Comparing Frameworks for "21st Century Skills"

Chris Dede
Harvard Graduate School of Education
July, 2009

Many groups have called for all students to learn "21st century skills." In response, some organizations have developed, as part of their institutional brand, frameworks for the new millennium content and processes teachers should convey as part of students' schooling. How diverse are these definitions for "21st century skills," and is the term becoming an umbrella phrase under which advocates from various groups can argue for almost any type of knowledge? Lack of clarity about the nature of 21st century skills would be problematic, since many educational reforms have failed because of a reverse Tower-of-Babel problem, in which people use the same words, but mean quite different things. What do the various frameworks for 21st century skills have in common, and what does each uniquely add to an overarching conception about the knowledge that graduates at this time in history should have as effective workers and citizens? After defining the nature of 21st century skills, this chapter provides a comparison of the themes major organizations' frameworks are presenting about what students need to know for full participation in the 21st century.

The Rationale for Formulating "21st Century Skills"

The 21st century is quite different than the 20th in the capabilities people need for work, citizenship, and self-actualization. 21st century skills are different than 20th century skills primarily due to the emergence of very sophisticated information and communications technologies. For example, the types of work done by people—as opposed to the kinds of labor done by machines—are continually shifting as computers and telecommunications expand their capabilities to accomplish human tasks. Economists Frank Levy and Richard Murnane (2004) highlighted a crucial component of what constitutes 21st century knowledge and skills:

> Declining portions of the labor force are engaged in jobs that consist primarily of routine cognitive work and routine manual labor—the types of tasks that are easiest to program computers to do. Growing proportions of the nation's labor force are engaged in jobs that emphasize expert thinking or complex communication—tasks that computers cannot do. (pp. 53–54)

These economists went on to explain that "expert thinking [involves] effective pattern matching based on detailed knowledge; and metacognition, the set of skills used by the stumped expert to decide when to give up on one strategy and what to try next" (Levy & Murnane, 2004, p. 75). What a skilled physician does when all diagnostic are within normal limits, but the patient is still feeling unwell is expert decision making: inventing new problem solving heuristics when all standard protocols have failed. "Complex communication requires the exchange of vast amounts of verbal and nonverbal information. The information flow is constantly adjusted as the communication evolves unpredictably" (Levy & Munane, 2004, p. 94). A skilled teacher is an expert in complex

communication, able to improvise answers and facilitate dialogue in the unpredictable, chaotic flow of classroom discussion.

As another illustration of how 21st century skills differ from the knowledge communicated by schooling through the 20th century, sophisticated information and communication technologies are changing the nature of "perennial" skills valuable throughout history, as well as creating new "contextual" skills unique to new millennium work and citizenship (Dede, in press). For example, "collaboration" is a perennial capability, always valued as a trait in workplaces across the centuries. Therefore, the fundamental worth of this suite of interpersonal skills is not unique to the 21st century economic context. However, the degree of importance for collaborative capacity is growing in an era where work in knowledge-based economies is increasingly accomplished by teams of people with complementary expertise and roles, as opposed to individuals doing isolated work in an industrial setting (Karoly, 2004).

Further, the nature of collaboration is shifting to a more sophisticated skillset. In addition to collaborating face-to-face with colleagues across a conference table, 21st century workers increasingly accomplish tasks through mediated interactions with peers halfway across the world whom they may never meet face-to-face. Thus, even though perennial in nature, collaboration is worthy of inclusion as a 21st century skill because the importance of cooperative interpersonal capabilities is higher and the skills involved are more sophisticated than in the prior industrial era.

In contrast, the ability to rapidly filter huge amounts of incoming data, extracting information valuable for decision making, is a "contextual" capability. Due to the prevalence of information and communications technologies, for the first time in human history people are inundated by enormous amounts of data that they must access, manage, integrate, and evaluate. Rather than rummaging through library stacks to find a few pieces of knowledge, an activity characteristic of information access in the 20th century, users of modern search engines receive thousands or even millions of "hits." However, many of these resources are off-target, incomplete, inconsistent, and perhaps even biased. The ability to separate signal from noise in a potentially overwhelming flood of incoming data is a suite of 21st century skills not in degree – because this is novel in history as a valuable capability – but in type.

Weinberger (2007) describes the power of "digital disorder," which takes advantage of the fact that virtual information can transcend the limited properties of physical objects (like books or index cards). Rather than relying on a single method of organization with a fixed terminology (such as the Dewey Decimal System as a means of categorizing knowledge), modern information systems now can respond to natural language queries and can instantly sort digital data into whatever category structure best suits a particular person's immediate needs. This creates a new set of contextual 21st century skills centered on "disorderly" knowledge co-creation and sharing.

