Defining a 21st century education

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Between 2002 and 2007, cell phones displaced landline telephones as the technology Americans say would be hardest to give up. Not only that, in just half a decade cell phones and the Internet both unseated the second most indispensable technology in 2002—the television. According to the researchers who published those findings, the numbers signaled an abrupt change not just in how but *where* people are accessing information: An astonishing 62 percent of Americans said they use mobile technology to access digital data and tools "on the go" outside of their homes and workplaces.[1]

Of course, technology broadly understood has been transforming human life in one way or another for thousands of years. The mechanization of agriculture transformed the American labor market in the first half of the 20th century. But in the computer age, the pace of technological change is very rapid. And when essential daily tools can change in just five years, the impact over longer stretches can be profound. Many experts say that since the 1970s, new technologies, combined with demographic, political, and economic trends, have altered Americans' work and social lives in ways that have significant consequences for today's young people.

Those trends have prompted some education reformers to argue that the traditional curriculum is not enough: schools must provide students with a broader set of "21st century skills" to thrive in a rapidly evolving, technology-saturated world. But defining what that term actually means can be daunting. As the author of a recent report lamented, "For all of the talk about 21st century skills, trying to figure out what they really are is not easy […]. The term is everywhere and used to describe pretty much every imaginable skill or attribute: soft skills, life skills, key skills, inter-personal skills, workforce skills, non-cognitive skills … the list of […] skills goes on and on."[2] One framework lists 22 separate sub-skills deemed necessary to succeed in the 21st century![3]

Before asking teachers to take on this new challenge, state and district leaders should dig deeper than the flashy phrases and poorly defined buzzwords that tend to characterize the "21st century skills" movement. As a first step, they should make a serious effort to understand the best empirical evidence on what skills will be necessary for students to succeed in careers and personal lives, and they should communicate that information in clear and concrete ways that make sense to the classroom teachers who ultimately will be responsible for teaching them. Simply asking teachers to "address" a long list of inadequately defined skills will not be sufficient. This paper represents an initial attempt to lay the groundwork for such an effort.

1. How is the world changing in ways that impact skill demands?

While it is difficult to peer into the future to ascertain what skills will be important 30 years from now, it is possible to examine trends that have change the demands of work and life in the recent past and continue to do so today. The most important are automation, globalization, workplace change, and policies increasing personal responsibility. In addition, one science—demography—does allow for more accurate longer-term predictions.

Automation

Anybody who has visited a factory recently understands that the impact of automation—the use of computers and computer-driven machinery to replace human labor—has been significant. "Whether the product being made is autos, tractors, light bulbs, chemicals, chocolate bars, dog food, or computers, the

overwhelming impression a visitor to a new U.S. factory receives is that machines are doing almost all, if not all, the work," observe James O'Toole and Edward Lawler in their recent book *The New American Workplace*.[4]

But automation means more than just replacing human limbs with computerized machinery on assembly lines. Today, computers also increasingly able to accomplish a wide range of work-related *thinking* tasks once performed by humans. Labor market economists Richard Murnane of Harvard University and Frank Levy of MIT have documented how computerization is increasing the demand for some kinds of skills even as it erases many jobs that once paid good wages. Across the economy, while computers are not yet "doing all of the work," they are increasingly doing most of the *routine* work.

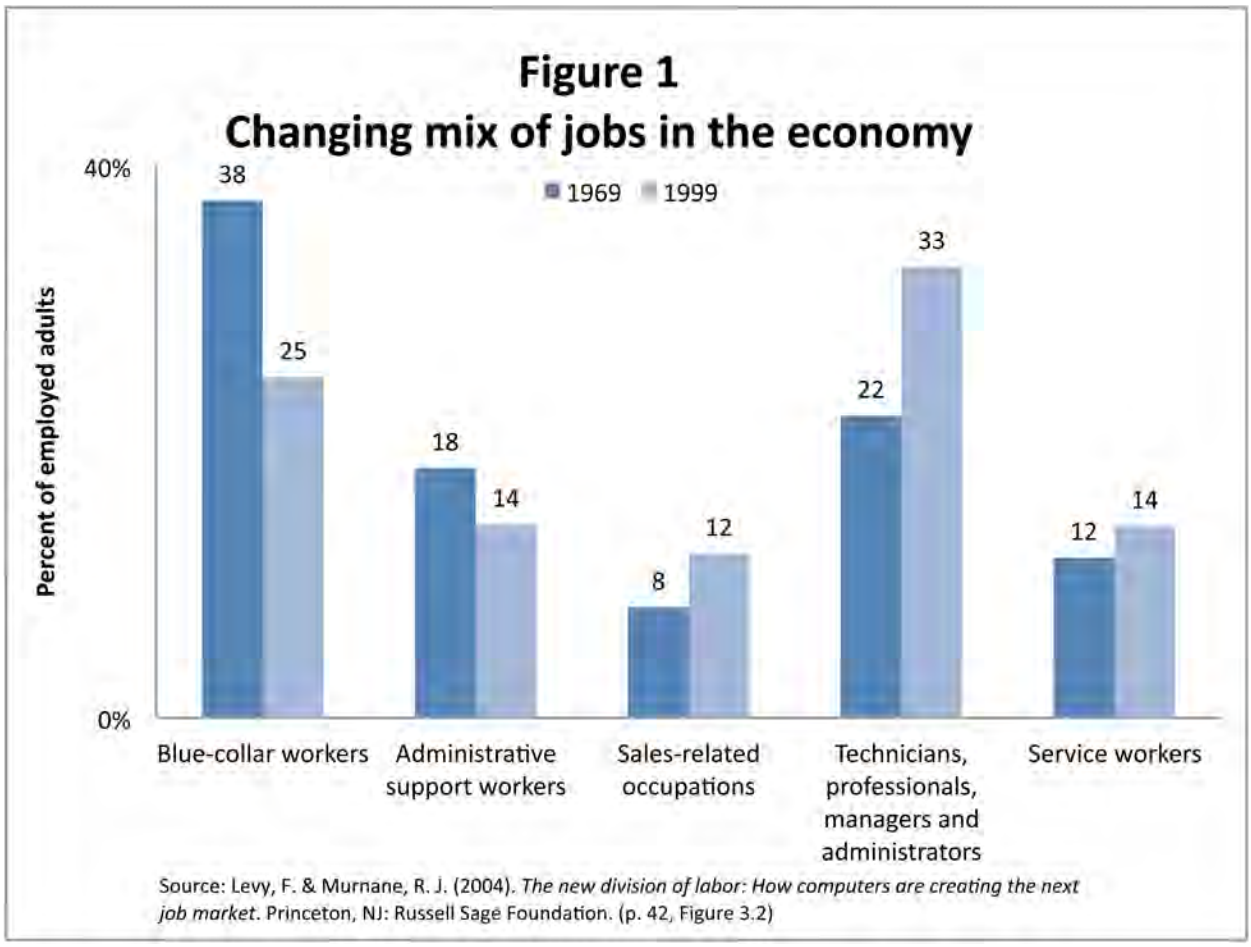
That is because computers are good at information processing, and *every* job requires information processing of some sort. "The financial analyst who reads numbers in a spreadsheet, the farmer who looks to the sky for signs of rain, the chef who tastes a sauce, the carpenter who feels his hammer as it hits a nail—all these men and women are processing information to decide what to do next or to update their picture of the world," Levy and Murnane point out.[5]

