I N S I G H T

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The 2005 edition of *InSight* marks the end of this publication, which, since 2000, has explored both vision and leadership in the use of new and emerging technologies in education. In its five-year history, *InSight* has presented many intriguing articles that have illuminated the potential value of new technologies as well as exemplified their current, practical classroom applications. This final edition focuses on two global issues that encompass most, if not all, of the topics explored in previous issues. With an emphasis on academic success for *all* children, we look at a method of universally designed assessment developed by the Kentucky Department of Education and based on the tenets of universal design for learning. This paper describes the leadership role taken by officials in this state to develop assessments for all students and the state's vision for future assessments. The other articles in this edition explore a foundational concept at the very heart of new and emerging technologies: technology literacy. We hope you find these articles thought-provoking as you consider the many ways technology can enhance teaching and learning. We invite you to also explore the entire range of articles featured on the *InSight* Web site.

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VISION & LEADERSHIP

Assessing Students with Disabilities:

Moving Assessment Forward through Universal Design

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The amendments to the Individuals with Disabilities Education Act (IDEA) of 1997 required all states to include students with disabilities in their state assessment and accountability systems. Compliance with this federal mandate made it necessary for states to develop accommodations to allow students with disabilities to participate in state assessments. Because most state assessments are administered in a paper format, students need reading, processing, organizational, and other skills to participate in the assessment. Some students depend on accommodations, such as extended time, a specialized setting, magnified text, or a human reader who reads text, as well as special paper or booklets. While such adaptations have done much to support inclusion of students with disabilities, there are several disadvantages. Students often regard the accommodations as stigmatizing, and fewer students use these supports as they get older.[1] Furthermore, traditional accommodations, such as read-aloud support, are not always administered to students individually. They may be administered in a group setting, where students are less inclined to ask for support, such as having passages reread, a strategy available to and often used by nondisabled students.

In the remainder of this article, we will present an innovative approach to standardized testing that allows students access to assessment materials and reduces the stigma associated with most testing accommodations. We will explain how this method utilizes the principles of universal design for learning and capitalizes on the flexibility of online presentation of content to better meet the needs of students participating in high-stakes achievement tests. The online assessment procedures were developed under the direction of the Kentucky State Department of Education (KDE) in collaboration with one of the authors, Preston Lewis, formerly of KDE Exceptional Children Services. The other two authors served as advisors during the pilot projects.

Universal Design for Learning

The 2004 reauthorization of IDEA attempted to level the playing field for students with disabilities by requiring states to develop universally designed assessments. The law states that "the state educational agency (or, in the case of a districtwide assessment, the local educational agency) shall, to the extent feasible, use universal design principles in developing and administering any assessments under this paragraph."[2] The principles of universal design for learning (UDL) grew out of the field of architecture. In the 1970s, a growing number of architects began to develop buildings that did not require retrofitting to accommodate all individuals, especially those with disabilities. The method of designing buildings that accommodated the access and movement of all individuals was called *universal design*. One unexpected result of universally designed buildings was that *all* individuals benefited from this type of construction. The ease of access and movement through universally designed buildings was appreciated as much by individuals pushing strollers as it was by persons in wheelchairs.

Beginning in the 1980s, the education community embraced the principles of universal design and applied them to teaching and learning. One of the first groups to advocate for the use of UDL was the Center for Applied Special Technology (CAST). David Rose and Ann Meyer, both from CAST, suggested "a set of principles that forms a practical framework for using technology to maximize learning opportunities for every student."[3] UDL focuses on designing instruction that is accessible from the outset, rather than retrofitting the learning materials with a variety of accommodations. In its purest form, UDL instructional materials and instruction are designed to meet the learning needs of individuals with varying levels of ability.

Three guiding principles to universally designed materials have been suggested by Rose and Meyer. They include (1) multiple representations of content, (2) multiple means of expression and control, and (3) multiple options for engagement. Each of these principles offers the learner various and increased forms of control and engagement with the materials.[4]

Multiple means of presentation. Materials that offer a wide range of media and formats give the learner increased options for access. For example, the traditional textbook creates a number of barriers to various groups of the population. For those who have difficulty with decoding words or comprehending text, the traditional textbook creates an enormous barrier to learning. For students with severe physical problems, the pages of a book may be too difficult to turn. For some students with visual impairments, a traditional textbook is useless for trying to access information. And for all students, a backpack full of textbooks can pose a daunting and physically demanding task.

A universally designed text would offer multiple ways to represent the content. For example, a digital text offers advantages over the traditional form for many students with disabilities. Using a computer with digital text, students with reading or vision problems can have the text read to them. The font size, type, and color can be controlled by the learner. Multiple digital pictures and movies can be used to supplement the text. Hyperlinks can be used to guide the learner to other information relevant to the topic being studied or provide assistance with definitions of words.

Multiple means of expression. Materials developed with universal design give students multiple ways to demonstrate mastery or understanding of what they have learned. For example, a universally designed writing environment could provide students with writing support, such as word prediction, read-back of what they have written, or dictionary and thesaurus support, all in the same environment. These features can help students with reading and writing difficulty, visually impaired students, and even second-language learners demonstrate knowledge, mastery, and understanding.

Text is not the only way students can express what they have accomplished. Other forms of expression include multimedia presentations, video projects, audio recordings, and even dramatic or musical performances. With UDL, students are given the opportunity to demonstrate knowledge in alternative ways.

Multiple options for engagement. A basic principle of UDL is that students are given materials that can be accessed in a variety of formats to enhance engagement. For example, digital materials might be accessed in visual or auditory formats. Students have the option of wearing earphones when listening to text to reduce outside distractions. The ability to control the speed at which text is read allows students to select a personally optimal speed. The student controls whether the text is reread and how many times it is reread. This form of control often promotes an enhanced level of engagement.

UDL and the Assessment of Students

Test accommodations for students with disabilities have been commonplace for a number of years. However, the design of assessments using UDL principles is relatively new, especially for high-stakes state tests. Like UDL, universally designed assessments should be constructed from the beginning to allow all students optimal opportunity to participate in the assessment and to achieve a score that represents what they know and understand.

Our experiences with representatives from state departments of education at national conferences and other meetings indicate that increasing consideration is being given to universal design in the delivery of state assessments. Yet, only a few states (e.g., Kentucky and Kansas) have actually moved toward incorporating UDL into their accountability testing systems. Many states have found that they do not have the technology infrastructure necessary to provide universally designed assessments statewide. Although the use of technology is not a requirement with respect to universal design, the dynamic and flexible nature of technology does lend itself to the principles and delivery of a universally designed assessment.

Kentucky's Universal Design for Learning Initiative

Perhaps one of the best examples of the benefits of including UDL in the design and delivery of a state assessment comes from recent experiences in Kentucky. It is important to note that Kentucky's attempts to provide a universally designed assessment originated out of a larger state effort to make UDL a statewide instructional initiative. The Kentucky UDL initiative consists of three components: (1) computerized literacy supports, (2) distribution of accessible digital curriculum, and (3) accessible electronic state assessment. Each of these components is explained in detail below.

Computerized literacy supports. The major factor that limits disabled students' access to the general curriculum is their inability to read at a level comparable to that of their same-age peers who do not have disabilities.[5] It was estimated by the Council for Exceptional Children that up to 80 percent of students with learning disabilities experience problems with reading.[6] Reading problems are exacerbated by the absence of alternatives to the print medium in classrooms. The lack of alternatives poses a major barrier to access to the general curriculum that directly affects student performance and participation in state assessment.

The inaccessibility of print-based materials is a prime example of where universal design could benefit students, both those with and without disabilities. It is too often assumed that if students do not have the skills or ability to access print, they cannot understand what is being taught. However, after UDL is implemented, teachers have discovered that students can understand the content of instruction when the content is presented in alternate formats. One key way to overcome the print barrier is to use media and tools that are available through digital technologies. One such technology-based method, computerized reading supports, has been shown effective in helping students with disabilities obtain access to printed material.[7] With this in mind, in 2000, the Kentucky Department of Education (KDE) began to address the issue of using technology to enhance access to the general curriculum by attempting to provide text-to-speech technology (i.e., a text reader) in every school in the Commonwealth.

After examination of the various text reader tools available, the KDE negotiated an agreement with TextHELP, Ltd. for a volume purchase of 100 to 200 site licenses per year. As a result, approximately 1,300, or 95 percent, of Kentucky schools have acquired site licenses, mostly for Read & Write Gold software. Read & Write Gold provides literacy support to students through functions such as speech feedback, spell checking, word prediction, and a talking dictionary.

There were two main reasons that the TextHELP product was chosen over other popular commercial tools. The first was cost. The KDE realized that the purchase of single-station copies of a text reader for selected computers in a school would not provide students the access needed across educational settings. Students needed this technology in special education resource rooms at isolated workstations but even more so in regular education settings, where the greatest barriers to the general curriculum tend to occur. TextHELP offered the most affordable price for a site license version of a text reader. Distribution of the site licenses also included assistance with teacher training and technical support.

The second reason for selection of the TextHELP product was the inclusive nature of the tool's browser. The Read & Write tool bar appears and operates directly from any window the user has open, whether the window contains a word processing document, an e-mail message, or a Web page. In contrast, all other similar commercial products require text to be imported into the software before it is read to the user. Not only does this process create an additional step for students, it also poses a security issue when used with state online assessments because questions used year after year could no longer be kept confidential once they were copied to a local computer.

Other literacy tools of the Read & Write product are equally important, such as the speaking spell check, dictionary, and word prediction tools. For instance, the word prediction tool has been very valuable in helping students develop their writing portfolios. This is true both for students with disabilities and for other students. These students also benefit from the vocabulary resources. In addition, with this product, students can listen to their compositions, reflect on what they have written, and make desired corrections.

Distribution of accessible digital curriculum. The use of computerized literacy supports to access the general curriculum is predicated on having instructional content and assessment accessible in a digital format. The KDE effort to meet this challenge was facilitated by passage of state legislation (Senate Bill 243) in 2002 that gave "preferential procurement" incentives to publishers who agreed to give KDE their text material in accessible format on CDs.[8] Annual provision of the digital text is tied to the KDE textbook adoption cycle, and about 80 percent of the materials are being provided each year from publishers for distribution to eligible students with disabilities. More than 1,000 texts are now available. KDE has collaborated with the University of Louisville to provide a repository for receipt, review, and distribution of the material through the Kentucky Accessible Materials Consortium (KAMC at http://kamc.louisville.edu/kyecontent/). Local schools can view and request digital text material through the Kentucky Accessible Materials Database (KAMD at http://apps.kde.state.ky.us/kamd/) located at the KDE.

A major issue that had to be addressed in the creation of this state digital text repository is copyright protection. This required developing a process for electronically embedding code numbers in every individual CD sent for student use. The numbers discourage copyright infringement by creating a tracking mechanism for unauthorized releases. Each participating school was also required to appoint a person to serve as the digital rights manager (DRM) to oversee appropriate distribution and use of the CDs by authorized teachers and students with disabilities.

While the KAMC provides an extensive and unique resource to schools for accessing digital text, local general curriculum content comprises an array of material that goes beyond use of specific textbooks. Providing access to the complete local general curriculum requires massive district and school commitment to using other methods, such as Web searches and scanning, to procure the total curriculum in accessible format. The KDE has facilitated this effort, in part, by providing 500 scanners to selected local schools that use the Read & Write software. The subsequent challenge has been for schools and/or districts to develop a local distribution system whereby teachers and students can access this electronic content in a way that is efficient but that still includes safeguards and usage limitations to assure copyright is preserved and protected.

Accessible electronic state assessment: CATS Online. With computerized reading supports and digital text in use across the Commonwealth to access the general curriculum, the KDE soon recognized the need to develop and deliver the state assessment in accessible electronic format. Conversations began in the late 1990s between the KDE and their assessment vendor, CTB McGraw Hill, about providing technology-based accommodations for eligible students with disabilities for the Kentucky Core Content Test (KCCT). At that point, additional expertise was needed for the digital test conversion and delivery. This led to including experts at eCollege of Denver in the discussions. eCollege had administered the Kentucky Virtual High School (KVHS), so its background in electronic design and accessibility was well established. As a result, a pilot online assessment project was launched in the spring of 2002, with 21 schools and 61 students, to test and refine the online interface. Another pilot study was conducted in the fall of 2002, with 74 schools and 457 students. This study included content across the seven grade levels of the KCCT, using previously released test items. This pilot also helped to identify local school and student access issues that had to be resolved for successful implementation.

The positive responses from teachers and students taking part in the two pilot studies[9,10] brought about Kentucky's first electronic assessment in the spring of 2003, known as CATS (Commonwealth Accountability Testing System) Online. Student and teacher comments throughout this paper are from these two pilot studies.

The eligibility criteria for use of the CATS Online accommodation require that students

- have an IEP, 504 Plan, or Program Service Plan (PSP) that specifies the need for a reader or assistive technology as an instructional and assessment accommodation
- routinely (daily to weekly) use text reader, screenreader (text to speech), or related technology to access printed material in classroom instruction and assessment
- access and use the CATS Online Practice Area until they are able to navigate the site and independently read the content with their text readers, screenreaders, or related technology

Twenty-nine schools and 204 students with disabilities participated in the 2003 online administration. In 2004, more than twice this number took the test online, with 74 schools and 510 students using the electronic accommodation. The most recent administration in spring of 2005 included 147 schools and 1,230 students with disabilities, plus 35 students with limited English proficiency (LEP). (See sidebar for eligibility criteria.)

Of particular importance is the use of the Practice Area of the assessment, which includes released items from all content and KCCT grade levels. Before students can access the actual test, there must be evidence that they spent time in the Practice Area. If there is not a record of their unique log-in ID, access to the test is denied. This is necessary to ensure that students are familiar with the Web site navigation and response system before they attempt to use it for the actual assessment. In addition to the Practice Area, there is a CATS Online DEMO area that is open for year-round preview and use by students, teachers, parents, and the general public (see sidebar).