Overall, the distinction between perennial and contextual skills is important because, unlike perennial capabilities, new, contextual types of human performances are typically not part of the legacy curriculum inherited from 20th century educational systems. Conventional, 20th century K-12 instruction emphasizes manipulating pre-digested information to build fluency in routine problem solving, rather than filtering data

derived from experiences in complex settings to develop skills in sophisticated problem finding. Knowledge is separated from skills and presented as revealed truth, not as an understanding that is discovered and constructed; this separation results in students learning data about a topic rather than learning how to extend their understand beyond information available for assimilation. Also, in 20th century instruction, problem solving skills are presented in an abstract form removed from their application to knowledge; this makes transfer to real world situations difficult. The ultimate objective of education is presented as learning a specific problem solving routine to match every situation, rather than developing expert decision making and metacognitive strategies that indicate how to proceed when no standard approach seems applicable.

In the legacy curriculum, little time is spent on building capabilities in group interpretation, negotiation of shared meaning, and co-construction of problem resolutions. The communication skills stressed are those of simple presentation, rather than the capacity to engage in richly structured interactions that articulate perspectives unfamiliar to the audience. Face-to-face communication is seen as the "gold standard," so students develop few capabilities in mediated dialogue and in shared design within a common virtual workspace.

Given that the curriculum is already crowded, a major political challenge is articulating what to deemphasize in the curriculum – and why – in order to make room for students to deeply master core 21st century understandings and performances. This is not a situation in which one must eliminate an equivalent amount of current curriculum for each 21st century understanding added, because better pedagogical methods can lead to faster mastery and improved retention, enabling less reteaching and more coverage within the same timeframe (Van Lehn and the Pittsburgh Science of Learning Center, 2006). However, what education should emphasize as its core outcomes is politically controversial even if substantial sections of the 20th century legacy curriculum are not eliminated.

Beyond curricular issues, classrooms today typically lack 21st century learning and teaching in part because high-stakes tests do not assess these competencies. Assessments and tests focus on measuring students' fluency in various abstract, routine skills, but typically do not assess their strategies for expert decision making when no standard approach seems applicable. Essays emphasize simple presentation rather than sophisticated forms of rhetorical interaction. Students' abilities to transfer their understandings to real world situations are not assessed, nor are capabilities related to various aspects of teamwork. The use of technological applications and representations is generally banned from testing, rather than measuring students' capacities to use tools, applications, and media effectively. Abilities to effectively utilize various forms of mediated interaction are typically not assessed. As discussed later, valid, reliable, practical assessments of 21st century skills are needed to improve this situation.

Lack of professional development is another reason 21st century skills are underemphasized in today's schooling. Providing educators with opportunities to learn about the ideas and strategies discussed in this volume is only part of the issue. A major, often unrecognized challenge in professional development is helping teachers, policy makers, and local communities unlearn the beliefs, values, assumptions, and cultures underlying schools' industrial-era operating practices, such as forty-five minute class

periods that allow insufficient time for all but superficial forms of active learning by students. Altering deeply ingrained and strongly reinforced rituals of schooling takes more than the superficial interchanges typical in "make and take" professional development or school board meetings. Intellectual, emotional, and social support is essential for "unlearning" and for transformational relearning that can lead to deeper behavioral changes to create next-generation educational practices. Educators, business executives, politicians, and the general public have much to unlearn if 21st century understandings are to assume a central place in schooling.

Reflecting educators' usage of 20th century pedagogy, current approaches to using technology in schooling largely reflect applying information and communication technologies as a means of increasing the effectiveness of traditional, 20th century instructional approaches: enhancing productivity through tools such as word processors, aiding communication by channels such as email and threaded asynchronous discussions, and expanding access to information via Web-browsers and streaming video (Dede, 2009a). All these have proven worthy in conventional schooling, as they have in workplace settings; however, none draw on the full power of information and communications technologies for individual and collective expression, experience, and interpretation – human capabilities emerging as key work and life skills for the first part of the 21st century. So how are various organizations that advocate for 21st century skills formulating these capabilities?

Current Major Frameworks for 21st Century Skills

Current conceptual frameworks for "21st Century Skills" include the Partnership for 21st Century Skills (2006), the Metiri Group and NCREL (2003), the American Association of Colleges and Universities (2007), and the Organization for Economic Cooperation and Development (2005). In the particular area of information and communications technology, which as discussed above is richly interwoven with 21st century skills, 21st century frameworks include the revised ISTE student standards for technology in the curriculum (2007), as well as digital literacy standards from the Educational Testing Service ICT Literacy Panel (2007). Individual scholars such as Dede (2005) and Jenkins et al (2006) have also formulated lists of "digital literacies" that complement reading, writing, and mathematics as core capabilities for the 21st century. In the boxes that follow, highlights of each framework are presented, followed by an analysis of what each formulation adds to the Project for 21st Century Skills (P21) framework.

The Partnership for 21st Century Skills Framework (2006) and P21's many ancillary publications produced since then serve as a baseline for this analysis because P21's conceptualization of 21st Century skills is more detailed and more widely adopted than any of the alternatives discussed later. For reasons of space, this chapter can present only a bare-bones outline of the P21 framework, which the reader is urged to browse in order to comprehend its full extent (http://www.21stcenturyskills.org).