Computers can perform a task if the information involved can be digitized and presented in a suitable form—one the computer can understand and process. And computers are particularly good at information-processing tasks that require following a set of prescribed rules. For example, airline customers once had to deal with another person if they wanted to fly somewhere. But today, anyone with an internet connection can purchase tickets for themselves by providing a computer with answers to a set of standardized questions online. Moreover, when they arrive at the airport, travelers need not interact with an airline employee to obtain their boarding passes; instead, they can print them out by punching information into an automated ticketing kiosk.

In addition, now that computers can perform some simple kinds of pattern recognition, they are taking over other formerly human tasks—for example, recognizing and acting on words spoken into a telephone. If a traveler becomes frustrated with the service he or she receives and decides to phone the airline, the first person that traveler is likely to speak with will not be a person at all but rather yet another computer. Jokes about "talking to machines" have become commonplace in our culture, but lost in the telling are all of the jobs that are disappearing as a result.

In fact, any job where information can be digitized and key tasks can be broken down into a set of predictable rules is vulnerable to automation. And because it is cheaper to use computers to follow directions than to pay humans to do so, those jobs are rapidly disappearing. The jobs that are most vulnerable are those in manufacturing and administrative support—work that used to pay good wages for supporting a family. Levy and Murnane calculate that between 1969 and 1999, the share of Americans in blue collar and administrative support jobs plummeted from 56 to 39 percent.[6] (See Figure 1) In fact, in manufacturing alone, the share of jobs is down from 50 percent in the 1950s to 25 percent in the 1970s to less than 10 percent today.[7]

But automation also has begun to replace humans in some kinds of more sophisticated "white collar work." For example, computer programs like Turbo Tax have taken jobs away from accountants. According to the recent report of the New Commission on the Skills of the American Workforce, "It turns out that many middle managers were paid in the past for collecting data, analyzing them in fairly routine ways, and passing the results up to senior management. Not any more. […] If work is routine, no matter how complex it is, chances are it can be automated."[8]



Between 1969 and 1999, the mix of jobs in the economy changed dramatically, with large increases in jobs that require better skills and more education.

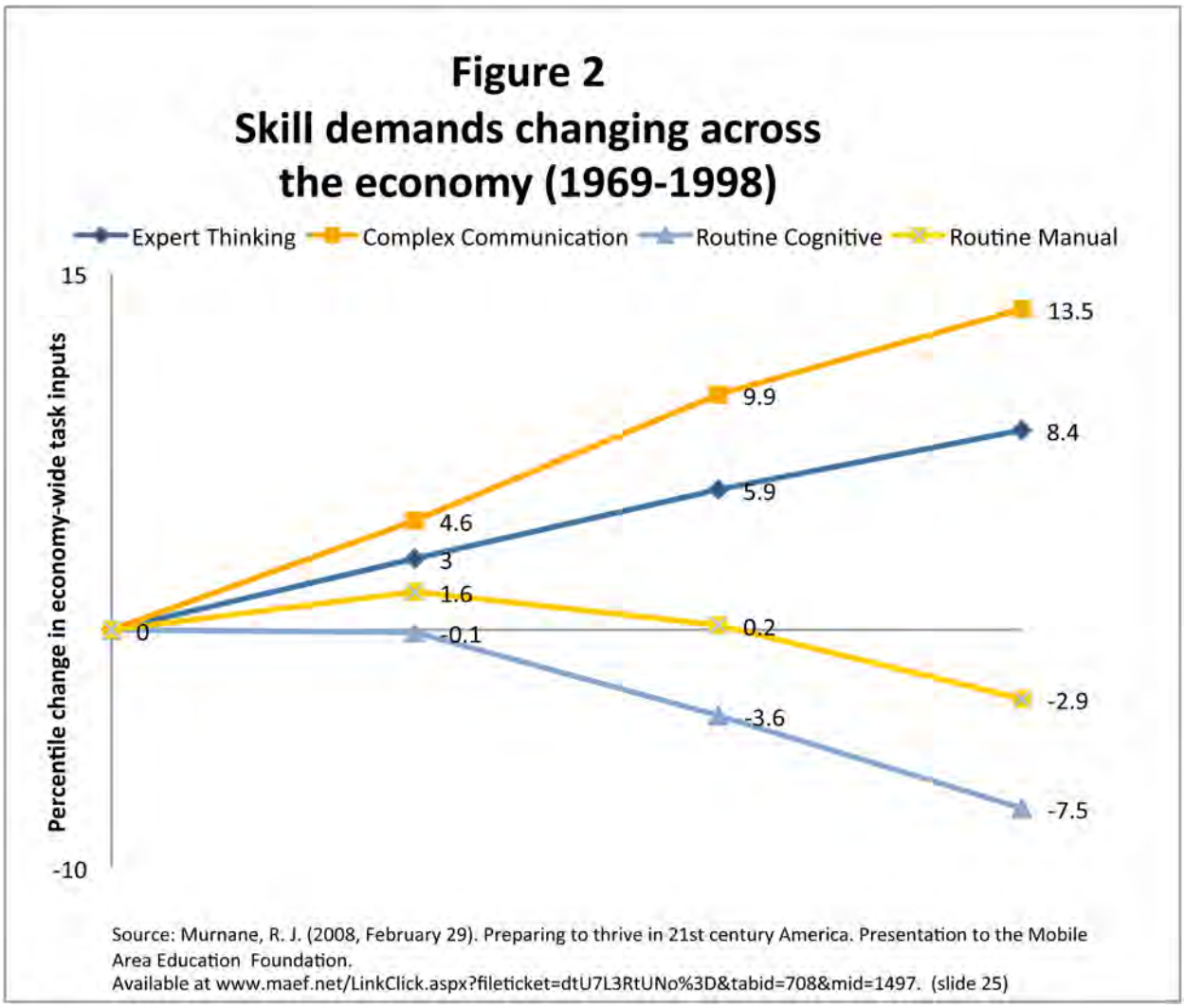
At the same time, there remain many tasks that computers still cannot perform, and those tasks are becoming more important in today's economy. Think about those automated ticketing kiosks so prevalent in airports these days. If they are so easy to use, why are so many travelers still standing in line to speak with a human ticketing agent? Of course, some travelers simply might not like dealing with computers. But in many cases it is because travelers have some kind of special problem the computer has not been programmed to handle, or because they have questions its software cannot answer.

