding learning benefits for students who build authentic products with tools—whether they be sand castles, computer programs, documents, graphs, building block constructions, or musical compositions. Such experiences provide students with deep insights into whatever domain of knowledge they pursue and whatever tools they use.

Information Technology

5

Adapted from: Committee on Information Technology Literacy, National Research Council. (1999). *Being fluent with information technology.* Washington, DC: National Academy Press. Available online: http://stills.nap.edu/html/beingfluent

Possible Social Effects

- **Freedom.** Information technology enables individuals to express themselves freely, unfettered by intermediaries. For a modest investment in a computer and the nominal cost of a connection to an Internet service provider, anyone can post anything on a personal home page or say anything in a chat room, and the potential audience for such postings is quite large. Such convenient, inexpensive, and sustained opportunities for free speech are unprecedented, as are the dark sides of easy expression (e.g., the ease of disseminating misinformation or disinformation, hate speech, child pornography, and so on).
- **World Connectivity.** Information technology is cheap, fast, "point to point," and asynchronous, giving e-mail a convenience and immediacy that postal and telephonic communications have never had, and a personalization that broadcast media cannot provide. With the World Wide Web, access to local information is possible at unprecedented speeds—one can read the Sydney Morning Herald in Sydney, Nova Scotia, at the same moment that Australians are reading it. The ease with which information technology allows citizens of the world to keep in touch with people and events elsewhere unifies the world profoundly. And this effect will increase as information technology becomes adopted more completely around the world.
- **Loss of Remoteness.** A corollary to the world-connecting property of information technology is that information resources are now much more accessible to individuals worldwide. Although the entire holdings of the New York Public Library will not soon be completely online, the information access advantages of those living in geographically remote areas with access to the World Wide Web compare favorably to those living in the Big Apple. The information needed by many people, though perhaps not scholars, is largely available electronically. Telecommuting is another manifestation of information technology's location independence.
- **Alienation.** There is recent, preliminary evidence that even a modest amount of time (one or a few hours per day) spent on the Internet can lead some users to feelings of depression and alienation. An apparent source of some alienation is that "friendships" formed via chat rooms can be more superficial than those formed through face-to-face interaction. In addition, the time spent in front of a screen reduces normal interpersonal contact. This topic requires

further study, and if the findings of the Carnegie Mellon University study are confirmed, they would suggest the need for attention to the mental health consequences of changes associated with the use of information technology.

- **Predominance of English.** Information technology is largely an English-oriented medium, because its development has followed the English-centric tradition of post-World War II science, and, perhaps more importantly, because the United States has played a dominant role in the deployment of information technology. While information in almost every written language can be found on the World Wide Web, a surfer must have at least a passable understanding of English to reap the greatest advantage of information technology globally. The implications for other natural languages are unclear, but it is likely that many world residents will want to be bilingual in the near future.

Summary

6

"The current and future health of America's 21st Century Economy depends directly on how broadly and deeply Americans reach a new level of literacy—'21st Century Literacy'—that includes strong academic skills, thinking, reasoning, teamwork skills, and proficiency in using technology."

—National Alliance of Business, 2000, *Building America's 21st Century Workforce*

A close look at business and industry over the last decade suggests the U.S. is well into a transitional period where the skills described in this document are critical to workers. One has only to look at the dramatic changes in the stock market, and trends such as disintermediation (Peters, 1997), which link customers directly to production. Other industry trends include universal access to data and the intelligent use of that data to quickly produce results that are customized to meet clients' needs.

The challenge to schools is in looking beyond economic forces to ensure that youngsters are not only ready to enter a Digital-Age workforce, but are also ready to be informed, responsible citizens, community members, and family members in this Digital Age.

An extensive review of the literature about 21st-century skills suggests that educational decision makers must acknowledge that the academics of yesterday are not sufficient for today. To adequately prepare for the future, students must learn content within the context of 21st-century skills.

The definition of the *enGauge* 21st-century skills presented here is an important step toward that end. The translation of these skills in Digital-Age places of learning, and, most importantly, the appropriate assessment of these skills through multiple measures will ultimately determine whether today's children will be prepared to live, learn, work, and serve the public good in a digital, global society.