The CATS Online Demo Area can be accessed by going to **http://catsonline.ecollege.com/**

Type in one of the following log-in IDs:

Grade 4 - Login ID: g04st2161

Grade 5 - Login ID: g05st9398

Grade 7 - Login ID: g07st9567

Grade 8 - Login ID: g08st4057

Grade 10 - Login ID: g10st7314

Grade 11 - Login ID: g11st6974

Grade 12 - Login ID: g12st1215

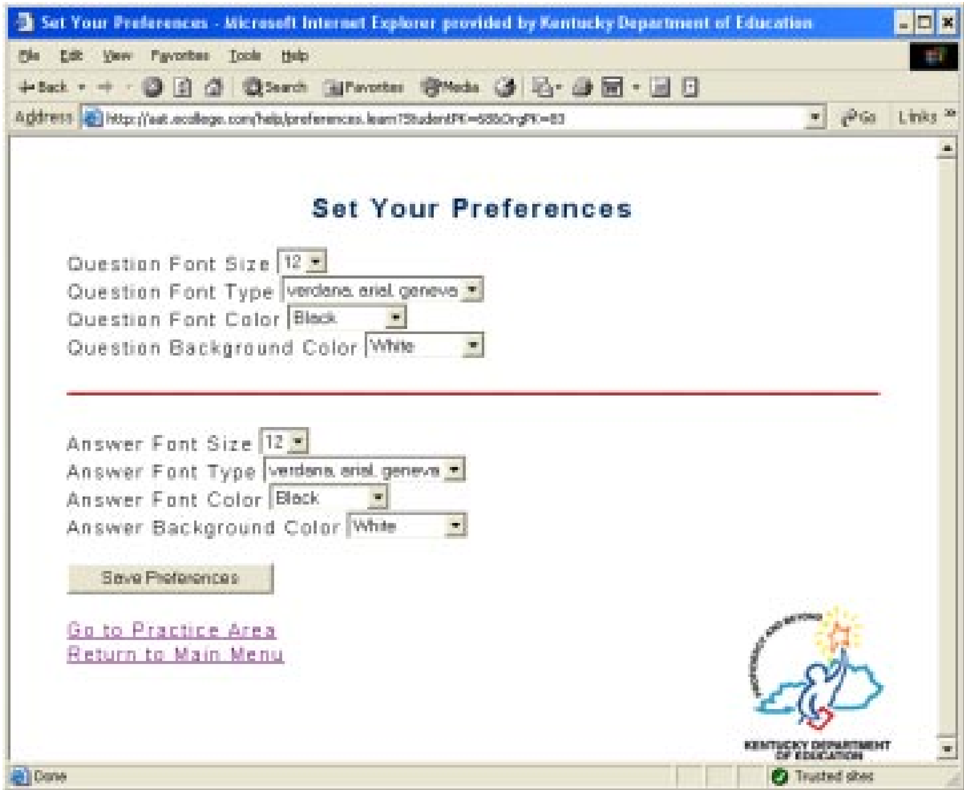
The Universal Design of CATS Online

The universal design of CATS Online is intended to give students a more personalized and equitable way to demonstrate what they have learned and to maintain the integrity of the assessment. This is accomplished by incorporating the three principals of UDL described earlier: (1) multiple means of presentation, (2) multiple means of expression, and (3) multiple means of engagement.

Multiple means of presentation. The contrast between CATS Online and previous versions of assessment is readily apparent—that is, between the static nature of paper-and-pencil test administration and the flexibility provided by use of the electronic format. A student using a computer screen is presented with just one question per screen, while a student using a paper version of an assessment has the challenge of focusing on one of five or more questions per page. The student response sheet may cause more confusion than the question booklet. Response sheets, with their densely compacted presentation of familiar bubbles for responses, can be overwhelming visually. Students using CATS Online click a radio button to respond to a multiple-choice item, while those answering on paper have to be sure they are answering the right question and matching it to the corresponding response bubble.

When a student opens a paper test booklet, there are no immediate options for altering the presentation, whereas with an electronic interface such as CATS Online,

Figure. Preferences/options for CATS Online



the first option given the student is to "Set Preferences" (see figure). This includes designating a preferred font size and type, which allows students to emphasize or enlarge type. Foreground and background colors can be individually determined, which is especially important for students with certain disabilities who benefit from alternative color schemes.

Though students can set font preferences, some students have visual or literacy issues that prevent them from operating within a text-based environment. A number of studies have found computerized read-aloud to be an effective accommodation in this situation.[11] The array of configurations of the read-aloud support in CATS Online further adds to the variety of presentation. Students can choose either a male or female voice, a "digital" voice, or the more humanlike "RealSpeak." Of special interest is the option to set the speed of the voice. It has been reported that some students with Attention Deficit Hyperactivity Disorder (ADHD) prefer to set the voice speed at or near the highest setting of 250 words per minute (wpm), which is well over the typical human average of 150 wpm. An interesting question is whether flexibility of modulation might have special auditory benefits for some children with ADHD. This is certainly an alternative in presentation that would not likely be provided by a human reader and would only be available through an electronic medium.

While students who are auditory learners might benefit from this option, others who are visual learners may prefer to change how the read-aloud text appears on their screen. Students can choose to have the text highlighted and read directly from the screen or have the text placed in a separate text box. The synchronized text reading with dual color highlighting adds another feature to the visual dimension. Choices are also offered for how reading passages and questions appear. Some students choose to set the preferences so that a text passage and the questions appear on separate screens. Others prefer to have a split-screen setting with both the passage and the question presented in a side-by-side or top-to-bottom screen mode.

The use of text-to-speech to assist students with decoding words is perhaps one of the most significant changes in presentation format and has the added benefit of being electronically constant. Concerns often arise about the possible differences in the way each human reader provides a read-aloud accommodation (e.g., intonation, accent, voice quality, etc.). The limitation of human read-

FACT—91 percent of students surveyed in the pilot study thought they scored better by taking the test online.

WHAT STUDENTS SAID—

"I really like how the letters were colored and were big enough to read what they said."

"I did not have to flip from page to page. That is how I would get messed up."

FACT—75 percent of teachers surveyed in the pilot study thought CATS Online was preferable to reading to the student.

WHAT TEACHERS SAID—

"This really helped my students feel confident and independent."

"From my observation of special needs students, a large majority of them thrive in a technology-related setting. Technology seems to be another learning style that many of them understand, where they might not typically understand the read/written process as well. It brings to mind positive differentiation and alternative learning style techniques."

Summary of CATS Online Multiple Means of Presentation

1. Students can select the font type and size and screen color scheme (contrast between background and foreground).
2. Students can select the voice type, volume, speed and pitch, and pace of reading.
3. Students can select how words are to be read (e.g., one sentence at a time or full screen) and how they appear (e.g., color of words, separate speech balloon or as appears in original textbox).
4. Students can choose continued scrolling or dual frame (e.g., question on top and text response box on bottom or question and response box side by side).
5. Design and delivery are user friendly (text reading vs. decoding, one question per screen instead of a page of questions, radio button response for each question vs. shading bubbles on an answer sheet).

aloud accommodation has previously been cited as threatening the adequacy of this support and as possibly compromising the test validity.[12]

Multiple means of expression. CATS Online allows students to select a variety of strategies for interacting with the assessment. With a traditional, human read-aloud accommodation, it is often difficult for students to ask for questions, response options, or passages to be reread, especially when this support is rendered in a group fashion. Plus, some students are reluctant to ask for this type of additional assistance.[13]

With electronic administration, students have more control and independence in determining how and when to use their mouse and/or keyboard, to read and reread questions or passages, and to respond. When completing open-response items, if consistent with students' IEP and classroom accommodations, they may use word prediction to help them decide what words to choose to support their sentence development or conceptual intent. Students report special value in using the text reader to read back to them what they have written, as this allows them to reflect on the structure and meaning of their compositions and to use their keyboards to make changes as needed. Getting this kind of support with a human reader becomes difficult, and trying to correct or change written responses certainly is more cumbersome and messier.

Multiple means of engagement. Having the test read to students in a resource room setting or library creates many opportunities for distraction and loss of

Summary of CATS Online Multiple Means of Expression

1. Students can use the keyboard and mouse to read and respond independently and selectively at their own pace.
2. Students can use word prediction to facilitate completion of open response.
3. Students can listen to what they have written, critically evaluate possible changes, and make corrections efficiently with the keyboard and mouse.

FACT—84 percent of students surveyed in the pilot study used the computer to reread questions.

WHAT STUDENTS SAID—

"I liked taking the test on a computer because everything was at my own speed and I did not have to rush to get it done."

"It was easy and I liked it because I could do it myself."

FACT—73 percent of teachers surveyed in the pilot study said their students reread questions more often online than when using a human reader.

WHAT TEACHERS SAID—

"I saw my students go back and read the passage several times for understanding. Many students will not do this when being read to by someone."

"They enjoyed [and] appreciated the status of taking the test online."

focus, especially if the read-aloud is in a group format. Sitting in front of the computer screen with headphones, attending to one question at a time, helps students concentrate, both aurally and visually, on the task at hand free from the many sights and sounds around them.

A comment heard over and over from students using CATS Online was "Now I can just do it myself!" Another frequent student comment was "I like being on the computer and not having someone read to me like a kid."[14] The sense of independence, freedom, and control students taking the test on a computer have is vastly different from the feelings they seem to have when they have to depend on a human read-aloud accommodation. While having to be read to by an adult in a separate setting seems to carry real stigma for some students, being able to say to their peers, "I'm taking my test on the computer," affords a sense of status.

Summary of CATS Online Multiple Means of Engagement

1. The computer screen offers additional visual cues, and headphones provide auditory engagement and reduce auditory distraction.
2. Increased student control of assessment via technology increases student efficacy compared to traditional accommodations.
3. Student self-concept and positive peer perceptions are enhanced by use of a computer accommodation.
4. Taking tests on the computer is often perceived as "easier" and "more fun" by students than paper-and-pencil versions.
5. Self-pacing and control of question/response review increases attention to content/response and time devoted to test completion.

FACTS—57 percent of students surveyed in the pilot study said taking the test online helped them pay attention.

63 percent liked being able to work at their own speed.

83 percent said it was easier to concentrate when taking the test online.

87 percent said they want to take the test online in 2006.

WHAT STUDENTS SAID—

"If I hadn't taken the test on the computer, I would not have done my best at all."

"It helped you figure out stuff that I thought I didn't know. It made me really use my brain."

"It helps me pay attention to the test."

"I got a headphone where it read to me online and that made me understand it a lot more."

"When I took the test on the computer, I found it was easier to concentrate because I only heard what was being read on the computer."

FACTS— 65 percent of teachers surveyed in the pilot study thought their students took more time to complete the test online than when using a human reader.

72 percent of teachers said their students were more engaged with online assessment than with pencil-and-paper testing.

WHAT TEACHERS SAID—

"Computers are motivating for the students."

"This is my second year using CATS Online, and I will never go back to paper-and-pencil testing as long as I have the available technology for my students."

"Students seemed to try much harder and seemed to put much more effort into the test than with pencil and paper."

Technology creates a sense of engagement that is incomparable to what most students experience with paper-and-pencil test administration. The self-directedness of the accessible online assessment gives many students a feeling of empowerment that can facilitate a more accurate display of student ability. As put forth by Lichtenstein, "the search for independence and the struggle for autonomy"[15] are foremost in the minds of many adolescents.

Impact of Universal Design on Student Performance

Both tangible and intangible factors that accompany assessment in a universally designed format appear to contribute to improved student performance. Recent research by Dolan, Hall, Banerjee, Chun, and Strangman found that computerized testing with text-to-speech support resulted in improved performance, especially on items with reading passages that exceeded 100 words.[16] Kentucky school districts also reported improved student performance with the use of CATS Online.[17]

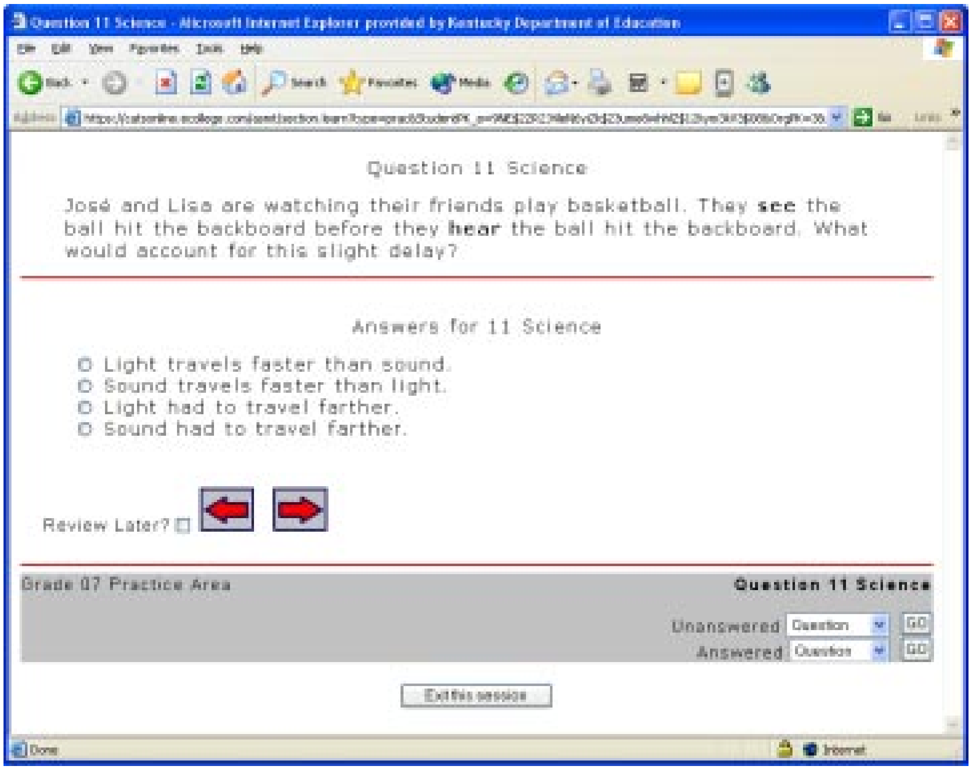
Of critical importance is that 91 percent of students surveyed[18] thought that they performed better on the state assessment by taking CATS Online (e.g., "I just want to say that this was a very good thing to do because I think that I have done better this year on the test than any other year."). The most frequent comments students made about taking the test online in Kentucky were that CATS Online was "easy" (e.g., "I like to take the test on the computer. It seems so much easier and I don't have to have a person read to me.") and "fun" (e.g., "I get to type instead of write. What could be more fun?" "Taking the test on the computer is very fun and relaxing to me."). In our experience, these descriptors have rarely, if ever, been used by students to convey their feelings about taking their state assessments in a traditional paper-and-pencil format. While higher test scores are the most obvious indicator of improved student performance, it is worthy to note that heightened student engagement, greater independence, and more learner control via the online assessment appear to significantly contribute to helping students effectively demonstrate what they have learned.