Partnership for 21st Century Skills (P21)

Core subjects. The No Child Left Behind Act of 2001, which reauthorizes the Elementary and Secondary Education Act of 1965, identifies the core subjects as English, reading or language

arts; mathematics; science; foreign languages; civics; government; economics; arts; history; and geography.

21st century content. Several significant, emerging content areas are critical to success in communities and workplaces. These content areas typically are not emphasized in schools today:
• Global awareness
• Financial, economic, business and entrepreneurial literacy
• Civic literacy
• Health and wellness awareness

Learning and thinking skills. As much as students need to learn academic content, they also need to know how to keep learning — and make effective and innovative use of what they know — throughout their lives. Learning and thinking skills are comprised of:
• Critical-thinking and problem-solving skills
• Communication skills
• Creativity and innovation skills
• Collaboration skills
• Contextual learning skills
• Information and media literacy skills

ICT literacy. Information and communications technology (ICT) literacy is the ability to use technology to develop 21st century content knowledge and skills, in the context of learning core subjects. Students must be able to use technology to learn content and skills — so that they know *how* to learn, think critically, solve problems, use information, communicate, innovate and collaborate.

Life skills. Good teachers have always incorporated life skills into their pedagogy. The challenge today is to incorporate these essential skills into schools deliberately, strategically and broadly. Life skills include:
• Leadership
• Ethics
• Accountability
• Adaptability
• Personal productivity
• Personal responsibility
• People skills
• Self-direction
• Social responsibility

21st century assessments. Authentic 21st century assessments are the essential foundation of a 21st century education. Assessments must measure all five results that matter — core subjects; 21st century content; learning and thinking skills; ICT literacy; and life skills. Assessment of 21st century skills should be integrated with assessments of core subjects. Separate assessments would defeat the purpose of infusing 21st century skills into core subjects. To be effective, sustainable and affordable, assessments must use modern technologies to increase efficiency and timeliness. Standardized tests alone can measure only a few of the important skills and knowledge students should learn. A balance of assessments, including high-quality standardized testing along with effective classroom assessments, offers students and teachers a powerful tool to master the content and skills central to success.

In contrast to the P21 framework used as baseline in this analysis, in 2003 the Metiri Group and NCREL produced a 21st century skills framework that pre-dated P21:

EnGauge Framework from Metiri/NCREL

Digital-Age Literacy
• Basic, Scientific, Economic, and Technological Literacies
• Visual and Information Literacies
• Multicultural Literacy and Global Awareness

Inventive Thinking
• Adaptability, Managing Complexity, and Self-Direction
• Curiosity, Creativity, and Risk Taking
• Higher-Order Thinking and Sound Reasoning

Effective Communication
• Teaming, Collaboration, and Interpersonal Skills
• Personal, Social, and Civic Responsibility
• Interactive Communication

High Productivity
• Prioritizing, Planning, and Managing for Results
• Effective Use of Real-World Tools
• Ability to Produce Relevant, High-Quality Products

The EnGauge Framework adds "visual literacy" as related to information literacy. "Curiosity" and "risk taking" are included as core skills, as is "managing complexity." "Prioritizing, planning, and managing for results" is stressed. "Multicultural literacy" is an explicit component. With the exception of the "Effective Communication" category, this shorter list focuses less than does P21 on the overlap with 20th century curriculum. More emphasis is placed on new contextual skills and knowledge.

In 2005, the Organization for Economic Cooperation and Development provided its conception of 21st century skills:

Organization for Economic Cooperation and Development

Competency Category 1: Using Tools Interactively
A. Use language, symbols and texts interactively
B. Use knowledge and information interactively
C. Use technology interactively

Competency Category 2: Interacting in Heterogeneous Groups
A. Relate well to others
B. Co-operate, work in teams
C. Manage and resolve conflicts

Competency Category 3: Acting Autonomously
A. Act within the big picture
B. Form and conduct life plans and personal projects
C. Defend and assert rights, interests, limits and needs.

The OECD competencies highlight "using language, symbols, and texts," as well as "managing and resolving conflicts." "Acting autonomously" is a major category in this framework that includes "life plans" and "defending and asserting rights, interests, limits, and needs." This framework focuses less than P21 on overlaps with the 20th century curriculum and, like the Metiri/NCREL skillset, more on new contextual skills. Affective and psychosocial skills receive greater emphasis than in frameworks generated by US organizations.