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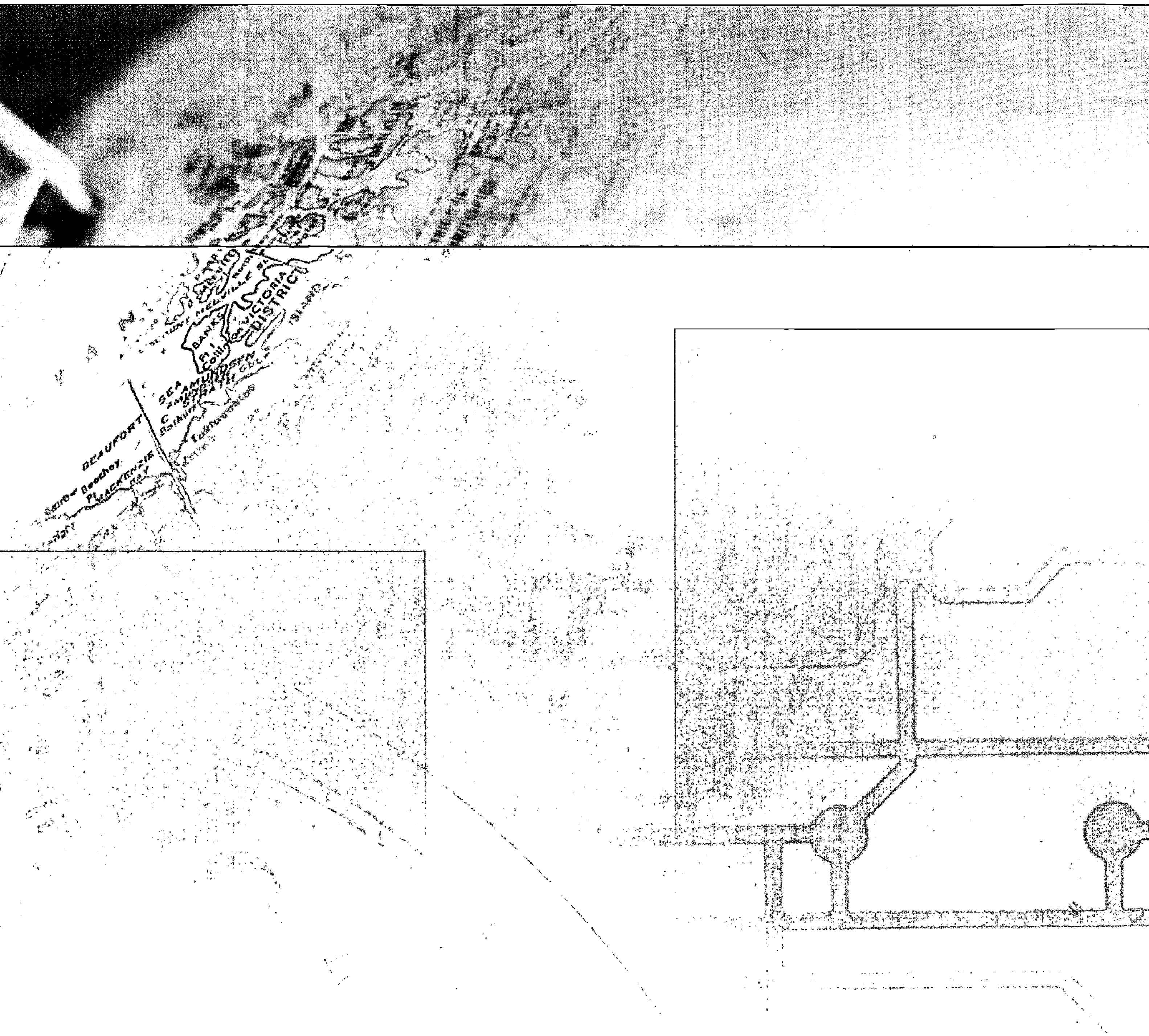

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