Next Steps

While more longitudinal data collection and empirical analyses are needed to verify the impact of Kentucky's online assessments on a large scale, the annual rate of increase in CATS Online participation of twofold or better over the past three years indicates strong movement from paper to computer administration in Kentucky. In fact, due to Kentucky's success with online assessment for students with disabilities, the KDE expanded online assessment in 2005 to two other areas as described below.

In February, the Kentucky Occupational Skills and Standards Assessment (KOSSA) was offered online for the first time to about 1,700 students in career and

Figure. Student view of practice area in continuous scrolling presentation mode



technical education programs, and a pilot of the KCCT for the general population was conducted with almost 900 students. Plans are under way for further expansion of these assessments for 2006. It is worthy of note that the KOSSA online allowed use of text-to-speech (using the Read & Write software) for any student who used this tool as a literacy support in instruction. Although it was used minimally during administration of the KOSSA in 2005, the authors hope to expand the use of this tool in 2006 and beyond. They expect more and more students and school staff to realize how text-to-speech technology can support access to career and technical education content for a range of students, not just those with disabilities.

Although some students have been afforded the opportunity to take the standardized assessment in the online format, not all students have been able to benefit from the accommodation. While Read & Write software is now available in almost every Kentucky school, recent investigation has shown that only about half of the schools are regularly using the technology as a literacy support due, in part, to technical support and training issues.[19] School districts also reported insufficient hardware with the capacity to run the software.

Although incorporating technology does not come without issues, Kentucky is staunchly supporting the use of online assessments because, as one teacher said, "Testing online is the future. I am proud that its beginning included our exceptional children. It has proven that they can perform with their age-appropriate peers."[20]

Notes

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Online Assessments of Technology Literacy:
The Perfect Petri Dish

by Mary Axelson

The path to assessing K-12 technology literacy has led to many surprises—and we've only just begun. Efforts to understand what students know about information and communications technology (ICT), for example, have prompted the development of assessments that involve computer-based simulations. Already, simulations of popular productivity software applications provide an environment for evaluating users' skills in using the software itself. But assessment designers are now brimming with not-so-apparent thoughts about how to harness such simulations in assessing content areas such as science, literature, and music. Improved communications between assessment and technology experts is fostering creative synergy as teams from both camps work together to develop an assessment of technology literacy. Meanwhile, the ongoing exercise of defining "technology literacy" may spin every state into a rewrite of content standards and place what many are calling "21st century skills" firmly in the curriculum.

Technology literacy assessments may become the foundation for the next generation of all other online testing. Most states are hoping to move their annual high-stakes assessments online, and some have already done so. Some even hope to create a much more comprehensive system of online formative, benchmark, and summative assessments. Online assessments enable a faster return of results and greater interoperability of the data with high-tech tools, but widespread acceptance of such assessments hinges on educators' confidence that using a computer is not a barrier for a student's ability to demonstrate what he or she knows.

A rush of activity directed at assessing technology literacy is evident worldwide. The ability to use high-tech tools is commonly regarded as an individual's foundation for lifelong learning and as a path to a nation's economic health. In this regard, many fear that the United States is ailing. That prevailing impression, however, has no measure. At this time, the government has no way to determine how much of the labor force can use commonly available technologies, schools cannot determine if their technology programs are effective, and policymakers do not know if technology funds are well spent.

The No Child Left Behind Act of 2001 (NCLB) gave impetus to the movement to evaluate technology literacy by stating a federal goal that all students will demonstrate technology literacy by the end of the eighth grade, beginning in 2006. Specifically, Title II, Part D Goal 2 (a) reads as follows:

> To assist every student in crossing the digital divide by ensuring that every student is technologically literate by the time the student finishes the eighth grade, regardless of the student's race, ethnicity, gender, family income, geographic location, or disability.

States have been given responsibility for defining what is meant by "technology literacy" and for developing a process to evaluate student proficiency in this area.

The Ever-Expanding Definition of Technology Literacy

Assessing technology literacy requires a precise definition of technology. The boundaries of technology could be limited to common software and hardware, set to include all information and communications technology (ICT), or expanded to include technologies beyond the realm of computing.

In 2002, the National Research Council Committee on Technological Literacy authored *Technically Speaking: Why All Americans Need to Know More About Technology*. This report defines technology not as simply computers, handhelds (PDAs), and other high-tech tools but as all tools and processes with which humankind adjusts the natural environment—from a shovel to the process by which scientists identify chromosomes on a strand of DNA.

Greg Pearson led the committee in creating both *Technically Speaking* and an upcoming report on assessing technology literacy. In an e-mail-based expert panel sponsored by the Institute for the Advancement of Emerging Technologies in Education (IAETE), he observed that equating technology literacy with ICT literacy is not wrong, just narrow. He writes:

> The Academies are far from the first to describe and promote this larger view of technology. Philosophers of technology, such as Langdon Winner, historians of technology, like Thomas Hughes, and technology critics, like Neil Postman, have all taken this larger view. So has the STS (science, technology, and society) movement in U.S. post-secondary education, and the International Technology Education Association, which represents technology education teachers in this country.

The word *literacy* has a correspondingly wide range of possible meanings, from mastery of basic skills, to fluency, to advanced levels of proficiency and creativity. Literacy, in *Technically Speaking*, includes the ability to use not only relevant technology tools but also critical thinking skills, including being able to analyze risks and benefits on issues ranging from genetically modified foods to oil drilling in environmentally sensitive areas. This definition of technology literacy seeks to guarantee informed participants in the democracy and the economy. For the scientific community, literacy is tied to the essential ability to apply the process of scientific inquiry. For others, it is closely tied to rhetoric as an academic discipline[1] and therefore implies a certain facility in responding to text and other forms of media. This information age literacy requires a level of discernment that was once considered an elitist part of the K-12 curriculum.

However, the Internet's simultaneous glut and wealth of resources requires sophisticated discernment in determining the reliability and accuracy of information. Workforce uses of ICT also require skills in communicating, analyzing and interpreting data, problem solving, and collaboration. While these skills may not be new, the tools that support them continually change. These changes—and the sense of immediacy the tools bring to information gathering and sharing—do require new skills. Indeed, millennial literacy may be

The concept of **technology competency** or **proficiency** became popular when microcomputers were introduced in the nation's classrooms in the 1980s. This concept concerns basic skills and knowledge related to hardware and software. Early courses on computer skills often focused on basic operations, troubleshooting, and programming in languages such as BASIC.

21st Century Learning Skills, as described by the Partnership for 21st Century Skills, can be divided into three categories: thinking and problem-solving skills, information and communication, and interpersonal and self-direction.

ICT literacy links 21st-century skills to information communication technology (ICT) tools—tools that can change over time—to support the development of and demonstration of critical thinking skills and higher-order cognition. Examples given of ICT literacy, according to the Partnership for 21st Century Skills, include the use of ICT to solve problems, to demonstrate creative ideas or thoughts, to access and evaluate information, or to enhance productivity and personal development.

interpreted as the ability to teach oneself within an environment of ever-changing tools and protocols. Precisely who is to be held accountable by the assessment of these expanded sets of abilities remains undefined.

What is taught in schools today is driven by content standards. Current definitions of ICT literacy include a complex web of skills and knowledge that incorporate information addressed by content standards as well as higher order thinking and performance skills that require the use of ICT tools used in many current and future careers. The assessment of ICT literacy must find a niche within the core content areas in order to be addressed in schools.

Do ICT skills, though, require a separate test? One approach to addressing this concern would be to have a baseline technology check included in a subject-area assessment to ensure that difficulties in using the technology do not hamper a student's ability to demonstrate content knowledge. Ensuring that students have basic technology skills is a prerequisite to teaching and assessing complex learning skills. Schools will need to address this concern if they are to fully utilize digital tools that allow for the collection, analysis, evaluation, synthesis, and creation of information across multiple media.

State directors of education technology have stepped up to assume responsibility for responding to the NCLB goal so far as it relates to technology proficiency. Even with that common goal, definitions are difficult. The State Education Technology Directors Association (SETDA) gathered a technology literacy assessment (TLA) work group to define technology literacy. Jerry Bates, a participant from the Tennessee Department of Education, wrote:

> With technology in the vanguard of virtually every social enterprise today, I knew we would bring a range of vested interests to the table. But what amazed me the most was how difficult it became to define the elephant in the center ring!

Those who have examined the issue seem to agree that addressing technology literacy in the schools will require more than ensuring equitable access to technology. It will require more than increasing the availability of hardware and access to, as well as safe and ethical use of key applications. Knowing how to surf the Web doesn't equate to expediently finding and capturing the reliable and credible information one is looking for. Will a student be fooled by slick graphics and authentic-sounding information created and posted by an individual posing as a nonprofit research center? Being able to copy and paste doesn't equate to being able to organize information in different formats and to communicate effectively. Will students know the rights of use for information they find and how to safeguard their personal information? Knowing how to reboot a locked computer or connect to a fileserver doesn't equate to evaluating and procuring hardware and software to meet the ever-changing needs of a lifelong learner. As Educational Testing Service (ETS) observes,

> We will surely one day succeed in closing the "digital divide" that separates the technology haves from the have-nots. But we will not succeed by merely providing access to equipment: we must also provide the intellectual tools to use technology effectively, in school and in the workplace.[2]

Similarly, the International Technology Education Association, which publishes *Standards for Technological Literacy: Content for the Study of Technology,* explains that

> technological literacy is far more than the ability to use technological tools. Technologically literate citizens employ systems-oriented thinking as they interact with the technological world, cognizant of how such interaction affects individuals, our society, and the environment. Technological literacy is the ability to use, manage, assess, and understand technology.[3]

SETDA's TLA work group arrived at a definition of their "elephant" as follows:

> The ability to responsibly use appropriate technology to communicate, solve problems, and access, manage, integrate, evaluate, and create information to improve learning in all subject areas and to acquire lifelong knowledge and skills in the 21st Century.[4]

This definition, combined with the National Educational Technology Standards for Students (NETS-S) from the International Society of Technology Education (ISTE), is the foundation that most states are using for meeting the eighth-grade goal mentioned in NCLB. The North Central Regional Educational Laboratory (NCREL) is in the process of building rubrics for NETS-S that educators can use to assess technology literacy.[5] Some NCREL NETS-S rubrics are completed and others are open to comments.

SETDA charts the status of each state in four categories: definition of eighth-grade technology literacy, policy for standards, process of evaluating progress, and reporting requirements and methodology. All are works in progress. Some states embed technology literacy standards in the core content standards; others create separate standards for technology literacy, and some states have no technology literacy standards at all.

Standards That Keep Pace with the Rate of Change

Technology changes quickly. Standards that specify a software program, or even a particular computing device, are likely to become obsolete in a hurry. For this reason, many technology standards (both state and national) have been written to focus on tasks rather than tools. Thus, ISTE's NETS-S reads, "Students use technology to locate, evaluate, and collect information from a variety of sources." Quite purposely, there is no mention of the Internet or other specific digital archives. Similarly, a fifth- through eighth-grade NETS-S science standard reads "Use appropriate tools and techniques to gather, analyze, and interpret data." For standards to withstand the shifting sands of technology, they must include the ability to recognize the most suitable tool for the job (see sidebar for the complete "Technology Foundation Standards" from ISTE NETS).

Technology Foundation Standards for Students

1 Basic operations and concepts
- Students demonstrate a sound understanding of the nature and operation of technology systems.
- Students are proficient in the use of technology.

2 Social, ethical, and human issues
- Students understand the ethical, cultural, and societal issues related to technology.
- Students practice responsible use of technology systems, information, and software.
- Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.

3 Technology productivity tools
- Students use technology tools to enhance learning, increase productivity, and promote creativity.
- Students use productivity tools to collaborate in constructing technology-enhanced models, prepare publications, and produce other creative works.

4 Technology communications tools
- Students use telecommunications to collaborate, publish, and interact with peers, experts, and other audiences.
- Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.

5 Technology research tools
- Students use technology to locate, evaluate, and collect information from a variety of sources.
- Students use technology tools to process data and report results.
- Students evaluate and select new information resources and technological innovations based on the appropriateness for specific tasks.

6 Technology problem-solving and decision-making tools
- Students use technology resources for solving problems and making informed decisions.

Emerging Assessments

The phrase "21st century skills" has emerged as an accepted descriptor for the advanced skills and knowledge that use, and often rely upon, ICT tools. These skills were the focus of an international ICT literacy panel convened by ETS. The panel's 2002 report identifies the desire of Statistics Canada, the National Center for Education Statistics (NCES) in the United States, and the Organisation for Economic Co-operation and Development (OECD) in Paris to include sophisticated ICT literacy skills in their international assessments of students and adults. Says the Educational Testing Service, "To date, however, no one has put forth a framework to assess if an individual has achieved ICT competency to function successfully in a knowledge-based society" (www.ets.org/Media/Research/pdf/ICTREPORT.pdf).