In 2007, the American Association of Colleges and Universities developed a framework delineating the 21st century skills graduates of higher education should attain:

American Association of College and Universities

The Essential Learning Outcomes

Beginning in school, and continuing at successively higher levels across their college studies, students should prepare for twenty-first-century challenges by gaining:

Knowledge of Human Cultures and the Physical and Natural World
• Through study in the sciences and mathematics, social sciences, humanities, histories, languages, and the arts

Focused by engagement with big questions, both contemporary and enduring

Intellectual and Practical Skills, including
• Inquiry and analysis
• Critical and creative thinking
• Written and oral communication
• Quantitative literacy
• Information literacy
• Teamwork and problem solving

Practiced extensively, across the curriculum, in the context of progressively more challenging problems, projects, and standards for performance

Personal and Social Responsibility, including
• Civic knowledge and engagement—local and global
• Intercultural knowledge and competence
• Ethical reasoning and action
• Foundations and skills for lifelong learning

Anchored through active involvement with diverse communities and real-world challenges

Integrative Learning, including
• Synthesis and advanced accomplishment across general and specialized studies

Demonstrated through the application of knowledge, skills, and responsibilities to new settings and complex problems

The AACU college-level essential learning outcomes (presumably developed as a foundation in K-12 schooling) add "knowledge of human cultures" to the P21 framework. This skillset stresses "engagement with big questions, both contemporary and enduring," an intellectual capability that higher education has long sought to inculcate. "Inquiry" and "quantitative analysis" are specifically cited as important analytic skills. Learning by doing, rather than by assimilation of information, is tacitly stressed in the language the AACU uses.

Current Conceptual Frameworks for Digital Literacies

In part to emphasize the ways in which information and communications technology skills are central to the 21st century, in 2007 the International Society for Technology in Education (ISTE) revised its student standards for technology in the curriculum:

International Society for Technology in Education ICT Skills

1. Creativity and Innovation
Students demonstrate creative thinking, construct knowledge, and develop innovative products and processes using technology. Students:
a. apply existing knowledge to generate new ideas, products, or processes.
b. create original works as a means of personal or group expression.
c. use models and simulations to explore complex systems and issues.
d. identify trends and forecast possibilities.

2. Communication and Collaboration

Students use digital media and environments to communicate and work collaboratively, including at a distance, to support individual learning and contribute to the learning of others. Students:
a. interact, collaborate, and publish with peers, experts, or others employing a variety of digital environments and media.
b. communicate information and ideas effectively to multiple audiences using a variety of media and formats.
c. develop cultural understanding and global awareness by engaging with learners of other cultures.
d. contribute to project teams to produce original works or solve problems.

3. Research and Information Fluency
Students apply digital tools to gather, evaluate, and use information. Students:
a. plan strategies to guide inquiry.
b. locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media.
c. evaluate and select information sources and digital tools based on the appropriateness to specific tasks.
d. process data and report results.

4. Critical Thinking, Problem Solving, and Decision Making
Students use critical thinking skills to plan and conduct research, manage projects, solve problems, and make informed decisions using appropriate digital tools and resources. Students:
a. identify and define authentic problems and significant questions for investigation.
b. plan and manage activities to develop a solution or complete a project.
c. collect and analyze data to identify solutions and/or make informed decisions.
d. use multiple processes and diverse perspectives to explore alternative solutions.

5. Digital Citizenship
Students understand human, cultural, and societal issues related to technology and practice legal and ethical behavior. Students:
a. advocate and practice safe, legal, and responsible use of information and technology.
b. exhibit a positive attitude toward using technology that supports collaboration, learning, and productivity.
c. demonstrate personal responsibility for lifelong learning.
d. exhibit leadership for digital citizenship.

6. Technology Operations and Concepts
Students demonstrate a sound understanding of technology concepts, systems, and operations. Students:
a. understand and use technology systems.
b. select and use applications effectively and productively.
c. troubleshoot systems and applications.
d. transfer current knowledge to learning of new technologies.

Beyond P21, the ISTE ICT skills stress “creating original works as a means of personal or group expression,” “using models and simulations to explore complex systems and issues,” and “identifying trends and forecasting possibilities.” Other capabilities include “identifying and defining authentic problems and significant questions for investigation” and “using multiple processes and diverse perspectives to explore alternative solutions.” “Safe, legal” use of information and technology is highlighted, as is “digital citizenship.” “Troubleshooting systems and applications” and “transferring current knowledge to learning of new technologies” are seen as key skills. As might be expected, the digital literacies this educational technology organization articulates are more detailed than those in the overall P21 framework.

In a similar vein, in 2007 the Educational Testing Service (ETS) ICT Literacy Panel released its digital literacy standards:

Educational Testing Service ICT Literacy

ICT LITERACY

ICT Proficiency

Access Manage Integrate Evaluate Create

Cognitive Proficiency Technical Proficiency

Cognitive Proficiency — the desired *foundational skills* of everyday life at school, at home, and at work. Literacy, numeracy, problem solving, and spatial/visual literacy demonstrate these proficiencies.

Technical Proficiency — the basic components of digital literacy. It includes a foundational knowledge of hardware, software applications, networks, and elements of digital technology.