Levy and Murnane call such tasks "non-routine" because they cannot be broken down into a set of predictable rules or simple kinds of pattern recognition. Their research shows that two kinds of non-routine skills are increasingly important. The first is "expert thinking," the ability to solve unexpected problems for which there are no predictable and programmable rule-based solutions. The second is "complex communication," which involves interacting with other people to acquire information, to explain it, or to persuade others of its importance. Those skills are not superseding traditional skills in reading, writing, and math but rather increasing demand for "the three R's," since basic skills provide a solid foundation for expert thinking and complex communication.

According to Levy and Murnane, people who can perform such tasks will have better job opportunities and will often be paid a premium for their work. On the other hand, students who leave school able to follow directions but without expert thinking and complex communication skills will have difficulty supporting their own families. Indeed, they found that as computers take over more and more routine tasks, the nature of work across the entire economy is undergoing rapid transformation. Between 1969 and 1999, the share of job tasks calling for expert thinking and complex communication rose sharply and steadily; but beginning in the early 1980s the share of tasks calling for routine thinking or routine manual work plummeted.[9] (See Figure 2.)

That is not to say that computers *only* drive up demand for higher thinking skills. After all, what about all of those food service jobs the Department of Labor data always show? According to Levy and Murnane, "the growing number of service workers (janitors, cafeteria workers, security guards) reflects the inability to describe human optical recognition and many physical movements in sets of rules."[10] Even so, because such tasks do not require a lot of education or special training, there are many people who can perform them; therefore, such jobs are generally considered "low-skilled" and are lower paying. However, while the number of such jobs may be increasing, they are not growing nearly as fast as higher-skilled work. As a result, the *overall* or "net" trend across the economy as a whole is toward creation of more cognitively demanding jobs.[11]

"Low-wage services jobs are a mixed bag of career and transitional jobs," economist Anthony Carnevale observes. "Their share of the total has not grown since Ike was president in the 1950s, at 28 million workers or about one-fifth of the available work opportunities." He adds that, "Many of these employees are young, some are in school, some are in transition to something better, and some are older workers moving towards retirement."[12] Yes, someone will have to perform these jobs. But given the overall trend toward higher skill demands and the transitory nature of many low-skilled service jobs, it makes more sense to prepare all students for postsecondary education or training so they have the chance for higher-skilled, higher-paying work.



The economists Frank Levy and Richard Murnane examined tasks performed on the job by all workers over several decades. Over time, workers are performing fewer routine tasks that can be better performed by computers while being called on to do more complex thinking tasks like solving unfamiliar problems and interacting with others.

In fact, the demand for non-routine skills actually is growing even faster than Figure 2 suggests. Levy and Murnane could only measure task trends related to changes in the overall mix of occupations shown in Figure 1, not how skill demands are changing *within* occupations that evolve—rather than disappear—because of technology. For example, bank tellers now spend more time addressing customers' unique concerns or selling them financial services rather than handling withdrawals, since most customers now use ATM machines when they need cash.[13] However, more recent research has shown that skill demands are indeed changing significantly within occupations. A study using data from Germany found that "occupations have experienced a shift toward analytical and interactive activities and away from cognitive and manual routine tasks. This development was ubiquitous in the sense that it occurred within occupations, within occupation-education groups, and within occupation-age groups."[14]

Examples of such "up-skilling" are abundant not just in white collar jobs but also among the so-called blue collar trades that continue to pay good wages. For example, on its website, the Electrical Training Institute of Southern California warns prospective apprentices: "Don't be influenced by those who see the electrical construction trade as an occupation requiring only a strong back and a weak mind. The electrical trades are becoming more technical each day."[15] The International Brotherhood of Electrical Workers has developed a new screening test that asks applicants for apprenticeships to solve algebra problems and answer reading comprehension questions.[16] And it's not just electrical work: ACT examined math and reading skills required for electricians, construction workers, upholsterers, and plumbers and concluded they match what's necessary to do well in first-year college courses.[17]

Economists predict that as technology continues to advance, computers will be programmed to tackle more and more tasks that only humans can perform now. However, since it is difficult to anticipate specific advances in computer programming, it is extremely difficult to predict precisely which kinds of jobs will be most at risk in 30 or 40 years. At a workshop on future skill demands in 2007, economist Stuart Elliott presented the results of a pilot study predicting that, based on current cutting edge research in artificial intelligence, by 2030 computers could substitute for human abilities in occupations that currently employ *60 percent* of the national workforce. However, even Elliott said the results should not be taken seriously because, at present, making such long-term predictions requires too many assumptions.[18]

Even if his projection is true, experience shows that automation does not lead to mass unemployment because new jobs also are being created at the same time—partly as a result of advances in technology and the new products and services they make possible.[19] For example, the intense competition that characterizes the modern economy creates a constant drive to leverage new technologies in order to develop new products and services, which then need to be produced and marketed. And all of that work "relies on the human ability to manage and solve analytical problems and communicate new information," say Levy and Murnane.[20]

For now, we know that computers are becoming very good at performing any kind of work that mainly involves following directions—even relatively complex tasks that involve decisions based on many possible "if then" scenarios. If the scenarios can be predicted, the task can be programmed. Therefore, any school curriculum that emphasizes following directions to find a single correct answer is, by definition, preparing students for jobs that probably will not exist by the time those students graduate. That does not mean following directions is not an important skill, but rather that it is no longer a sufficient skill for earning a middle-class wage. As Levy and Murnane put it, educating students to compete with a computer is to educate them for a competition they cannot win.[21]

To summarize, computers are substituting for humans in performing "routine" work tasks that require the rote following of rules or directions. At the same time, people are increasingly being called on to perform more complex thinking tasks that computers still cannot perform, such as those that involve complex interactions with other humans (whether collaborating, persuading, or selling) or that require solving unexpected problems using expert thinking. Strong math and reading skills are essential, too, since they form the foundation for complex communication and expert thinking. That does not mean that schools should no longer ask students to memorize any information or learn how to follow directions, but rather that such learning will be insufficient for success in the job market of the 21st century.