As reflected in a 2005 report from the Partnership for 21st Century Skills (P21), the intervening three years have seen the introduction of some new models. The P21 report, *Assessment of 21st Century Skills: The Current Landscape,* identifies numerous assessments that target complex cognition within the context of using ICT tools. P21 is an organization formed in 2002 to define the new abilities required for our high-tech information age. It came together with support from the U.S. Department of Education, the National Education Association, and numerous corporations and their educational programs (AOL Time Warner Foundation; Apple Computer, Inc.; Cable in the Classroom; Cisco Systems, Inc.; Dell Computer Corporation; Ford Motor Company; Microsoft Corporation; and SAP among others). These entities have worked to define 21st century skills; to encourage the incorporation of 21st century skills within state content standards; and to advance the nation's ability to assess the complex cognition required for problem solving, collaboration, and understanding economic systems.

P21 has identified the key goals for providing a 21st century education as follows:[6]

- Emphasize core subjects.
- Emphasize learning skills (information and communication skills, thinking and problem-solving skills, and interpersonal and self-directional skills).
- Use 21st century tools (ICT tools) to develop learning skills.
- Teach and learn in a 21st century context (global awareness, financial, economic and business literacy, and civic literacy).
- Teach and learn 21st century content.
- Use 21st century assessments that measure 21st century skills.

Clearly, interrelationships weave an intricate network, but separate assessments target each. The June 2005 draft of P21's assessment report, speaking to assessment of the broader notion of ICT literacy, explains that

> . . . interest has grown in developing assessments that (1) reveal the cognitive skills that students employ in conjunction with their use of technology and (2) use technology as their means of delivery. The process of creating such assessments is only beginning even among the leading-edge education ministries, with the exception of the United Kingdom.

Developing Models of ICT Assessment

Described below is new assessment work from Britain's Qualifications and Curriculum Authority (QCA), the North Carolina Department of Public Instruction, the Florida Department of Education, ETS, Learning.com, and the International Computer Driving License (ICDL). The focus of the assessments range from technology literacy to the more expanded notion of ICT literacy, but all use simulated software environments for an on-screen assessment. Lessons learned from each illustrate possibilities for the development of new types of assessments, as well as assessments that measure more complex skills. Additionally, the National Center for Education Statistics' NAEP (National Assessment of Educational Progress, also referred to as the Nation's Report Card) intends to explore the creation of such an assessment for 2012.

The UK's Key Stage 3 ICT Literacy Assessment

The United Kingdom is currently piloting its Key Stage 3 (ages 11-14) ICT Literacy Assessment.[7] The effort stands out as a model for computer-based testing of technology literacy, with the goal of assessing ICT literacy in the future. Created by the British government, it uses a simulation-based environment—a virtual town dubbed Pepford—to assess students' technology skills and their ability to apply computer-based tools to common problems. An adaptive test (combined with a teacher's estimation of a student's skill level) determines students' entry level and assigns a series of tasks. For example, students may be placed in the role of movie theater employee and asked to prioritize needs, assemble documents, and schedule events by communicating via simulated e-mail and to report information they have found and synthesized in a Gantt chart. One task, for example, might require the student to find the theater's seating chart online. These tasks are tackled with what the creators of the simulated computer environment call a "walled garden" of applications, Web sites, search engines, and other resources that allow students to demonstrate their abilities without accessing the Internet.

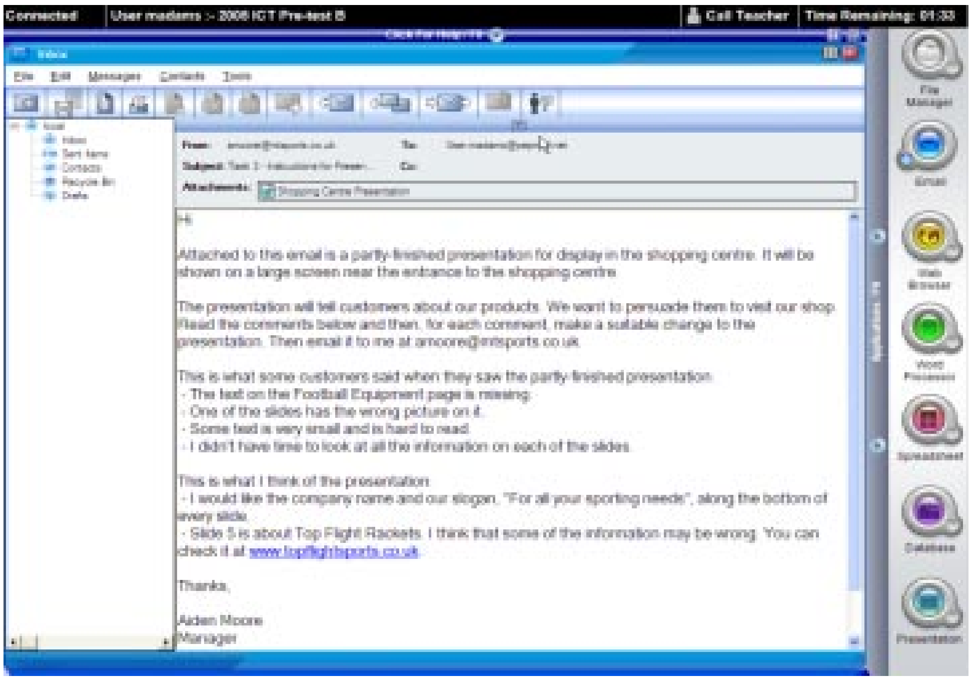
The environment allows students' actions to be closely tracked and analyzed at a depth unparalleled by any other assessment used in K-12 schools today. The resulting reports are used as a way to identify students' individual strengths and weaknesses and as wider summative measures of school performance. Explains Martin Ripley, director of e-strategies for QCA:

> The use of simulations is a key development. A simulator provides the context within which authentic assessment tasks can be designed and delivered to students. It also facilitates the development of assessment tasks which invite students to combine a range of capabilities and skills. The combination of these two aspects enables us to assess higher - order information technology capabilities—such as choice or communication.
>
> For scoring purposes, the software records and scores the actions that the student takes while completing the test. For example, a higher order capability for a 14 year old student in England includes designing a system for someone else to use. That capability in turn includes an assessment of the end-users requirements. This we assess dynamically in the virtual world of Pepford by collecting evidence of the student researching into those requirements, by sending and receiving e-mails to ask about requirements, by the student refining their system to meet requirements and so on. To achieve this we have worked with an extensive range of teachers to document the processes that students go through when producing eloquent or satisfactory responses to the task set. We use this to create a matrix of plausible routes that a student will take when en route to complete a satisfactory (or better) response.[8]

The on-screen test is not technically online in terms of being delivered over the Internet from a central server, and its creators don't know that it ever has to be. The pilots and first rounds of delivery use software distributed to the schools located on and delivered from a school-based server. Ripley explains that schools' Internet connections are not reliable enough to guarantee that students will not lose access—or, worse, lose data on their work.

Ripley wants to link the Key Stage 3 test environment with "the broader notions" of 21st century literacy. He clarifies, "And I don't mean technological literacy. I mean citizenship, functional literacy, numeracy, problem solving, independence, self-learning, motivation, all of those sorts of abilities." All are areas of knowledge, says Ripley, that "paper-based assessments just can not reach." He also wants to expand the test environment to include items such as PDAs, cellular phones, probeware, and other devices that students might have access to at home or in subsequent careers. “One of the key challenges for us in this test development project,” explains Ripley, “is to extend the simulator well beyond its current focus on a PC desktop environment, to include other technologies and to assess a wider range of technological capabilities” (for more information, visit www.rm.com/qca/mainpage.asp?cententref=QCAP368909).

Figure 1.
Example Problem from Key Stage 3 ICT Literacy Assessment



The North Carolina Online Test of Computer Skills

North Carolina’s Department of Public Instruction (NCDPI) has been assessing technology literacy since 1996, and passing the exam has been required for high school graduation since 2001. In October of 2005, the department implemented its online assessment of the new 2004 technology standards, the North Carolina Online Test of Computer Skills. This involved testing every one of the state’s approximately 100,000 eighth graders. The online assessment greatly simplified the process by replacing two separate tests that students had been required to pass, one multiple choice and one performance based.

For the performance-based assessment, explains Mildred Bazemore, section chief for the Test Development Section of the NCDPI, students had to be at a computer with their paper-and-pencil answer sheet. Administering this assessment was a challenge. Various schools within a district were using computers and operating systems that ranged from an Apple IIe to a desktop equipped with the most recent version of Microsoft Windows. Schools also used various brands of productivity software (word processing programs, spreadsheet software, and databases). As a result, the state had to make 67 different applications available for every testing event. The costs and frustration of those logistics, and the endless paper stream of hand-scored assessments, made the online option stunningly attractive. Indeed, any online version of an assessment holds promise for an improvement to logistics. In a personal communication with the author, Bazemore explains:

> We're constantly exploring ways of doing things more effectively and efficiently. I don't know if you've ever seen a testing warehouse with all the forklifts, and the test books, the pieces of paper, the dust mites, the paper mites and so forth. In North Carolina we have 115 districts and probably just under a hundred charter schools, and all of these pieces of paper have to go in all these different directions. It's very costly, very time consuming. There's too much touching of the test by too many people that you can't control.

NCDPI's commitment to assessing technology literacy stems from the conviction that such literacy is an essential foundation for lifelong learning (see sidebar). Its project benefited from the state having had previous experience with designing an online assessment. North Carolina has fully developed an adaptive assessment that was intended to be used for state accountability purposes by students with learning disabilities. Adaptive tests are not currently used for federal reporting requirements because they limit the number of standards presented to a student and not all students may see questions related to the same set of standards; thus that particular assessment is not in use at this time. Bazemore adds that the state has had the technical know-how to deliver assessment online since 2001, but infrastructure at the school level has only recently been able to receive it. Technically, some schools are still not able to do so. For these schools and for students needing assistive technology, NCDPI has created two portable labs. NCDPI has also created an alternate technology assessment that is not computer based.

North Carolina's Definition of Eighth-Grade Technology Literacy

In keeping with the philosophies and content of the North Carolina Standard Course of Study and the ABCs of Public Education, technology will nurture and empower the development of students to become self-directed, life-long learners; complex thinkers; quality producers; collaborative workers; community contributors. Students will learn how to select, evaluate, and use a variety of technology applications and resources for their personal and academic needs. Through the acquisition of skills and knowledge, students will have the ability to participate and thrive in the American economic and political systems. Administrators and teachers will use technology to address the learning styles of today's students more effectively.

Excerpted from a SETDA chart of state responses to assessing technology literacy, www.setda.org/Toolkit2004/evaluation_06_State_of_States.htm

For the technology literacy assessment, the state worked closely with North Carolina State University to build a proprietary software environment known as NCDesk. This collection of programs, developed in the programming language Java, replicates common applications such as word processing, spreadsheets, databases, e-mail, and file management. Additionally, NCDesk includes a test interface and a test simulation that are used to teach students how the testing interface works.

A test simulator movie is available online (cskills.ncsu.edu/ncdesk/simulationdemomovie.asp). It features such items as a request to insert a picture of a car in the home page of a video company, a multiple-choice question to identify the best search terms, and a multiple-choice question asking for the most recent information on a spreadsheet of sales for five different video games. The actual online assessment requires about two hours, including administrative tasks and breaks. All 72 items are new and reflect the 2004 computer skills curriculum (54 items constitute the assessment and 18 are being field-tested).

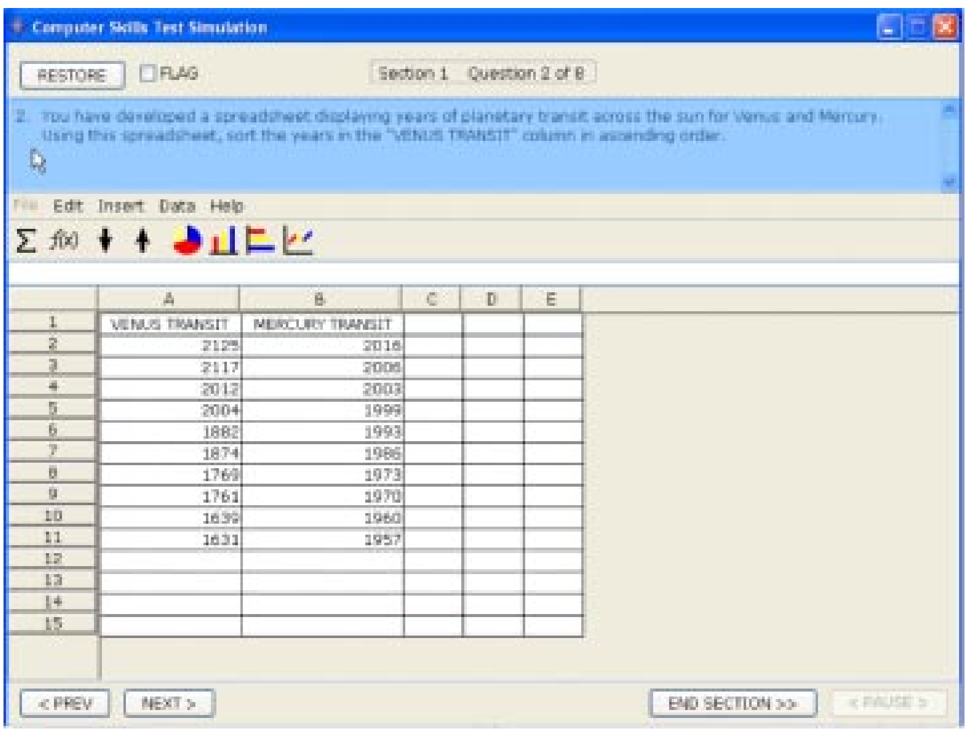
NCRegistration is an administrative tool built to accompany NCDesk. The application manages user access, registers students in bulk or individually, handles scheduling of test sessions, provides Student Information Questions (SIQ) for additional data collection, and issues reports. The assessment resides on a central server, and student responses are reported directly to the server as students move between questions. The feature minimizes the risk of losing data should a power outage or system crash interrupt the assessment.