ICT Proficiency — the integration and application of cognitive and technical skills. ICT proficiencies are seen as enablers; that is, they allow individuals to maximize the capabilities of technology. At the highest level, ICT proficiencies result in innovation, individual transformation, and societal change.

As an illustration of the five levels listed above (2007, pg. 20):

Access Select and open appropriate e-mails from inbox list.

Manage Identify and organize the relevant information in each e-mail.

Integrate Summarize the interest in the courses provided by the company.

Evaluate Decide which courses should be continued next year, based on last year's attendance.

Create Write up your recommendation in the form of an e-mail to the vice president of human resources.

The ETS Digital Literacy skills add "technical proficiency: a foundational knowledge of hardware, software applications, networks, and elements of digital technology." The example digital literacy activities provided in this framework seem less sophisticated than those implied by the other frameworks analyzed; the illustration is closer in spirit to the ISTE framework for digital literacies developed in the late 1990s.

As the ISTE and ECS ICT frameworks suggest, much of what distinguishes 21st century skills from 20th century competencies is that a person and a tool, application, medium, or environment work in concert to accomplish an objective unobtainable otherwise (e.g., remote collaboration via groupware among a problem finding team scattered across the globe). However, ICT are not mere mechanisms for attaining the desired behavior; through distributed cognition, the understandings they enable are intrinsic to the fluent performance (e.g., a group co-constructing a sophisticated conceptual framework using the representational tools available in a wiki).

Frameworks that discuss new "literacies" based on the evolution of ICT help to illuminate this aspect of 21st century learning. With funding from the Macarthur Foundation, Henry Jenkins and his colleagues produced a list of digital literacies (2006):

Jenkins' Literacies based on New Media

Play — the capacity to experiment with one's surroundings as a form of problem-solving

Performance — the ability to adopt alternative identities for the purpose of improvisation and discovery

Simulation — the ability to interpret and construct dynamic models of real-world processes

Appropriation — the ability to meaningfully sample and remix media content

Multitasking — the ability to scan one's environment and shift focus as needed to salient details.

Distributed Cognition — the ability to interact meaningfully with tools that expand mental capacities

Collective Intelligence — the ability to pool knowledge and compare notes with others toward a common goal

Judgment — the ability to evaluate the reliability and credibility of different information sources

Transmedia Navigation — the ability to follow the flow of stories and information across multiple modalities

Networking — the ability to search for, synthesize, and disseminate information

Negotiation — the ability to travel across diverse communities, discerning and respecting multiple perspectives, and grasping and following alternative norms

These digital literacies have a different tone than the ISTE and ETS frameworks above. The emphasis is not on proficiency with the tool, but on types of intellectual activity performed by a person working with sophisticated ICT. While some perennial capabilities are listed (e.g., judgment), other skills (e.g., performance) are contextual in their emphasis on new types of 21st century capacities.

All these digital literacies not only represent skills students should master for effective 21st century work and citizenship, but also describe the learning strengths and preferences people who use technology now bring to educational settings. Dede (2005) presented a framework of "neomillennial learning styles" that are based on new digital literacies:

Dede's Neomillennial Learning Styles

Fluency in multiple media, valuing each for the types of communication, activities, experiences, and expressions it empowers.

Active learning based on collectively seeking, sieving, and synthesizing experiences, rather than individually locating and absorbing information from some single best source.

Expression through non-linear, associational webs of representations as well linear media (e.g., authoring a simulation and a webpage to express understanding, in contrast to writing a paper).

Co-design by teachers and students of learning experiences personalized to individual needs and preferences.

Since the articulation of this framework, the emergence of Web 2.0 media has fueled a shift in leading-edge applications on the World Wide Web that reinforces these learning strengths and preferences. The predominant learning activities on the Internet have changed from the presentation of material by website providers to the active co-construction of resources by communities of contributors. Whereas the twentieth-century web centered on developer-created material (e.g., informational websites) generated primarily by a small fraction of the Internet's users, Web 2.0 tools (e.g., Wikipedia) help

large numbers of people build online communities for creativity, collaboration, and sharing.

Dede (2009b) delineated a category system for current Web 2.0 tools:

1. *Sharing*
    - Communal Bookmarking
    - Photo/Video Sharing
    - Social Networking
    - Writers' Workshops/Fanfiction
2. *Thinking*
    - Blogs
    - Podcasts
    - Online Discussion Forums
3. *Co-Creating*
    - Wikis/Collaborative File Creation
    - Mashups/Collective Media Creation
    - Collaborative Social Change Communities

This framework shows a loose progression from top to bottom, with sharing leading to thinking together and then collective action in which sophisticated groups seeking change use subsets of the nine media listed earlier to accomplish their collective objectives. Overall, growing usage of these Web 2.0 tools has led to an intensification of the learning styles and digital literacies described above.