Globalization

Another major trend shaping future skill demands is "globalization," the breaking down of economic, social, and intellectual borders between nations. Globalization has not taken place independently of technological change. In his now-famous book on the topic, *New York Times* columnist Thomas Friedman

describes how advances in digital technology and telecommunications have acted as "flatteners," leveling the playing field so that American workers no longer enjoy a home court advantage and face increasing competition for skilled, high-paying jobs.

The spread of Windows-enabled computers, fax machines, and dial-up models soon after the fall of the Berlin wall set the stage. Then the Internet boom of the 1990s fueled investment in the hardware (fiber optic cables) and software (web browsers) necessary for the emergence of an "information super highway" along which all kinds of digitized work products could travel. Finally, work-flow software and common technical standards allowed disparate software packages to talk to each other, which in turn enabled work projects to be carved up into parts, sent out to whomever could perform them best and cheapest, and then reassembled into a final product.

The result was a new platform for conducting business, one that allowed for much more sophisticated collaboration across much greater distances. In fact, geographic distance is becoming increasingly irrelevant. "Suddenly more people from more different places could collaborate with more other people on more different kinds of work and share more different kinds of knowledge than ever before," writes Friedman. Eventually, a whole new set of business practices evolved to take advantage of this new platform—offshoring, outsourcing, supply-chaining—signaling a shift from "vertical" production to "horizontal" collaboration.

As fate would have it, over the same period during which these technological advancements took place, another set of political and economic changes were occurring that would vastly increase the number of people around the globe who could participate in such horizontal collaboration. Historic political and economic developments freed up more than 1 billion people in Russia, Eastern Europe, China, India, and other developing countries who formerly could not compete in the global economy. Harvard economist Richard Freeman calls this "The Great Doubling" of the global workforce.

"The result," according to the Skills Commission, "is a world in which it is just as easy to create work teams composed of people on four continents as it is to create work teams composed of people from four divisions of the same firm located in the same city." The commission emphasized that, in the kind of flat world Friedman describes, "highly skilled people with roughly the same qualifications are competing directly with each other, no matter where they are located on the globe."[24] As Bill Gates told Friedman, several decades ago, simply being born in America was like winning "the ovarian lottery" because the vast majority of well-paying jobs had to be performed here.[25] But now educated and ambitious people can "plug and play" from wherever they happen to be in the world. They do not have to be born here; they no longer even have to move here. Instead, the work comes to them.

According to Levy and Murnane, so far automation and globalization have tended to eliminate many of the same kinds of jobs, since tasks that can be reduced to rules that can be programmed on a computer can also be scripted and outsourced to someone thousands of miles away. "The call-center work that moves offshore is heavily scripted and rule-like, while other call-center work […] is lost to speech recognition software," they point out. "Assembly-line work is lost to both offshore producers and to robotics. The preparation of basic tax returns is lost to offshore accountants and software programs like TurboTax and TaxCut."[26]

However, other experts worry that such a formulation ultimately underestimates the offshoring side of the equation. "Jobs that involve higher-order thinking, judgment, and communication skills are relatively immune from the competition of machines," Princeton economist Alan Blinder writes in response to Levy and Murane. "[However], because of advances in telecommunications and the Internet, plus the large number of well-educated, English-speaking people in India and elsewhere, more and more high-skill jobs

that require expert thinking and/or complex communication (but not physical presence) will be deliverable remotely in the future. That includes many high-wage jobs that may never be routinized and performed by computers, such as […] writing software."[27]

Last year Blinder set off a vigorous debate among economists by estimating that 22 to 29 percent of all jobs in the U.S. workforce are potentially offshorable within the next few decades.[28] His estimate used the U.S. Department of Labor's O*NET database to identify how many jobs involve services that potentially can be delivered to an end-user electronically over long distances. (Figure 3) Last spring a team at Harvard Business School replicated his findings.[29] "Increasingly, jobs are being viewed as groups of tasks that can be bundled, unbundled, and sent to different places," says Jan Rivkin of the Harvard team.[30]

Figure 3
Which jobs are most vulnerable to offshoring?

Occupation	Offshorability Index
Computer programmers	100
Telemarketers	95
Computer systems analysts	93
Billing and posting clerks and machine operators	90
Bookkeeping, accounting, and auditing clerks	84
Computer support specialists	92/68
Computer software engineers, applications	74
Computer software engineers, systems software	74
Accountants	72
Welders, cutters, solderers, and brazers	70
Helpers—production workers	70
First-line supervisors/managers of production and operating workers	68
Packaging and filling machine operators and tenders	68
Team assemblers	65
Bill and account collectors	65
Machinists	61
Inspectors, testers, sorters, samplers, and weighers	60
General and operations managers	55
Stock clerks and order fillers	34
Shipping, receiving, and traffic clerks	29
Sales managers	26
Business operations specialists, all other	25

Source: Blinder. A. S. (2007, March). How many U.S. jobs might be offshorable? CEPS Working Paper No. 142. Princeton, NJ: Princeton University Center for Economic Policy Studies. (p. 24, Table 2)

Economist Alan Blinder created an index to measure the potential of various jobs to be offshored over the next few decades. The index is based primarily on his estimate of how easy or hard it will be to deliver a service to an end-user electronically over long distances given predictable advances in technology. Occupations that score higher on the index are potentially more vulnerable to offshoring.

One thing economists do agree on is that the jobs lost to automation and offshoring are unlikely to return. They also increasingly agree that whether schools can adapt will not only have an impact on opportunities for individual workers, but also on the larger U.S. economy—and, by extension, state and local economies. Now that economists have access to several decades' worth of educational and economic data, they are able to analyze the relationship between a nation's skills and its economic prosperity in more sophisticated ways. Several recent studies have found that cognitive skills as measured by international assessments of math, science, and reading are powerful predictors not only of individual earnings but also the distribution of income in a society and long-term economic growth at the national level.[31]

According to one set of studies led by Stanford economist Eric Hanushek, student performance on standardized tests that is half standard deviation higher (a little less than the difference between top-performers like Finland or Singapore and the United States) translates into one full percentage point higher growth in gross domestic product over a 40 year period.[32] That is a huge amount when one considers that the normal annual growth rate is about 2 to 3 percent. In fact, Hanushek and his colleagues estimate that if the U.S. improved its students' performance on international tests to the level of top performing nations, its gross domestic product would be an additional five percent in higher 32 years from now—enough to entirely pay for K-12 education—and an astonishing 36 percent higher in 75 years.[33]