The development process included a feasibility study and trial with adults at volunteer sites in the fall of 2003. An expanded study and trial in the fall of 2004 included a minimum of 10 locally chosen students per school, for a total of 5,620 students starting the test at 608 schools. Of these, 4,783 students, or about 85 percent, finished. A spring 2005 field test sampled the population of schools and students. In a window that ran from April 11 to June 15, 8,510 students were tested. With 6,361 starts and 6,198 finishes, the completion rate increased to approximately 95 percent. Jim Kroening, program manager for Performance Assessments within NCDPI's Test Development Section, attributes that rise to an increased awareness of the technical requirements, schools responding to those requirements, and improvements in the technology and the delivery of the assessment at the central level. All testing rounds were followed by further development and debugging of the technology, test environment, and items. A technical readiness survey confirmed that every school had computers and sufficient bandwidth to administer the assessment. Multiple forms of the test provide additional security should students' eyes wander around the computer lab.

To address online opportunities for students with special needs, Bazemore is working to add a read-aloud feature to the technology assessment. This feature has not been affordable within their Java environment as text-to-speech software is often highly specific to the applications with which it can operate, and Java is not as widely supported as the basic programming language of the Web, HTML. She also wants to move other alternate assessments online and expand the simulation items to other disciplines, such as science.

Looking back, Bazemore advises other states to seek a top-down approach for such a project, stopping short of actually recommending the effort to be legislated. Theirs was a grassroots approach involving schools and the test development department at NCDPI, and Bazemore says they were fortunate to gain support from the legislature via individual line items. Being able to respond to a state initiative, says Bazemore, would eliminate considerable red tape.

Figure 2.
Example Problem from North Carolina Online Test of Computer Skills

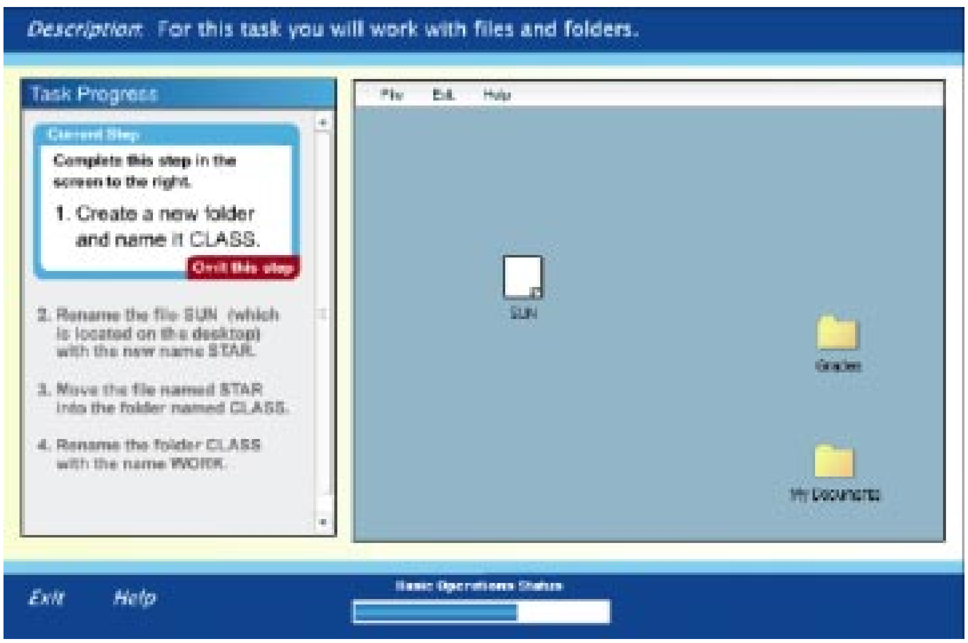


The Florida Inventory for Teacher Technology Skill

In April of 2006, the Florida Department of Education will begin field-testing its online inventory of technology skills for eighth graders. Last summer the department rolled out the predecessor of this tool, the Inventory for Teacher Technology Skills.

Kate Kemker, director of Instructional Technology for the Florida Department of Education, explains that the state's 67 districts were looking to the state for assistance in understanding the technology proficiency levels of their teachers and students from a skills-based level. Kemker's team started with the teachers. "We said, let's really develop a tool that's going to be performance-based and simulated, and we can really get at what the teachers know," recalls Kemker.[9] This decision propelled the development team to delve into the more complex notion of ICT literacy, rather than limit its work to basic technology skills assessment. The finished product simulates common productivity and communication software applications and includes many situational and multiple-choice questions.

Figure 3.
Example activity from Florida's Inventory for Teacher Technology Skills



Florida began its development process by focusing on ISTE's NETS for Teachers (cnets.iste.org/teachers/t_stands.html):

- Technology Operations and Concepts
- Planning and Designing Learning Environments and Experiences
- Teaching, Learning, and the Curriculum
- Assessment and Evaluation
- Productivity and Professional Practice
- Social, Ethical, Legal, and Human Issues

The test development process took a year and half. In the end, Florida had both an assessment and a robust assessment environment that the department could customize to assess various content areas or use for different versions of the same content, such as an assessment of students' ICT literacy. The Florida Department of Education expects that this will allow them to roll out the eighth-grade assessment as early as April 2006. Kemker explains that some areas need refinement—tasks with spreadsheets, for example, are proving to be problematic—but she has great confidence in the programming of the software shell.

Districts are not required to use the online assessment, but 3,000 teachers had already taken the assessment by the fall of 2005. Kemker and Florida education administrators were enjoying a "data rush." Patterns were emerging that will help districts to identify clear professional development needs, and individual teachers were designing their professional development plans based on the measures of proficiency reported by the assessment. Though professional development is the district's responsibility, Kemker is working to tie assessment results to recommended resources.

The student version of this technology literacy assessment, targeted at the eighth-grade level, begins with a clear goal: Florida plans to eventually have its high-stakes assessment, the Florida Comprehensive Assessment Tests (FCAT), online. At that time, says Kemker, "We can not let technology be the barrier. So we need to make sure that students have those skills, that they're comfortable with using the computer; that when they go to take that online assessment, that it is not any barrier to their success."

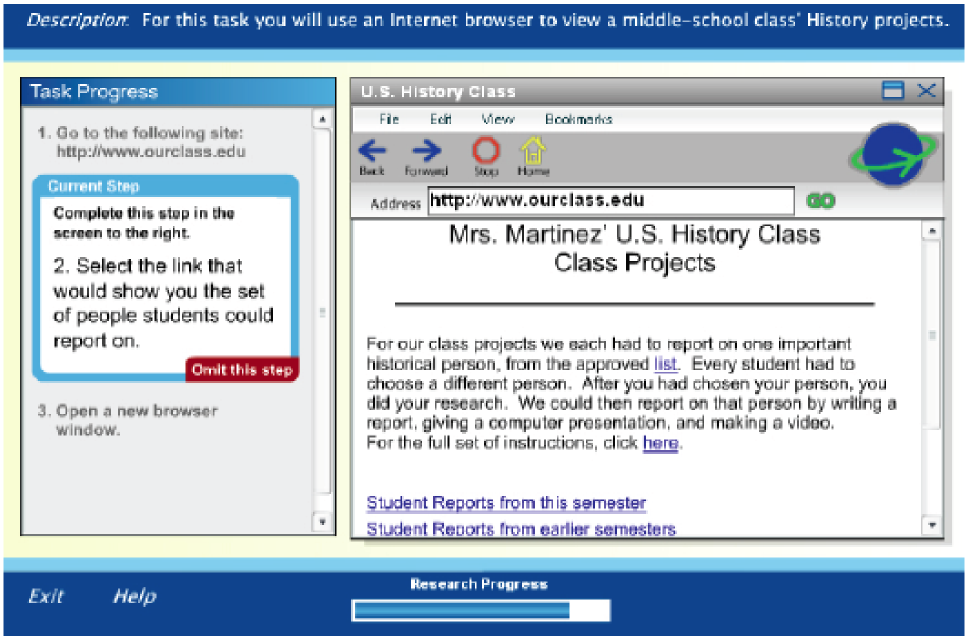
The current assessment for teachers, explains Kemker, measures only basic technology skills, not technology integration. Similarly, the eighth-grade assessment is confined to computer skills and does not address the more complex cognition that can accompany them, such as using computer skills to analyze, synthesize, evaluate, or create information.

The Pre-Invented Wheel

"We have an incredible tool," says Kate Kemker, describing Florida's Inventory for Teacher Technology Skills. What's more, it was created with federal funds, so the state hopes to make it freely available to others. The structure of such licensing, and perhaps hosting, has not yet been determined, but inquiries are welcome.

North Carolina has had numerous inquiries from districts and states about licensing its technology literacy assessment, but the state has had no time to consider this stage of their project.

Figure 4.
Example activity from Florida's Inventory for Teacher Technology Skills



The ETS ICT Literacy Assessment

The ICT Literacy Assessment from ETS also provides a simulated environment for authentic, on-screen tasks. This assessment is designed for higher education students and can potentially double for assessing educators' ICT literacy. Terry Egan, ICT project manager, says ETS has received many requests to extend the work to K-12.

One example of a task for postsecondary students follows:

> You've volunteered to create a flier for a community clean-up day to be held in your neighborhood. Include the map below, along with the following information, and create an attractive one-page flier for the event. The event will take place on Saturday, May 6, from 1:00 to 4:00 p.m. at Lincoln Square Park. Event organizers want a tear-off sheet to print names, addresses, and phone numbers.

A simulated document layout program is provided to help students complete the task shown in the example (create a flier), and the final product is scored for accuracy and completeness. Explains the ETS report, "Additional scoring points might include evaluating the layout and inclusion of graphic design elements such as borders and lines." Human scorers make those determinations.

Another task gives the scenario of a sibling with a "rupture of the anterior cruciate ligament," and the task is to "find several reliable sources on the Web that recommend treatment and rehabilitation for this condition." Asked how devious the assessors get in terms of replicating the vast amount of incorrect or misleading information on the Web as a form of distracter, Egan laughed as she explained that test authors don't try to trick anybody. However, the range of Web sites that can be returned from a search can include off-base personal Web sites, advertisements, and dated medical articles, as well as current information that has been written or reviewed by experts.

Before creating their ICT literacy assessment, ETS convened an international panel to "examine the need for a measure of ICT literacy across countries and within specific organizations, such as schools and businesses" and "to develop a workable *framework for ICT literacy*" that could be used internationally. The resulting report, *Digital Transformation: A Framework for ICT Literacy,* concludes that ICT literacy is "a continuum of skills and abilities" and that "the concept of ICT literacy should be broadened to include both critical cognitive skills as well as the application of technical skills and knowledge." A desire to address "the digital divide" and to "help technology fulfill its potential transformative role" motivated the broad approach.

Participants on the international panel arrived at a common definition of ICT literacy: "ICT literacy is using digital technology, communications tools, and/or networks to access, manage, integrate, evaluate, and create information in order to function in a knowledge society." Explains Egan, "The construct, or the framework, or the definition of *critical thinking skills*—there's not a lot of agreement on it. But, without a doubt, when people see the types of tasks we have on the assessment, they recognize immediately that it involves problem solving and critical thinking." The environment that simulates common digital technologies, such as communication tools and productivity software, helps students demonstrate these higher order skills within the context of a technology-supported environment.

Learning.com's TechLiteracy™ Assessment

Learning.com, a company in Portland, Oregon, is in the process of developing assessments of technology literacy that are a direct response to the NCLB goal. The company has created two assessments—one for grade five and another for grade eight—and aligned them to ISTE NETS-S and its performance indicators. Kris Homsi, manager of product strategy, explains that the company focused on performance indicators rather than the actual NETS-S standards. The company also found the performance indicators of Texas, New Jersey, and North Carolina to be "well operationalized" guidelines and used them as guidelines in their development of their assessment.

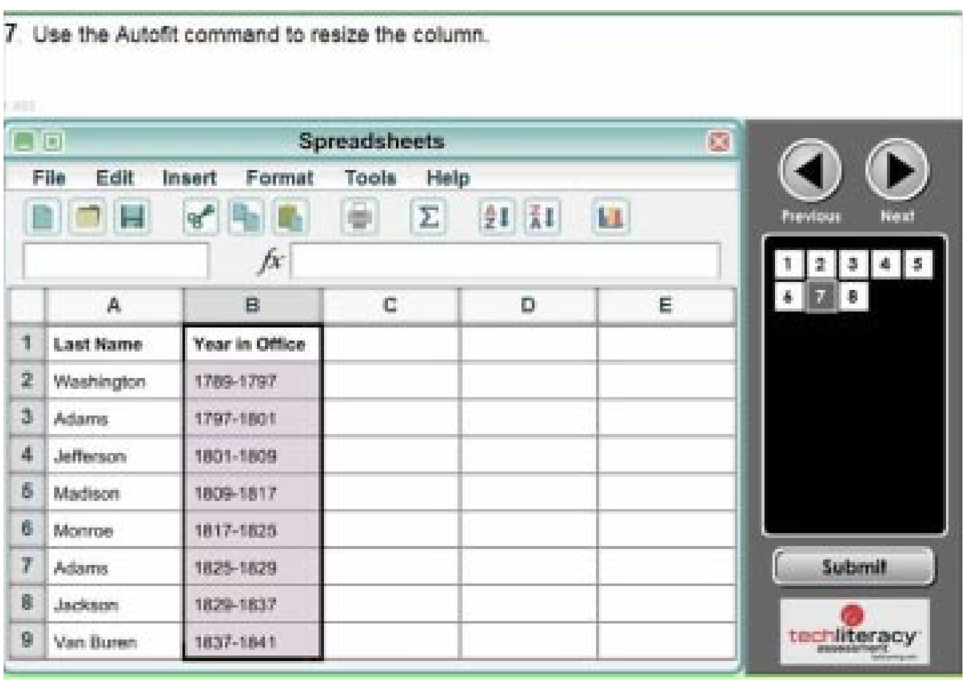
The assessments at both grade levels include a mix of simulation-based activities and multiple-choice items, and they are designed to be administered in a single, 50-minute class period. The scope is limited to what Homsi identifies as "foundation skills" organized around seven modules:

1. word processing
2. telecommunications/network (includes Web browsing and e-mail skills)
3. multimedia/presentation (audiovisual tools; graphics tools; presentation software; and, for the elementary version, visual mapping software)
4. spreadsheets
5. databases
6. social and ethical issues
7. systems and fundamentals (including basic software operations, file management, navigation, and other system-level tasks)

Learning.com has also developed a technology skills curriculum program known as EasyTech. Eventually, this and other resources will be tied to results for remediation.