Leu and his colleagues (2007) described four characteristics of the "new literacies" generated by ICT. First, emerging ICT tools, applications, media, and environments require novel skills, strategies, and dispositions for their effective use. Second, new literacies are central to full economic, civic, and personal participation in a globalized society. Third, new literacies constantly evolve as their defining ICT continuously are renewed through innovation. Fourth, new literacies are multiple, multimodel, and multifaceted. These characteristics are in accord with the media-based styles of learning presented above and with the 21st century capabilities this chapter discusses.

Comparing Alternative Frameworks for 21st Century Skills

In summary, all these 21st century skills frameworks are generally consistent with each other. The additions to the P21 skillset the alternative frameworks offer are of two types. First, other groups identify some subskills within P21 categories as particularly important. As an illustration, "troubleshooting systems and applications" is seen as a key subskill by ISTE within the P21 overall category of ICT Literacy, and this ISTE subskill requires the foundational subskill of "technical proficiency: a foundational knowledge of hardware, software applications, networks, and elements of digital technology" advocated by ETS. Highlighting this subskill may reflect an assessment of which aspects of a larger capability teachers are likely to overlook given the current culture of schooling; for example, students seldom have opportunities to learn "troubleshooting" because teachers instinctively don't ever want problems to emerge in an instructional situation.

Second, groups other than P21 stress some areas they feel are underemphasized in its categories. As an illustration, "students acting autonomously" is a major category for OECD that, again, is contrary to the current culture of US schooling. Similarly, the Metiri/NCREL framework stresses student "risk taking," but this is unlikely to be encouraged by many US teachers unless special emphasis is put on this skill as crucial to 21st century work and citizenship.

The stress on what may be underemphasized because those skills are inconsistent with current classroom culture highlights a substantial challenge to infusing these 21st century skills frameworks into educational practice and policy. At this point in history, the primary barriers to altering curricular, pedagogical, and assessment practices are not conceptual, technical or economic, but instead psychological, political, and cultural. We now have all the means necessary to move beyond teaching 20th century knowledge in order to prepare all students for a future quite different from the immediate past. Whether society has the professional commitment and public will to actualize such a vision remains to be seen.

Advances in the Assessment of 21st Century Skills

Several metrics for assessing 21st century skills are discussed in the Education Board's report, "Measuring Skills for the 21st Century" (Silva, 2008). Which parts of the synthesized 21st century skills framework do these assessments cover?

The College Work and Readiness Assessment

The College and Work Readiness Assessment (CWRA) measures how students perform on constructed response tasks that require an integrated set of critical thinking, analytic reasoning, problem solving, and written communication skills. The CWRA is delivered entirely over the Internet in a proctored setting… Critical thinking, analytical reasoning, problem-solving, and writing are "collective outcomes" that cannot fully be taught in any one class or year; so all teachers and faculty have a responsibility to teach for such skills within each subject area and discipline.

Performance Tasks Students must complete a "real-life" activity (such as preparing a memo or policy recommendation) by using a series of documents that must be reviewed and evaluated. Completion of these instruments does not require the recall of particular facts or formulas; instead, the measures assess the demonstrated ability to interpret, analyze and synthesize information.

Analytic Writing Tasks Evaluate students' ability to articulate complex ideas, examine claims and evidence, support ideas with relevant reasons and examples, sustain a coherent discussion, and use standard written English.

The Programme for International Student Assessment (PISA)

PISA is based on the OECD Definition and Selection of Key Competencies project (DeSeCo), discussed earlier under formulations of 21st century skills. PISA seeks to measure how well young adults, at age 15 and therefore approaching the end of compulsory schooling, are prepared to meet the challenges of today's knowledge societies – what PISA refers to as "literacy". The assessment is forward looking, focusing on young people's ability to use theirknowledge and skills to meet real-life challenges, rather than merely on the extent to which they have mastered a specific school curriculum. This orientation reflects a change in the goals and objectives of curricula themselves, which increasingly address what students can do with what they learn at school and not merely whether they can reproduce what they have learned.

The domains of reading, mathematical and scientific literacy are covered not merely in terms of mastery of the school curriculum, but in terms of important knowledge and skills needed in adult

life. Pencil-and-paper tests are used, with assessments lasting a total of two hours for each student. Test items are a mixture of multiple-choice items and questions requiring students to construct their own responses. The items are organized in groups based on a passage setting out a real-life situation. A total of about seven hours of test items is covered, with different students taking different combinations of test items. Students answer a background questionnaire, which takes 20-30 minutes to complete, providing information about themselves and their homes. School principals are given a 20-minute questionnaire about their schools.

Key Stage 3 ICT Literacy Assessment

This ICT literacy assessment gauges students' ICT capability at the end of "Key Stage 3" (ages 12-13) in Great Britain's national curriculum. The test not only assesses students' ICT skills, but also their ability to use those skills to solve a set of complex problems involving research, communication, information management, and presentation. Test results provide both summative information - in the form of a national score for each student - and detailed feedback about student performance that could be used formatively to inform future teaching and learning.