Hanushek and his colleagues concluded that, "As the world becomes increasingly interdependent or 'flat,' to use *New York Times* columnist Thomas Friedman's familiar terminology, enhancing human capital will become increasingly critical."[34] And it is not just about cultivating the talent of America's highly gifted students. The researchers also investigated the question, "Which is more important for growth—having a substantial cadre of high performers or bringing everyone up to a basic level of performance?" They found that both strategies have a positive impact on economic growth.[35] That makes sense. The elite rocket scientists in a society may contribute to the creation of new technologies, but in order to fully realize the potential of such innovations to boost overall productivity, members of the workforce have to be skilled enough to learn how to apply them in their own jobs.[36]

Unfortunately, compared with their peers in other industrialized nations, U.S. teenagers achieve largely mediocre results on international assessments that look at the kind of problem-solving skills Levy and Murnane describe. On the 2006 Program for International Student Assessment (PISA), which assesses students' ability to apply their knowledge to solve unfamiliar problems, U.S. 15-year-olds ranked below the international average in both math and science literacy among 30 industrialized nations.[37] Three years earlier, American 15-year-olds ranked at the international average in reading literacy and below the average in problem solving among 29 developed countries.[38] According to the Organization for Economic Cooperation and Development, which oversees PISA, "the United States does not just have more students performing badly—it also has many fewer students performing well."[39]

Moreover, the recent Skills Commission report argued that, for the U.S. to maintain its global competitiveness, it will not be enough for America to ensure students are merely competent in traditional school subjects. Other countries will still have workers who excel in those subjects and who are willing to work for lower wages. According to the Commission, Americans will have to offer something else: "The reason—and the only reason—that the rest of the world would be willing to pay us twice as much as equally competent people is if we add creativity and innovation on a grand scale to sheer competence," not just among elite managers but for virtually everyone in the labor force.[40]

But wait: If all this is true, why has the U.S. economy continued to achieve relatively robust economic growth? Didn't the famous *Nation at Risk* report make the same claim 25 years ago? The reason is that up until very recently, the U.S. led the world in other areas also related to economic growth. First, America virtually invented mass high school education in the 20th century, and it opened up higher education to

many citizens through policies like the GI Bill. Along with its relatively large size, that gave the U.S a massive lead in the sheer *number* of skilled workers available.[41]

Second, U.S. higher education has long been the envy of the world. In fact, one recent study found that higher education helps many young Americans "catch up" to the average skill level among industrialized nations even though they tend to leave K-12 with skills below the international average.[42] Finally, America's open and agile economy, flexible labor markets, and intellectual property protections have long enabled industry to *make better use* of the human capital available.[43] Hanushek and his colleagues estimate that substantially improving cognitive skills can add 0.9 percentage points per year to economic growth in closed economies with heavy restrictions on international trade, but 2.5 percentage points—more than twice as much—in open economies like the U.S.[44]

But these historic advantages will not last forever; in fact, they already are eroding. Other countries are responding to the challenges and opportunities presented by the global knowledge economy with education and economic reforms of their own. America's high school graduation rate, once the best in the world, now ranks 18th among industrialized OECD countries. As for higher education, "here, too, other countries are passing the United States," observe Andreas Schleicher of the OECD and Vivien Stewart of the Asia Society. "The United States ranked second in 1995; by 2006, it ranked 13th among 24 countries with comparable data, behind such countries as Australia, Iceland, New Zealand, Finland, Denmark, Poland, the Netherlands, and Italy—and, for the first time, even behind the OECD average."[45]

Already, America's share of the world's college students has dropped from 30 percent in 1970 to less than half that today.[46] And because of their sheer size, China and India will surpass both Europe and the United States in the number of secondary and postsecondary graduates they produce over the next decade.[47]

Many countries are also instituting economic reforms, and developing strong skills is part of the mission. China's *Eleventh Five-Year-Plan* adopted in 2006 focused on technological innovation and the need for a "rich talent base," calling on the government to "cultivate talents with creativity and completely improve our capacity of self-innovation so top universities in China will become an important force for the establishment of an innovation nation."[48] A 2008 study revealed that big pharmaceutical companies like Merck, Eli Lilly and Johnson & Johnson already are beginning to offshore some of their advanced research and development work to China and India.[49] "Globalization is happening faster than people think," says Vivek Wadhwa, the researcher and former entrepreneur who led the study. "Having India and China conduct such sophisticated research and participate in drug discovery was unimaginable even five years ago."[50]

Similarly, in 2000, the leaders of the European Union's member states adopted a strategic goal for the EU to "become the most competitive and dynamic knowledge-based economy in the world, capable of sustainable economic growth with more and better jobs and greater social cohesion."[51] To help reach the goal, EU leaders set a series of educational targets to be met by the same deadline.[52] And in 2006, the EU Parliament and Council adopted *Key Competences for Lifelong Learning—A European Reference Framework*, which begins, "As globalisation continues to confront the European Union with new challenges, each citizen will need a wide range of key competences to adapt flexibly to a rapidly changing and highly interconnected world."[53]

Globalization is clearly influencing skill demands in several ways. First, because they will face a job market in which Americans no longer have such a large "home court" job advantage, students will need to ensure that they have sufficient skills and enough education to compete for good jobs in a truly global economy. And "sufficient" increasingly means much more than basic. Lower skilled jobs are the first to be outsourced, but higher skilled work is increasingly vulnerable—especially as other nations catch up to