One possible advantage of Learning.com's solution is that the company hosts the administration and reporting capabilities. That limits the technical burden on schools and generally requires less technical support. When the latter is needed, the company can supply it. Schools do need to ensure that they have adequate bandwidth, operating systems, browsers, and sound and animation drivers. For more information on Learning.com's TechLiteracy Assessment, visit www.learning.com/tla.

Figure 5.
Example problem from Learning.com's TechLiteracy ™ Assessment



The International Computer Driving License

The International Computer Driving License (ICDL), a for-profit company, offers adults and students certification with a series of tests on basic computer skills rather than ICT literacy. There are seven module tests. The first (concepts of information technology) uses a multiple-choice format, but modules two through seven are performance-based items within simulations of applications. The other modules are titled Using the Computer and Managing Files, Word Processing, Spreadsheets, Database, Presentation, and Information and Communication. The tests are administered online in proctored testing centers.

The syllabus is created by the European Computer Driving License Foundation Ltd. (ECDL-F), a nonprofit organization that is the global governing agency for ECDL certification. Outside of Europe, the same program is identified as ICDL. In all, it is used in 138 countries, with a single licensee managing it within each country.

In the summer of 2004, ISTE, Vantage Learning, and ICDL-US, which licenses the ICDL certification, announced their intention to build an assessment as a direct response to the NCLB goal for assessing technology literacy in the eighth grade. However, explains Heather Shay, vice president of education for ICDL-US, subsequent research did not show an adequate market for such an investment, and the partners shelved the project (for more information, visit www.icdlus.com).

Making the Assessments a Reality

The authors and developers of all of these assessments are confident that simulations can help them better understand each student's understanding of a topic. The research base to support that impression, however, is thin, and this is a barrier to investment. States have encountered difficulties moving a multiple-choice test to an electronic environment, one being that differences in the look or amount of information displayed on the screen can alter performance.[10] Oregon found that some items in their online assessment perform differently with certain student populations, but the state hasn't yet "cracked the code" on that mystery.[11] Additionally, most educators and decision makers grew up in an era of paper-based assessments with familiar multiple-choice response formats. The uncertainty of not only using different media but sometimes radically different questioning formats can be unnerving to some.

The interplay between cognition and high tech tools is a complex, chicken-and-egg issue. As media theorist Douglas Rushkoff asks, "Does using Microsoft Word lead me to write differently than when I'm using Eudora? Why? And how does a particular program lead to a particular set of behaviors or values? If I use Quicken, will I start to think that balancing my checkbook is more important? If I trade online, will I make more trades than if I have a broker I talk to on the phone?"

Martin Ripley, referencing all forms of "e-testing," including simulation, explains:

> I like to remind colleagues that paper-based testing has been in use for 140 years. The science and business of paper-based testing is well refined and well evidenced. A person experienced in managing, researching or administering one set of paper-based tests is likely to be able to move in a straightforward way to a similar role in relation to other paper-based tests. In contrast, there is little stability yet in e-testing. The business processes are immature. Even when the e-test consists of closed response or multi-choice items, the on-screen delivery involves making design decisions on the basis of emergent thinking, not on industry best practice standards (which do not yet exist).

Speaking specifically of simulation, he observes, "The nature and extent of innovation in this type of redesign challenges psychometric expertise and wisdom." Greg Pearson, in the midst of preparing a National Academies report on assessing technology literacy, observed, "The assessment literature is mostly silent on simulation and essential psychometric issues such as reliability, validity, and precision."

Pearson identifies three circumstances essential to expanding the research base: (1) having a critical mass of opinion within the relevant communities (e.g., simulation developers, educators, assessment designers, and policymakers) that such research is needed, (2) having enough people with the requisite backgrounds and skills to do the research, and (3) funding. He points out that there is a tremendous amount of work exploring computer simulations in areas outside of K-12, such as that performed by the Department of Defense and the training industry, and asserts that these are resources of value.

Simulation work is also happening within the K-12 sector, but it tends to focus more on learning than assessment. One notable project, Multi-User Virtual Environment Experiential Simulator (MUVEES) (muve.gse.harvard.edu/muvees2003/index.html), creates a simulated, collaborative environment that multiple students can use to figure out the source of illness in a late-nineteenth-century town. Chris Dede, the lead researcher on the project, is carefully exploring what software developers call the *clickstream*—the vast range of information that can be gleaned by choices that students make. This simulation makes it possible to record and analyze mouse movements and where a student is looking on the screen. The diagnostic possibilities are astounding.

Measuring technology proficiency is a goal and a reporting requirement of NCLB. If states are motivated by this requirement to go beyond basic proficiency to address the complex skills and knowledge supported by and demonstrated by ICT tools, then states may pursue these opportunities and generate the needed research. It will require patience. Ripley explains, "We started our project to develop the ICT test for 13-year-olds in 2001. We aim to have it rolled-out to all of our secondary schools (high schools) by 2008. I do not believe that we could achieve our aims in less than seven years!"

Moving Beyond the Tag Team Development Process

Ripley observes that QCA's core team for designing a computer-based assessment "numbers around 15-20 and can be led effectively as a single team. There is no parallel in my experiences with paper-based tests, which are often developed in a linear process, with different teams (involving large numbers of people) responsible for the various stages of development, administration and marking."[12] The design scenario throws assessment and technology people together. With the right leadership, it can generate creativity.

Kemker corroborates. "Within the state of Florida," she says, "the assessment team and the technology team, in particular, are talking more and more and realizing how we can work together," to create technology literacy assessments. "It has just opened up communications between the assessment, accountability, measurement, research, and technology teams. We're working a lot closer together," she adds.

Kemker does recommend a structure for organizing the efforts of all these creative people. Asked to discuss the design process in an IAETE-sponsored panel, Kemker wrote:

> The key ingredient was to have a leader that focused on the scope of the project, or basically the project manager. This individual understands every aspect of the process, so that the focus remained the development of a performance-based tool. At times she was very strict with the group, but it was definitely needed. . . . It is critical to have the team leader be a measurement expert so that the team does not stray from the original scope of the project. In addition the team needs to be forward thinking so that the tool developed will have longevity.

Bazemore echoes both the appreciation of improved communications and the need for psychometric leadership. Recalling the experience of creating North Carolina's technology literacy assessment, Bazemore says, "It has done for technology what the alternate assessments did with exceptional children. We have come to know each other. . . . We couldn't get this job done without working collaboratively." Jim Kroening with NCDPI's Test Develop Section adds, "Those folks in the field who are local education agency test coordinators and others are now having to work with their counterparts in technology—all the way down to the school level—to make this happen, and that's never happened before."

Asked for advice to other states, Bazemore counsels, "Always remember you are building a test; you cannot compromise any of the technical properties of that test just so that you can get it online." She also advises making security, confidentiality of the data, and accessibility for every child early priorities.

What Next?

As a result of the "extreme success" of the May 2005 pilot of the Key Stage 3 project, which included 45,000 students, Martin Ripley, director of e-Assessment for QCA, says, "We have proven beyond any reasonable doubt the feasibility of running a national test on screen—and of using the sort of approach we've used on this project."

That positive feedback, he adds, "has given me a platform to voice, more clearly, my views of where we should be going next." He wants to bring simulation-based assessment to other disciplines besides ICT literacy, and he wants to start with science and language. "Science," he explains, "because. . . a virtual science laboratory is a key tool, and it is a natural extension of the programming work. . . fitting behind the work that we've done to date. . . [and] language because I think that extends our capability." Explaining that England has a required test of a scene within a Shakespeare play, Ripley says, "That, to date, has been a paper-based test, but an environment that enables us to present multimedia tasks and activities to students can get them to respond to more than the printed word of Shakespeare. You can look at production, you can look at performance issues, you can look at character and setting and casting issues, all on screen. That's more of an ambition for me—to move into that sort of area." Kemker, who has a background in music education, similarly envisions applying simulation-based assessment to music.

Experience with assessing technology literacy has also tempted Ripley to encourage the development of assessments that better pinpoint a student's decision-making process and understanding, or misunderstanding. Assessing problem-solving abilities with "micro-world assessments" is one project he has had under way since 2001.[13] In one example of a task, a student is asked to grow the world's tallest sunflower by controlling two variables: plant food A and plant food B. Explains Ripley:

> A student's response is scored by recording the greatest height that the student achieved. We didn't, in 2001, seek to define other process variables such as time taken by the student or eloquence of the method used by the student to reach the solution. Nor did we score optimization—i.e., the method(s) used by the student to determine that their sunflower could not be made to grow any taller . . . . These are all attributes that we would, if starting over with the World Class Test activities, now be seeking to score.

As North Carolina's Kroening says, "The thing that makes the online computer skills different from any other online test that's out there is the fact that there are performance tasks. It's not all about getting the right answer, but it's about how did you go about getting to the right answer?"

Notes

1. An observation from Douglas Rushkoff

2. From *ICT Literacy Assessment: An Issue Paper from ETS* (Princeton, NJ: Educational Testing Service, 2004). See http://www.ets.org/Media/Tests/Information_and_Communication_Technology_Literacy/0202heapaper.pdf

3. http://www.iteawww.org/TAA/TAA.html

4. http://www.setda.org/NLItoolkit/TLA/tla01.htm

5. http://www.ncrel.org/tech/nets/rubrics.htm

6. Partnership for 21st Century Skills. *Learning for the 21st Century. A Report and MILE Guide for 21st Century Skills.* (Washington, DC: Author, n.d.).

7. http://www.qca.org.uk/2914.html

8. M. A. Axelson. The Online Assessment of K-12 Technology Literacy, *Soapbox, 5*(2), 2005. www.edvantia.org/soapbox/

9. M. A. Axelson. The Online Assessment of K-12 Technology Literacy, *Soapbox*, 5(2), 2005. See htpp://www.edvantia.org/soapbox/

10. M. A. Axelson. *Technology for Assessment: Tackling the Policy Issues* (Charleston, WV: AEL, 2005).

11. M. A. Axelson. *Technology for Assessment: Tackling the Policy Issues* (Charleston, WV: AEL, 2005).

12. M. A. Axelson. The Online Assessment of K-12 Technology Literacy, *Soapbox, 5*(2), 2005. www.edvantia.org/soapbox/

13. See http://www.wordlclassarena.org

For more than 20 years writer and editor **Mary Axelson** has explored the potential for technology to significantly improve education. A former writing teacher at the high school and university levels, she edited *Internet Strategies for Education Markets*, a trade publication from The Heller Reports, and has authored numerous articles and reports for The Heller Reports, *Electronic School*, Find/SVP, Jupiter Communications, *New Media Magazine*, Quality Education Data, The Software Publishers Association, and other organizations. Ms. Axelson graduated *summa cum laude* from the University of Colorado at Boulder with a bachelor's degree in English. She currently moderates Soapbox, IAETE's technology-centered series of online panel discussions.

V I S I O N

Beyond Technology Competency:

A Vision of Information Communication Technology Literacy to Prepare Students for the 21st Century

Ken Kay and Margaret Honey

> The technological and business changes brought about by the Web, wireless communication and distributed work have introduced discontinuity in where and how people work, how their performance is measured, and how their objectives are set. . . . Assignments, work settings, peers, employers and work choices are increasingly changeable and fluid, . . . switching from the employer-centric world of predefined employee activity and career paths to a worker-designed world in which individuals pursue their own portfolio of experiences, assignments, workplaces, projects, task forces and teams.[1]

In a world where the relentless pursuit of technological progress has rewired not only the ever-shrinking integrated circuit but also the complex circuitry of how people work and businesses run, is it enough for our students to know how to turn on a computer and launch a program, or even how to complete a writing assignment using a word processing program?

Asking the Bigger Question

In the last decade, technology has moved out from the periphery of our lives into the everyday, becoming a pervasive part of how we live, work, and learn. Networked communications and computer technology have transformed the modern workplace dramatically, touching nearly every profession and job category, from auto mechanic to office clerk. Skills once confined to a geeky few are now basic requirements for the mainstream many. As a result, the need to prepare students not only to participate but to excel in this technology-enriched world has begun to influence the thoughts and decisions of more and more teachers, parents, and policymakers. Such preparation is critical not only to individual students' success but also to our nation's global competitiveness.

For our nation's schools, this means it is no longer sufficient to target mere technology competency—a skills-based approach focused on hardware and software operations and rooted in a narrow definition of what it means to be technologically literate. The realities of the day demand something different of our schools. As lifelong learning and versatility[2] replace lifetime employment and static skill sets, we must shed technology competency as the prevailing standard and embrace the concept of information communication technology (ICT) literacy. ICT literacy asks the bigger question: "Can students use technology to demonstrate critical learning and thinking skills?"

Building Capacity in Our Schools

It's no secret that information and innovation drive the U.S. economy.[3] These market forces also hold important implications for the U.S. education system. For many years, educators have emphasized the importance of technology in schools partly in response, albeit delayed, to the influence of technology integration in the workplace.