The ICT test is set in a complex virtual world, within which students carry out tasks using a "walled garden" of assets (e.g., text, pictures, data and "canned" websites) to take the test without access to the Internet. Students are also provided with a toolkit of applications to enable them to complete the tasks; all of these assets are generic software programs developed by the QCA to provide the same capabilities as familiar productivity software on the level playing field of a non-brand-specific platform. As students work through the test session, their actions are tracked by the computer and mapped against expected capabilities for each level of the national curriculum; this includes both technical skills and learning skills, such as "finding things out," "developing ideas" and "exchanging and sharing information." The information collected about a student's performance allows a score to be awarded along with a profile of individual strengths and weaknesses.

All three assessments potentially could cover substantial amounts of the 21st century skills delineated in the frameworks above. However, CWRA and PISA are limited in their effectiveness by their formats: paper-based and at times test-item-focused. The Key Stage 3 has more potential to measure the full range of 21st century capabilities, including digital literacies, because it is conducted in a virtual world and based on activities more sophisticated than making forced-choice decisions among a limited number of alternatives.

Beyond these current assessments, many researchers are working on virtual performance assessments for specific higher order intellectual performances, such as scientific inquiry, that soon may provide reliable, usable, and valid measures for many 21st century skills (Ketelhut, Dede, Clarke, Nelson, & Bowman, 2007). Research has documented that higher order thinking skills related to sophisticated cognition (e.g., inquiry processes, formulating scientific explanations, communicating scientific understanding, approaches to novel situations) are difficult to measure with multiple choice or even with constructed-response paper-and-pencil tests (Resnick & Resnick, 1992; Quellmalz & Haertel, 2004; National Research Council, 2006). In the late 1980s and 1990s, educators attempted to use performance assessments in accountability programs. However, the developers of both hands-on and virtual performance assessments encountered a number of technical, resource, and reliability problems in large scale administration (Cronbach, Linn, Brennan, & Haertel, 1997; Shavelson, Ruiz-Primo, & Wiley, 1999). At that time, these problems were substantial enough to undercut the potentially greater construct validity for science inquiry that performance assessments can provide over paper-and-pencil tests. Now, however, teams of scholars are using

modern technologies to develop virtual performance assessments of various types (e.g., http://virtualassessment.org) that may solve this problem of providing reliable, valid measurements for sophisticated intellectual and psychosocial skills (Quellmalz & Pellegrino, 2009).

Overall, the increasing availability of valid assessments for 21st century skills is leading to calls for all states to participate in "international benchmarking": comparing their educational processes and outcomes to the best models around the world (National Governors Association, Council of Chief State School Officers, and Achieve, Inc., 2008). Widely used international assessments centered on curricular areas include the Trends in International Math and Science Study (TIMSS) for grades four, eight, and twelve, as well as the International Association for the Evaluation of Educational Achievement PIRLS assessment of fourth grade reading levels (Silva, 2008). "Benchmarking for Success: Ensuring US Students Receive a World-class Education" calls on states to implement five types of benchmarking (page 6):

Action 1: Upgrade state standards by adopting a common core of internationally benchmarked standards in math and language arts for grades K-12 to ensure that students are equipped with the necessary knowledge and skills to be globally competitive.
Action 2: Leverage states' collective influence to ensure that textbooks, digital media, curricula, and assessments are aligned to internationally benchmarked standards and draw on lessons from high performing nations and states.
Action 3: Revise state policies for recruiting, preparing, developing, and supporting teachers and school leaders to reflect the human capital practices of top-performing nations and states around the world.
Action 4: Hold schools and systems accountable through monitoring, interventions, and support to ensure consistently high performance, drawing upon international best practices.
Action 5: Measure state-level education performance globally by examining student achievement and attainment in an international context to ensure that, over time, students are receiving the education they need to compete in the 21st century economy.

Recent US federal activities to promote coordination among states in developing comparable, high quality curriculum standards are building momentum to generate and use assessments that can measure sophisticated intellectual and psychosocial skills needed for the 21st century.

Conclusion

Fortunately, groups developing conceptualizations of 21st century skills have built sufficiently on each other's ideas to avoid a "Tower of Babel" situation. As this analysis shows, organizations that argue for 21st century skills have frameworks largely consistent in terms of what should be added to the curriculum. However, each group has different areas of emphasis within the overarching skillset. As an illustration, taking the P21 framework as a baseline, groups focused on technical skills--such as ISTE, ETS, and those who advocate for digital literacies--emphasize that aspect of P21 and articulate in greater detail which fluencies in information and communications technologies are most important.

Each rganization also each introduces complementary ideas to the concept of 21st century skills. For example, as discussed earlier additions to the P21 framework from OECD and Metiri/NCREL incorporate autonomous actions by students that typically are not a part of conventional classroom culture. This highlights a meta-cognitive challenge

for the 21st century skills movement: to systematically examine all the tacit beliefs and assumptions and values about schooling that are legacies from the 20th century and the industrial age. Compilations such as this volume are making important contributions in aiding this reconceptualization of education for the 21st century.