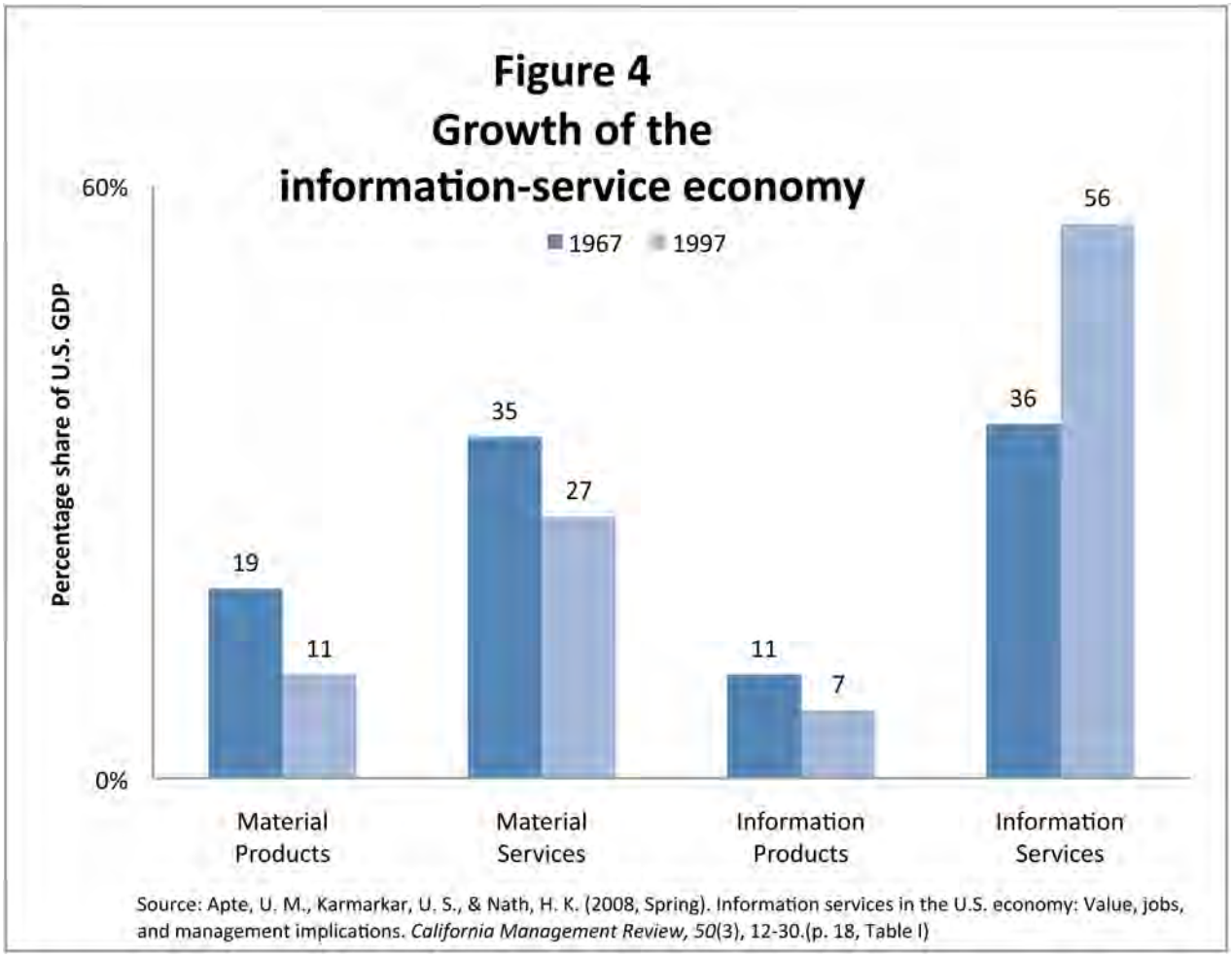
and surpass the U.S. in K-12 and higher education. Globalization also is affecting the types of knowledge and skills students will need to thrive. Since they will be collaborating with people around the world, they will need to have greater "global literacy"—knowledge about the people and cultures outside the U.S.

Workplace change

"Corporations have changed dramatically in the last twenty years in terms of the ways that work is organized," says Karen Bruett, manager of strategic business development in K-12 education at Dell Computer Corporation. "Most companies used to have big hierarchies, and were very top-down in their management styles, and employees were very specialized in their functions," she explains. However, "If you look at what's going on in any company today, the organization has been flattened."[54]

One set of studies provides a valuable look at what Bruett means: In 1973, the U.S. Secretary of Health, Education, and Welfare released a special task force report called *Work in America*, which warned of the consequences of many Americans being engaged in narrow, repetitive, routine jobs. Several years ago the writer of that report, James O'Toole, decided to follow it up with a new study conducted using the same methodology. How much has work—and the workplace itself—changed since then?

The answer is "massively." In response to technological change, globalization, and other competitive forces, American companies have radically restructured how work takes place and how jobs are defined and performed. Part of the transformation has to do with the transition to a knowledge and service economy. The share of America's gross national product from information services grew from 36 percent in 1967 to 56 percent in 1997. (Figure 4)



More than half of U.S. wealth is now generated by the growing information-service sector of the economy, which means more people are engaged in jobs that require manipulation of information.

Ten years later, according to James O'Toole and Edward Lawler in *The New American Workplace*, the largest U.S. corporations and biggest employers now focus on information services. Of course, some are retailers like Wal-Mart. But others once categorized as manufacturers—IBM, Xerox, General Electric, Sun, and Cisco—have become service providers too, and what they are selling is knowledge. O'Toole and Lawler:

> They may still make some goods (or sell products made abroad by other companies under their brand name), but most of their profits and growth come from services rather than manufacturing. For example, large American information technology (IT) companies no longer simply sell 'boxes' to their corporate clients; instead, they sell 'information systems and solutions'—basically their expertise is in systems design (what laypeople think of as engineering and consulting work). And these companies often manage the systems they install in other large companies as outsourcing contractors. […] *In plain English, today more large American companies can make more money selling knowledge than they can by making and selling things.55* [emphasis added]

Many companies have realized that in a "global knowledge economy," human capital is their most important resource. And they are using their human capital in very different ways than they did 30 years ago. Especially in globally competitive firms, jobs have changed in a number of key ways:

Less hierarchy and supervision

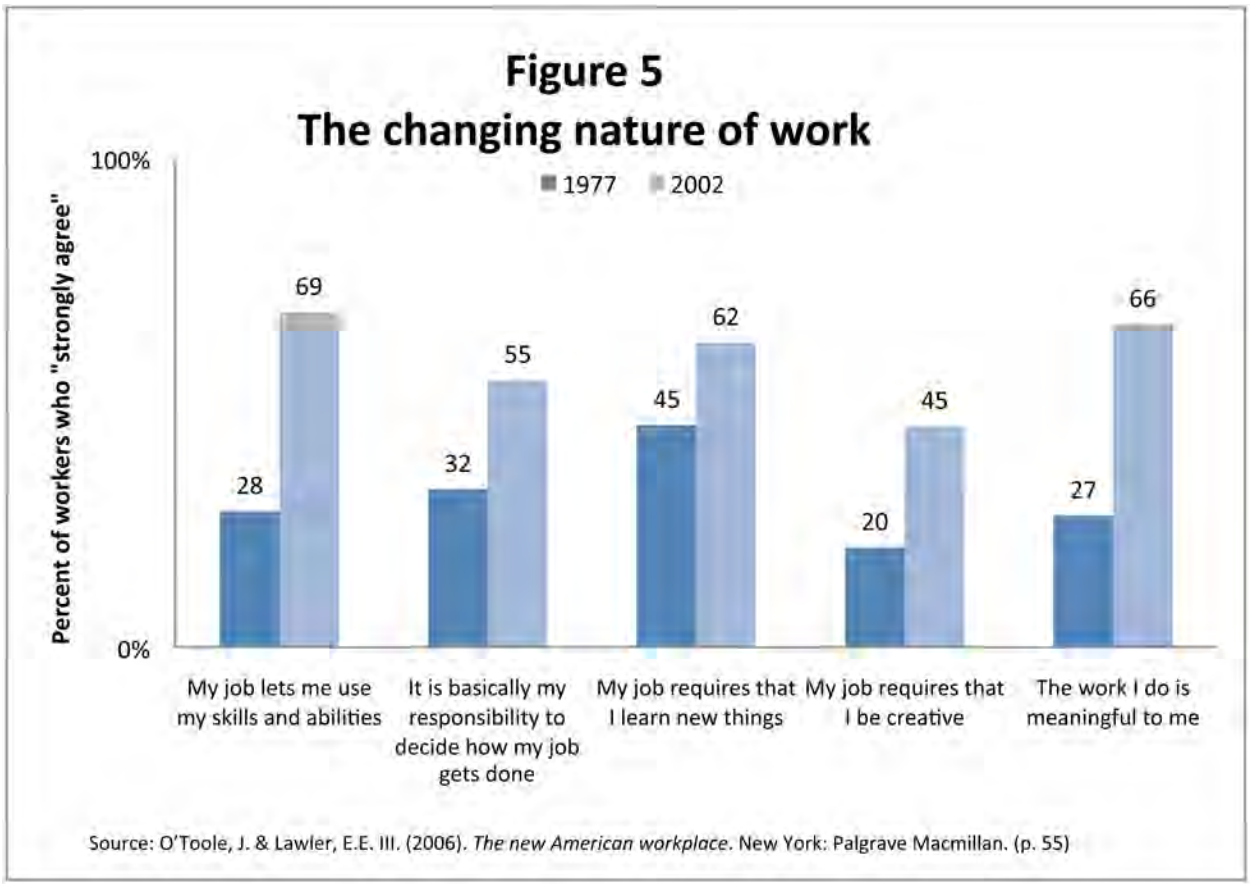
According to O'Toole and Lawler, "Historically, the most important relationships in corporations were hierarchical: all workers reported to bosses who told them what to do. Lateral relationships were unimportant because bosses coordinated the efforts of workers' peers as well."[56] But that is no longer as true. During the 1990s, corporate restructuring efforts cut costs by eliminating layers of management deemed to be unnecessary—which means fewer supervisors must now oversee more people.

Mark Maddox, human resource manager at Unilever Foods North America, describes the change in his company: "In 1991, we began a journey toward 'continuous improvement.' Prior to that, employees reported to work, and supervisors told them what to do. But since then," says Maddox, "layers of management have been taken out. That's what the real change has been about. […] Direct labor is what adds value to your product, so why not just use the intellect as well as the functional capacity of those folks to do the whole job."[57]

More autonomy and responsibility

Because work hierarchies have been flattened, today's employees are expected to take much greater responsibility for managing their own work. In 1997, only 32 percent of American workers strongly agreed that "it is basically my responsibility to decide how my job gets done," but by 2002 that percentage had climbed to more than half (55 percent). (Figure 5)

As O'Toole and Lawler put it, the absence of supervisors means more freedom for workers: "Managers in globally competitive corporations are likely to have more people reporting to them, to be reporting to two or even three different people themselves, and to have fewer organizational layers above and below them—all of which can free them (and their subordinates) to take initiative, be creative, and assume responsibility."[58] Information technology gives them access to the knowledge they need to manage their own work.[59]



Far more Americans say their jobs are intellectually challenging and meaningful than they did several decades ago.

More collaboration

However, that does not mean workers are acting alone. In fact, just the opposite is true. "The way work is organized now is lots of networks of cross-functional teams that work together on specific projects," says Bruett.[60]

Indeed, perhaps the biggest change in the American workplace is the massive increase in "horizontal" collaboration. "Employees in factories and stores organized in self-managing work teams select their own members," explain O'Toole and Lawler, "make their own work assignments, and are paid bonuses based on their performance."[61] A survey of Fortune 1000 companies found that the percentage using self-managing work teams rose from 28 percent in 1988 to 65 percent in 2005.[62]

Moreover, because of Freidman's "flatteners," many work teams are both virtual and global. That is, they take advantage of digitization and telecommunications to connect people—fellow employees, consultants, contractors—from different parts of the state, the country, or the entire world in pursuit of a common task. "We have teams working on major infrastructure projects that are all over the U.S.," says Christi Pedra, the President and CEO of Siemens Hearing Instruments, a subsidiary of the international corporation Siemens AG. "On other projects, you're working with people all over the world on solving a software problem. They don't work in the same room, they don't come to the same office, but every week they're on a variety of conference calls; they're doing web casts; they're doing net meetings."[63]

Less predictability and stability

O'Toole and Lawler found that in the modern American workplace, the traditional concept of "job" is changing, if not disappearing.[64] In many companies, formal and static job descriptions are no longer an essential management strategy. Instead, companies often use more flexible work-assignment descriptions, such as the title of a project an employee is working on. "Work is no longer defined by your specialty; it's defined by the task or problem you and your team are trying to solve or the end goal you want to accomplish," says Dell's Bruett.

Moreover, over the long term, all employees must adapt to new demands. "The increasing speed of technology change, the increasing sophistication of foreign competitors, the export of manufacturing jobs, downsizing due to pressure to increase productivity amount to an almost perfect storm," argue O'Toole and Lawler, "creating an ever-increasing need for workers to update their skills regularly and, often, to develop entirely new ones." At the same time, employees are increasingly responsible for developing skills themselves, because companies now provide much less workplace training and increasingly hire the talent they need for a particular job, project, or task.

Michael Eskew, then-CEO of UPS, summed it up this way in a 2005 speech on what UPS looks for in new employees:

> We look for people who can learn how to learn. While information is much richer today, complexity and uncertainty have not abated. In fact, they've increased. That's also why we want to make it possible for people to have six or more different jobs in the course of a career at UPS.[68]

Workplace and corporate change is having a large impact on skill demands. To succeed in "flat" organizations characterized by less supervision and greater individual autonomy, individuals need to be able to act independently to identify opportunities and solve problems on their own. They also will need strong interpersonal skills—written, oral, social—to collaborate effectively with colleagues on self-managed work teams. (And, again, to the extent that collaboration is becoming global in nature, they will need strong "global literacy" so they have a firm context for understanding the people they must deal with around the world.) Finally, they will need to know how to acquire the information they need to do a job, and they will need to be able to learn new skills as corporations change strategies to stay competitive.