For example, a decade after the technology boom in business, access to computers and other technologies has mushroomed in our nation's schools. According to the *Secretary's Fourth Annual Report on Teacher Quality,* released in 2005, 99 percent of all schools have access to the Internet.[4] By comparison, only 35 percent of schools had access to computers in 1994, according to the National Center for Education Statistics (NCES). Public schools have also made consistent progress in expanding Internet access in instructional rooms. In 1994, 3 percent of public school instructional rooms had Internet access, compared with 93 percent in 2003. And between 1998 and 2003, the student-to-connected-computer ratio went from 12-to-1 to 4.4-to-1.[5]

Most early efforts to provide technology access operated on a computer lab model (a model still in use today); students would participate in one or two classes with a computer teacher per week.[6] These classes typically focused on basic computer use and were rarely connected to what students were learning in their core academic classes. Recently, educators have pushed toward a more sustainable approach to technology in education, one in which technology is integrated into curricula and learning.

The steady progression of technology use and innovation in education has clearly had an effect on students in the United States: the majority are familiar with diverse technologies and capable of operating them. Nevertheless, the difference between operating technology and applying it to solve problems and think critically is a large one. Educators who use technologies in instruction commonly require students to develop technical skills (such as using word processing programs, downloading files, and using spreadsheets) but seldom use technology as a medium for developing learning skills (such as analyzing and evaluating information from a Web site or collaborating with others to research and film a documentary). It cannot be overstated that students will be on the outside looking in if they cannot use technology to find and evaluate information in a variety of formats from numerous sources and to synthesize or otherwise use that information to support ideas or build new conceptualizations. It is vital that we teach these skills to our students *now*.

Responding to the New Paradigm

Education in the 21st century will need to go beyond the notion of technology competency and teach students to engage with technological change in productive ways. Students need to know how to use technology adaptively to solve problems and accomplish complex tasks.

We must embrace a new definition of what students need to know, one that embraces information communication technology literacy, more commonly referred to as ***ICT literacy***.[7] This broad concept—which acknowledges the need for students to develop learning skills that enable them to think critically, analyze information, comprehend new ideas, communicate, collaborate, solve problems, and make decisions—recognizes that technology is essential to realizing these learning skills in today's knowledge economy.

> Consider that today, with a $500 digital video camera and software that comes pre-installed on many computers, you can produce video content that only a few years ago would have required tens of thousands of dollars worth of equipment and highly trained technicians. This means that our communication, both personal and professional, will not be limited to text, and if writing is all our children are learning to do, then they will not be literate in the 21st century.[8]

This new paradigm of ICT literacy requires a series of changes in how we envision the skills and tools that students and educators need.

First, we recommend that the education community work with its partners in the private sector to redefine the learning skills that will make students successful citizens in the 21st century. Already, several factors are prompting business leaders, education specialists, and the general public to reexamine the skill set of U.S. students. Increased concern about the competitiveness of the U.S. labor force, the drive for more accurate assessment measures led by No Child Left Behind (NCLB), the growth of the high school reform movement, and the low-ranking performance of U.S. students on the international PISA[9] (Programme for International Student Assessment) and TIMSS[10] (Trends in International Mathematics and Science Study) tests are all fueling discussions about the need for a new 21st-century skill set. Responding to these indicators, leaders ranging from Education Secretary Margaret Spellings[11] to former Secretary of State Colin Powell[12] have signaled that today's students are not prepared to compete internationally. A critical first step is to define what skills our students need if they are to compete successfully on the global playing field. The Partnership for 21st Century Skills has begun to field that conversation.[13]

Second, educators need to revise pedagogy. How teachers are integrating technology into the classroom needs to be wholly reexamined. By replacing the goal of technology competency with the goal of ICT literacy, we challenge ourselves—whether teachers, schools of education, or states—to see technology as a set of rapidly changing tools that students actively manipulate as they develop skills in communication, critical thinking, problem solving, and information analysis.

Third, the education community will need to construct and implement new assessment tools that measure students' critical thinking skills and their ability to use information and communication technologies to demonstrate those skills.

Going with the Flow: New Opportunities, New Skills

Unlike previous generations, today's students cannot rely as heavily on teachers, librarians, or publishers to act as filters, compilers, organizers, and presenters of information who carefully pre-sort data, distill ideas, or select textbook and reference books to guide students' learning, satisfy students' demand for information, and gently lead students down the path to knowledge. Today's students encounter an unfiltered, unfettered environment marked by a free flow and free trade of information. Primary sources, statistical data sets, and mass media, once difficult to acquire and manipulate, now come in oversupply. An abundance of sources and material—of varying degrees of accuracy, usefulness, and appropriateness—are now available on the Web alone: by Google's count, more than 8 billion pages. And the amount of data continues to grow. Worldwide we create 5 exabytes (5 billion gigabytes) of unique information per year, roughly 800 megabytes (the equivalent of a 30-foot stack of printed books) for every man, woman, and child on earth. Printed documents of all kinds, however, account for only 0.003% of the total.[14]

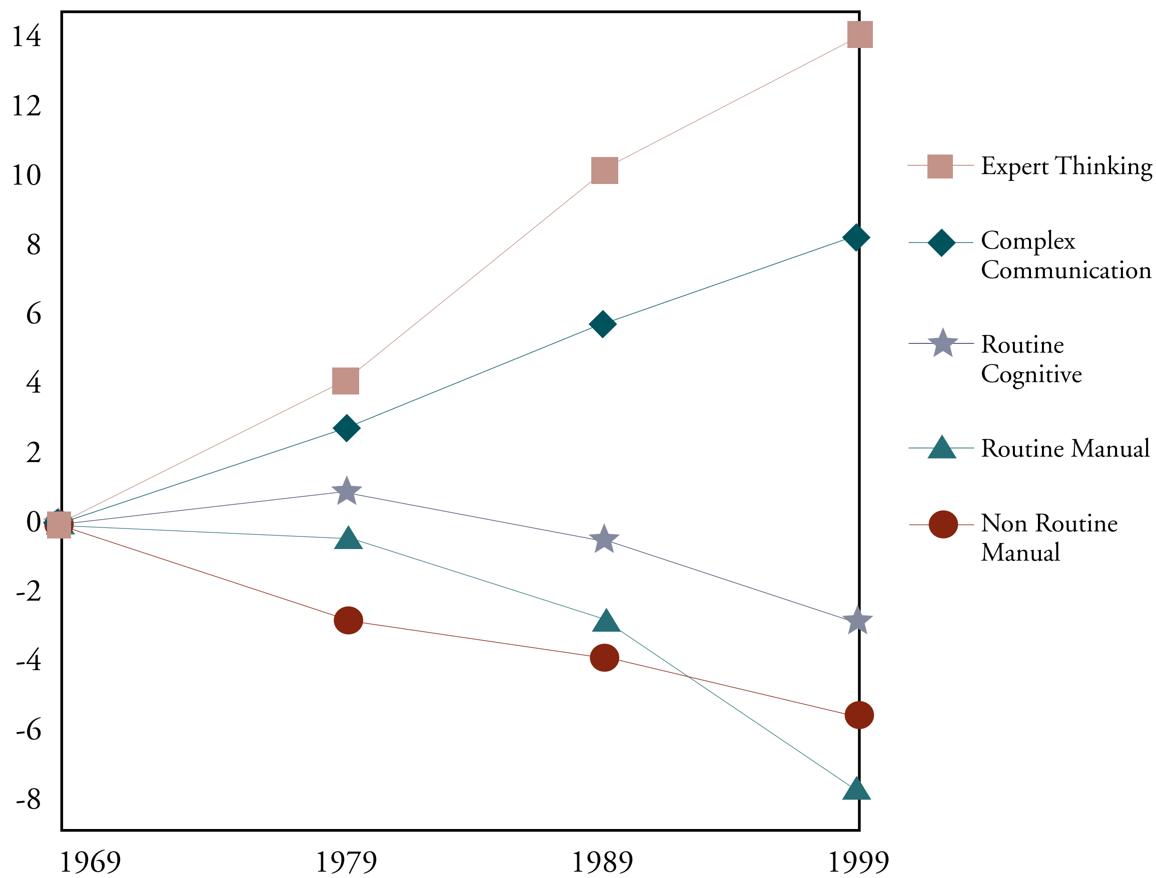
To navigate this wealth (or glut) of data, draw conclusions, and communicate with others proficiently, teachers and students require whole new sets of skills in accessing, interpreting, analyzing and evaluating complex sets of images, words, numbers, and sounds. Through ongoing conversations with leaders of policy, education, and industry, the Partnership for 21st Century Skills has identified at least six arenas of skills that are increasingly required in today's workplace and community, presenting students with new opportunities and requiring new kinds of learning skills.

1. *Communicate effectively:* Technology's progress has not brought an end to paper and pencil, but it has added to students' communications tool kit audio, video, animation, design software, and other tools as well as a host of new environments (e.g., e-mail, Web sites, message boards, blogs, streaming media). Students need to master a range of digital literacy skills to operate these tools, which require critical intellectual awareness of how to communicate effectively in a 21st-century context, a context where communication travels across a range of tools and environments, both new and traditional.

2. *Analyze and interpret data:* With so much data available today, students need to be able to look across data sets and compare, contrast, vet, and choose. They must be able to consider the relative merits of multiple sources and representations of information, because such alternatives are omnipresent.
3. *Understanding computational modeling:* Simulations and computational models (such as those used to predict election results, weather systems, or the behaviors of solar systems) have emerged as a primary means of representing information and conducting research (e.g., crash testing of automobiles, pharmaceutical design, oil exploration). Students need to understand both the power and limitations of these kinds of data representation systems. This means not only understanding how these tools can support research in a wide range of scientific disciplines, but also understanding the mathematical, computational, and content-based assumptions that underlie computational models and simulations.
4. *Managing and prioritizing tasks:* The increased presence of technology in society has necessitated a host of multitasking, selection, and prioritizing skills. Today, knowledge workers move fluidly among teams, assignments, and communities of practice within 70 percent of knowledge-based businesses.[15] Managing project-based work and collaborating within a team—skills that are expected in today's workplace—hinge on the ability to prioritize and complete tasks. Now more than ever, students need to develop and refine this ability.
5. *Engaging in problem solving:* In an information-based economy where change is constant and the value of knowledge diminishes rapidly, static answers to technical and intellectual problems no longer exist. Not only must people constantly refresh their knowledge base to stay current, but they must also develop the skill to apply past experiences and understandings to solve new problems, fulfill new assignments, and answer new questions. Students need to understand how to apply what they know to new situations.
6. *Ensuring security and safety:* With increased access comes increased risk, both to information and to people. In an environment where it takes only a few keystrokes to conduct financial transactions, engage in criminal behavior, or otherwise expose oneself to real-life risks and dangerous situations, students need to be armed with the insights and strategies to acknowledge, identify, and negotiate risk in the 21st century.

Figure 1

Economy–Wide Measures of Routine and Non Routine Task Input (1969–1998)



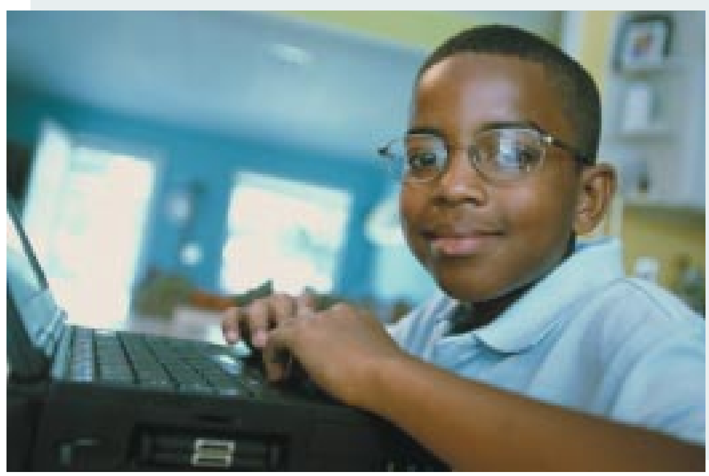
F. Levy and R. J. Murnane. *The New Division of Labor: How Computers Are Creating the Next Labor Market* (Princeton, NJ: Princeton University Press, 2004, page 50). (Used by permission.)

The stakes are high. Young people who lack the ability to negotiate their way through the clutter face the prospect of limited success not only in school but also in contemporary society and in the workplace, as learning skills and technology now intersect nearly every endeavor people encounter (see Figure 1). Leaders should be alarmed that today's students are preparing for tomorrow's society and workplace on yesterday's technology. After all, technology is not static. Technology continues to change, grow, and expand every day—creating opportunities for application where none previously existed and adding new requirements to what people need to know to fulfill their roles as citizens. Merely learning the technical skills to operate existing technologies, which are likely to be outstripped by the time students reach working age, falls considerably short of preparing them to succeed.

With fields transformed sometimes overnight by technology, businesses, entrepreneurs, employees, and *teachers and students alike* must embrace, adapt to, exploit, and anticipate technology to remain competitive; otherwise they risk obsolescence. Students face an economic environment in which the prospects of continuous, lifetime employment and a single-profession career are dim at best,[16] an environment in which the ability to receive ongoing training will play a pivotal role in their lives.[17] In 21st-century society, only the ICT literate—those who resourcefully combine technical skills with an intellectual tool box enriched with experiences, collaboration, and knowledge—will be able to meet the challenges imposed by a global playing field.[18]

Gaining Traction: The Role of Assessments in ICT Literacy

Defining ICT literacy and standards will be vital to creating learning environments that foster 21st-century skills. However, efforts to encourage the development and application of ICT literacy skills will languish unless viable assessments of student achievement are created. The challenge of measuring 21st-century skills will be to develop complex, real-world tasks that capture students' thinking. Standardized tests capture only a portion of the skills and knowledge that students need to know, and they do not access how students apply those skills or knowledge to solving problems. Therefore, these assessments are of limited value in gauging ICT literacy and in helping teachers make decisions about how to improve learning in the context of daily instruction. Instead, 21st-century assessments should offer teachers ongoing diagnostic information that could be used to develop students' learning over time *and* summative outcomes that quantify students' progress to date.