References

American Association of Colleges and Universities. (2007). College learning for the new global century. Washington, DC: AACU.

Cronbach, L. J., Linn, R. L., Brennan, R. L, & Haertel, E. H. (1997). Generalizability analysis for performance assessments of student achievement or school effectiveness. *Educational and Psychological Measurement*, 57, 373-399.

Dede, C. (in press). Technological supports for acquiring 21st century skills. In E. Baker, B. McGaaw, & P. Peterson (Eds.), International Encyclopedia of Education, 3rd Edition. Oxford, England: Elsevier.

Dede, C. (2009a). Determining, developing, and assessing the skills of North Carolina's future-ready students. Friday Institute White Paper Series, Number 2 (May). www.fi.ncsu.edu/whitepapers

Dede, C. (2009b). Technologies that facilitate generating knowledge and possibly wisdom: A response to "Web 2.0 and classroom research." *Educational Researcher* 38(4), 60-63.

Dede, C. (2005). Planning for "neomillennial" learning styles: Implications for investments in technology and faculty. In J. Oblinger and D. Oblinger (Eds.), Educating the net generation, pp. 226-247. Boulder, CO: EDUCAUSE Publishers.

Educational Testing Service. (2007) Digital transformation: A framework for ICT literacy. Princeton, NJ: ETS.

International Society for Technology in Education (2007). The national educational technology standards and performance indicators for students. Eugene, OR: ISTE.

Jenkins, H., Clinton, K., Purushotma, R., Robinson, A. J., & Weigel, M. (2006). Confronting the challenges of participatory culture: Media education for the 21st century. Chicago, IL: The MacArthur Foundation.

Karoly, L. A. (2004). The 21st century at work: Forces shaping the future workforce and workplace in the United States. Santa Monica, CA: RAND Corporation.

Ketelhut, D., Dede, C., Clarke, J., Nelson, B., & Bowman, C. (2007). Studying Situated Learning in a Multi-User Virtual Environment. In E. Baker, J. Dickieson, W. Wulfeck, & H. O'Neil (Eds), Assessment of Problem Solving Using Simulations, pp. 37-58. Mahweh, NJ: Erlbaum.

Leu, D. J., Zawilinski, L., Castek, J., Bannerjee, M., Housand, B., Liu, Y., & O'Neil, M. (2007). What is new about the new literacies of online reading comprehension? In A.

Berger, L. Rush, & J. Eakle (Eds.) Secondary school reading and writing: What research reveals for classroom practices. Chicago, IL: NCTE/NCRLL.

Levy, F., & Murnane, R. J. (2004). The new division of labor: How computers are creating the next job market. Princeton, NJ: Princeton University Press.

Metiri Group & NCREL. (2003). EnGauge 21st century skills: Literacy in the digital age. Chicago, IL: NCREL.

National Governors Association, Council of Chief State School Officers, & Achieve, Inc. (2008). Benchmarking for success: Ensuring US students receive a world-class education. Washington, DC: National Governors Association.

National Research Council. (2006). Systems for state science assessment. Washington, DC: The National Academies Press.

Organization for Economic Cooperation and Development. (2005). The definition and selection of key competencies: Executive summary. Paris, France: OECD.

Partnership for 21st Century Skills. (2006). A state leader's action guide to 21st century skills: A new vision for education. Tucson, AZ: Partnership for 21st Century Skills.

Quellmalz, E., & Pellegrino. J. (2009). Technology and testing. *Science* 323 (2nd January), 75-79.

Quellmalz, E. S. & Haertel, G. (2004). Technology supports for state science assessment systems. Paper commissioned by the National Research Council Committee on Test Design for K-12 Science Achievement. Washington, DC: National Research Council.

Resnick, L.B. & Resnick, D.P. (1992). Assessing the thinking curriculum: New tools for educational reform. In B. Gifford & M. O'Connor (Eds.), Changing Assessments: Alternative Views of Aptitude, Achievement, and Instruction. Norwell, MA: Kluwer Academic Publishers, 37-75.

Shavelson, R. J., Ruiz-Primo, M. A., & Wiley, E. W. (1999). Note on sources of sampling variability in science performance assessments. *Journal of Educational Measurement*, 36, 61-71.

Silva, E. (2008). Measuring skills for the 21st century. Washington, DC: Education Board.

Van Lehn, K., & the Pittsburgh Science of Learning Center. (2006). The Pittsburgh Science of Learning Center theoretical framework. Pittsburgh, PA: PSLC. http://www.learnlab.org/clusters/PSLC_Theory_Frame_June_15_2006.pdf

Weinberger, D. (2007). Everything is miscellaneous: The power of the new digital disorder. New York: Times Books.

.