Measuring 21st-century skills necessitates a shift in assessment from measuring discrete knowledge and skills to measuring their *application*—the ability to think critically; examine problems; gather information; and make informed, reasoned decisions. To achieve this, we need a sustainable research and development infrastructure for measuring complex and real-world tasks, one that is coherent across all education levels.

Currently, Educational Testing Service (ETS) provides an assessment of ICT literacy, but only for higher education. The International Society for Technology in Education (ISTE) and Microsoft are developing a performance-based assessment aimed directly at eighth grade, the NETS Online Technology Assessment. Other existing assessments are designed for niche markets (such as economic and financial literacy, civic engagement, or global awareness) that may incorporate technology in their presentation. We need widely available assessment tools that are meaningful in what they measure and in the kind of information/feedback they offer. These measures need to address how students perform in complex, real-world tasks; diagnose students' needs for ICT literacy intervention; assess the education system's effectiveness in teaching ICT literacy skills; and permit students to demonstrate their proficiency in ITC literacy skills to educational institutions and prospective employers.

Meeting the International Community's Challenge

Without a comprehensive plan for 21st-century assessment, U.S. students will continue to lag behind their international counterparts in industrialized countries, who now outperform them on international assessments of 21st-century skills. Two-thirds of non-U.S. 15-year-olds performed better than U.S. students on the PISA, a test designed to measure how students apply reading, mathematics, and science content knowledge and skills in analyzing and evaluating information and solving problems and issues in real-life contexts. The PISA results show that our economic competitors recognize the interrelatedness of education reform, 21st-century skills, and competitiveness in the global economy and are taking action. Many countries have already begun the process of building 21st-century skills into their national education plans, while creating standards and assessment systems designed specifically to measure students' application of 21st-century skills.

Britain's Key Stage 3 (ages 12-13) ICT Literacy Assessment is an emerging tool that provides a good starting point for a discussion of what 21st-century skills assessment should resemble. Key Stage 3 measures content-area and thinking skills using technology and provides national data on students' capabilities and disaggregated data on individual students. Administered online, the Key Stage 3 assessment requires students to use

The concept of **technology competency** or **proficiency** became popular when microcomputers were introduced in the nation's classrooms in the 1980s. This concept concerns basic skills and knowledge related to hardware and software. Early courses on computer skills often focused on basic operations, troubleshooting, and programming in languages such as BASIC.

21st Century Learning Skills, as described by the Partnership for 21st Century Skills, can be divided into three categories: thinking and problem-solving skills, information and communication, and interpersonal and self-direction.

ICT literacy links 21st-century skills to information communication technology (ICT) tools—tools that can change over time—to support the development of and demonstration of critical thinking skills and higher-order cognition. Examples given of ICT literacy, according to the Partnership for 21st Century Skills, include the use of ICT to solve problems, to demonstrate creative ideas or thoughts, to access and evaluate information, or to enhance productivity and personal development.

their ICT literacy skills to solve a set of complex problems involving research, communication, information management, and presentation. Test activities take place within a "virtual town" environment that includes various visual and informational assets (text, pictures, data, and "canned" Web sites) and a tool kit of generic software programs developed by the British government's Qualifications and Curriculum Authority. These software programs provide the same capabilities as familiar productivity software without introducing specific platform brand bias.

In one task, students must draft and publish a journalistic article investigating the ethnic diversity of a small town's police force and teaching pool. In the course of their work, students use search engines; navigate Web-based information sources; exchange e-mails with content experts; and employ spreadsheets, word processors, and presentation software to analyze and present their research. They must collect and analyze employment data, secure source permissions via e-mail, and present research data in both graphic and written form. Simultaneously, the Key Stage 3's assessment engine tracks and responds to the test-taker's performance on both technical and problem-solving tasks by mapping their actions against the technical skills and learning skills they are expected to demonstrate at each level of the national curriculum. The test engine's final output includes both a numerical score (useful for national ranking purposes) and a detailed profile of the test-taker's performance and areas for potential improvement.

This particular assessment tool, while a significant step forward on the path toward assessing 21st-century skills and learning, is only a start. It signals an important trend in assessment development that the United States would be wise to follow. It also presents an opportunity. With few assessment tools as ambitious as the Key Stage 3 assessment in existence, a concerted national effort to craft ICT literacy standards and the means to measure students' level of ICT literacy could position us to leapfrog our economic competitors and help safeguard our leadership position in the world economy. To help achieve this vision, we offer the following roadmap.

Achieving ICT Literacy in the United States: A Roadmap

The concept of ICT literacy acknowledges technology as a constantly evolving and ubiquitous tool that can be used to accomplish a multitude of tasks. Teaching ICT literacy skills effectively in schools requires that we alter how we think about learning and technology, migrating our focus from technology competency to ICT literacy. This transition hinges on a comprehensive reexamination of four major areas: public policy, standards, assessment, and research and development. Key questions and suggestions in each area follow.

Public policy. Public policy will set the tone for the transition from technology competency to ICT literacy in our schools. Building consensus among lawmakers and other stakeholders is critical to implementing policies that support ICT literacy standards, assessment, professional development, and research and development.

First, citizens and leaders alike must recognize that effective education policy in the 21st-century needs to acknowledge the real-world transition from school to life and work by focusing on ICT literacy. Opening up a dialogue between the private and public sectors will help strengthen the idea that students are in a "pipeline" that carries them from school into the workplace and society at large. ICT-literate students will be able to think critically, solve problems, and communicate effectively—skills that will be vitally important to their success in and out of school.

The federal government also plays a critical role in public policy, and it is currently in an important position to change technology learning standards. While the No Child Left Behind Act of 2001 (NCLB) established an eighth-grade technology literacy requirement, the requirement is not a full statement of ICT literacy and does not include a mechanism for ensuring accountability.

What steps can be taken to ensure that ICT literacy is recognized and supported by state and federal policy? By taking the lead in revising the eighth-grade technology literacy requirement, adopting a national standard consistent with ICT literacy, and establishing clear guidelines for assessing states' progress in meeting the standard, the U.S. Department of Education could move ICT literacy forward. Such revisions could be included in the reauthorization of NCLB in 2007. When this reauthorization comes up, the education community, as well as state and federal departments of education, can urge Congress to modify the legislation to include the complete ICT standard and accountability mechanism. Furthermore, educators and policymakers at all levels can establish mechanisms that hold schools accountable to the ICT literacy standards by providing them with the tools and skills to teach and assess ICT literacy effectively.

Standards. It is important to student success that every state adopt and embed into core curricula a set of standards for ICT literacy by 2010. These standards should be comprehensive and crosscutting. They should also transcend the speed at which technology changes by focusing on skills that would apply to any technological tool. For example, one of the ICT literacy standards developed by the Partnership for 21st Century Skills is using technology to communicate effectively. This standard would apply to current technologies, such as presentation software or handheld devices such as portable digital assistants (PDAs), as well as to future technologies.

While ICT literacy standards should emphasize the skills that technology facilitates, and not the technology itself, it is critical to recognize that the *implementations* of the standards are not static. As technology evolves, educators will need to revisit the way that ICT standards are implemented. The business community will be an important partner in that business leaders can help educators understand how technology is changing, and this knowledge can help educators implement ICT literacy in schools.

How can states embark on the task of generating new standards for ICT literacy? Who should be involved? First, organizations in a position to define ICT literacy, such as the State Educational Technology Directors Association (SETDA), the International Society for Technology in Education (ISTE), and the Partnership for 21st Century Skills, need to meet and agree on standards for ICT literacy that feature the use of technology to acquire and demonstrate learning and learning skills. While developing these standards may sound daunting, the skills described by these standards will be content independent, meaning they will apply across content areas and can be addressed at every grade level.

Second, state education leaders and technology directors are encouraged to examine efforts to create assessments of ICT literacy in the United States and the United Kingdom to determine the degree to which current and emerging online assessment tools can be aligned with the standards.

Third, state education leaders and technology directors need to develop a strategy for periodically consulting the broader business community for advice on the specific technologies most closely associated with the learning skills identified in the standards. This relationship between business leaders and educators recognizes that while skills encapsulated in ICT literacy standards are likely to remain relatively constant, the technologies involved will likely change every few years. For example, if students need to demonstrate their ability to effectively communicate in a 21st-century context, their performance should be demonstrated by using industry-standard tools to address realistic and relevant issues. While the principles of good communication, as embodied in the standards, aren't likely to change, the modes of effective communication, as identified by the business community, will change over time.

Comparison of Skills Across Approaches

Tech Competency Examples	NETS–S Standards[19]	ETS ICT Literacy Skills[20]	21st Century Skills ICT Literacy Model[21]
This commonly used approach is based on operating different tools and emphasizes the following: • Basic computer operating skills • Use of technology for rote memorization • Repetitive use of software without adaptation to task • Use of technology to gather undifferentiated information	Student technology foundation skills are organized under six broad skill categories: • Basic operations and concepts • Social, ethical, and human issues • Technology productivity tools • Technology communications tools • Technology research tools • Technology problem-solving and decision-making tools	Comprehensive test of ICT proficiency for the higher education environment. Offered at two levels of difficulty; test-takers use technology to demonstrate seven proficiencies: • Define • Access • Manage • Integrate • Evaluate • Create • Communicate	Emphasizes the ability of a student to use technology to demonstrate the following: • Critical thinking • Problem solving • Communication • Collaboration • Project management • Global awareness • Civic engagement • Business and financial literacy

Assessment. Although the federal government has emphasized assessments for the purpose of accountability as demonstrated by the need for schools to measure and report adequate yearly progress (AYP), current assessments do not measure the skills our students need for the 21st century. In response, the Partnership for 21st Century Skills has worked to build consensus around ICT literacy and has articulated a plan for 21st-century assessments:

> The creation of diagnostic, formative, and summative assessments that measure students' content knowledge, skill development, and ICT literacy present an important opportunity to feed a variety of assessment data back into our nation's school systems at their appropriate levels, from the trend and pattern data needed by policy makers, state officials, and district administrators to the individual and class level student data on particular tasks, skills, and topics needed by classroom teachers, students, and parents. While creating more diagnostic, performance-based measures requires some investment, embracing the teaching and assessment of 21st century skills presents us with a unique opportunity to leap ahead of our competition in the global community. The Partnership [for 21st Century Skills] believes that the movement to embrace 21st century skills will be greatly enhanced by identifying ways to measure these skills. Conversely, the lack of such assessments will hinder progress toward widespread adoption of 21st century skills.[22]

As the Partnership for 21st Century Skills indicates, it is critical that the nation's investment in assessment development, which is expected to reach several billion dollars[23] between fiscal years 2002 and 2008, focus not only on fulfilling the federal mandate, but also on addressing our children's ICT literacy skills. The private sector has a critical role to play in developing ICT literacy assessments. The for-profit assessment community's experience in assessment design makes it an important partner for educators who need to develop effective ways to assess ICT literacy—an indicator of children's preparedness to meet the demands of tomorrow's workplace and global community.

How can states address the need for ICT literacy assessments? Can the private sector be more involved in developing ICT literacy assessments? Bridges must be built between the educators who will administer assessments, the policymakers who want reports on assessments, and the private sector that will be called on to develop those assessments. Private sector companies are beginning to measure ICT literacy within higher education. States could capitalize on these efforts and create testbeds for these tools in the K-12 environment. It is important that state education leaders examine the pioneering investments being made by the United Kingdom in ICT literacy assessment and draw on these ideas to create similar measures here. Another possibility would be meeting with private sector companies in the United States to better understand their capabilities in measuring ICT literacy and offering to help them create pilot projects that foster the creation of ICT literacy assessments. In conjunction with these efforts to foster connections between assessment developers and schools, a robust dissemination mechanism needs to be established that allows states to tap into the results of these pilot collaborations. The Institute for the Advancement of Emerging Technologies in Education (IAETE) at AEL has taken some initial steps through its annual conference series on technology-supported assessments (www.edvantia.org/publications/index1.cfm?&section=publications&area=publications&id=631). The Partnership for 21st Century Skills has also launched an online database, Assess 21 (www.21stcenturyskills.org/assess21/) for tracking the creation of ICT literacy assessments worldwide across key 21st-century dimensions.

Research and development. Building an education system that effectively teaches ICT literacy will require a national research and development infrastructure for developing standards for teaching as well as assessments of learning cognitively complex and real-world-related tasks. Currently, there is not a sufficient foundation of research and development to support the full range of tools that could be used to teach and assess ICT literacy in the 21st century.

The federal government could assume an important leadership role in establishing this infrastructure to ensure high-quality, cutting-edge research. Other governments around the world have already begun to make these investments. A commitment to funding research on ICT literacy and 21st-century skills will help to facilitate a more uniform approach to teaching and measuring ICT literacy nationwide. The federal government could also work with state and local leaders to develop ICT literacy tools and assessments and to build the infrastructure and action agenda necessary for implementation. Education research institutions, both in higher education and in the public sector, can also play a role in the production of research and development for ICT literacy.

How do we foster a national research agenda in ICT literacy? National and state education leaders and the business community need to make a clear and consistent case for ICT literacy's critical role in our educational systems, present and future—a case that commands a higher priority in our nation's schools, schools of education, and communities. Increasing federal funding will be needed to meet the challenge head-on and to create real momentum for change. At the same time, education agencies need to cooperate broadly and specifically to develop strategies that maximize and extend existing resources in teaching ICT literacy.

2015: An Education Odyssey

Shifting the focus in education from technology competency to ICT literacy is a daunting yet necessary task. However, embracing ICT literacy as a goal worthy of pursuit will require philosophical changes in terms of how we prepare children in schools, financial changes related to public policy and research and development, and organizational changes related to the way schools are structured for 21st-century learning. These changes are well worth the investment of stakeholders who are committed to preparing the nation and its students for success in the 21st century. Twenty years from now, we may look back on the term *technology competency* the way we look back today at rote memorization—as a lower-level skill that simply does not prepare young people for today's technology-driven, global society. With a well-coordinated roadmap and a vision of what a new culture of learning reinforced by 21st-century skills and assessments will offer, ICT literacy will be an achievable goal.

Notes

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