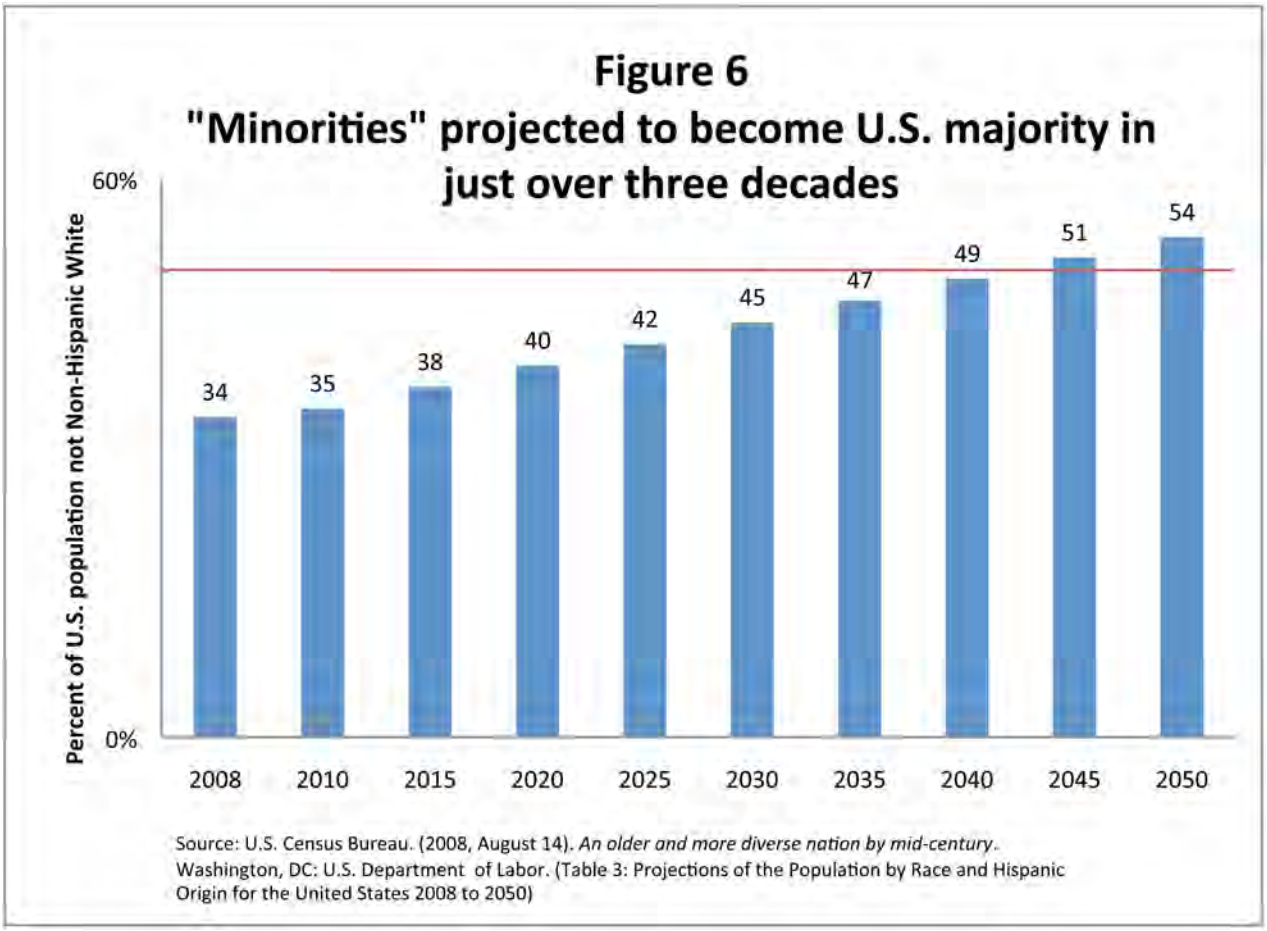
How will workplaces and business practices change in the future? Once again, making accurate long-term prediction is extremely difficult if not impossible. However, one recent trend that has garnered much attention is the outsourcing of specific design problems not to someone but to "anyone." In new books like *Wikinomics* and *Crowdsourcing*, journalists have described the trend toward solving problems and designing innovations collaboratively on the internet. Some companies have begun to investigate whether they can leverage that new model. For example, a firm called Innocentive posts on its website ornery problems that other companies have not been able to solve. Anyone who can solve a problem earns a fee. One North Carolina patent lawyer suggested a new way to mix large batches of chemicals.[69]

So far, according to *Wired* writer Jeff How, the impact on skill demands seems to mirror the impact of automation and globalization: "Crowdsourcing accelerates the globalization of labor and the economic dislocation that we see in outsourcing. Like the Internet through which it operates, crowdsourcing recognizes no boundaries. The network doesn't care if you're down the block, downstate, or down under—if you can perform the service, design the product, or solve the problem, you've got the job."[70]

Demographic change

Last year the U.S. Census Bureau projected that by the time all of the Baby Boomers reach age 65 in 2030, nearly one out of every five U.S. residents will be 65 and older. In fact, the 65 and older population is expected to more than double between 2008 and 2050, while the 85 and older population is expected to more than triple.[71] That's one reason we should be concerned with maintaining economic growth, according to the Skills Commission report: "Fewer of us will have to support many more of us than has ever been the case before. If each of us only produces only as much as each member of the baby boom generation, then each of us will be poorer than we have been, because there will be more mouths to feed."[72]

But another trend identified in that Census Bureau report is just as significant. Demographers now predict that "minorities" will constitute the majority of schoolchildren by 2023, of working-age Americans by 2039, and of all Americans by 2042.[73] (Figure 6) Although such demographic changes will be greater in some parts of the country than others, today's young people can expect to live in communities and work in companies that are much more diverse than in the past. When virtual interactions are added to that picture, it is not surprising that employers surveyed in a recent Conference Board study placed the ability to handle diversity among the top five work-related skills they expect to increase in importance over the next five years.[74]



The U.S. Census Bureau predicts that by 2042, non-Hispanic whites will no longer constitute a majority of Americans.

Obviously, such demographic changes present challenges for schools. On the one hand, schools obviously will need to develop the capacity to teach a more diverse population of students. On the other hand, they will need to prepare those students to deal with diversity, too, since those students will need to interact effectively with more diverse groups of people both in their communities and at work.

Personal risk and responsibility

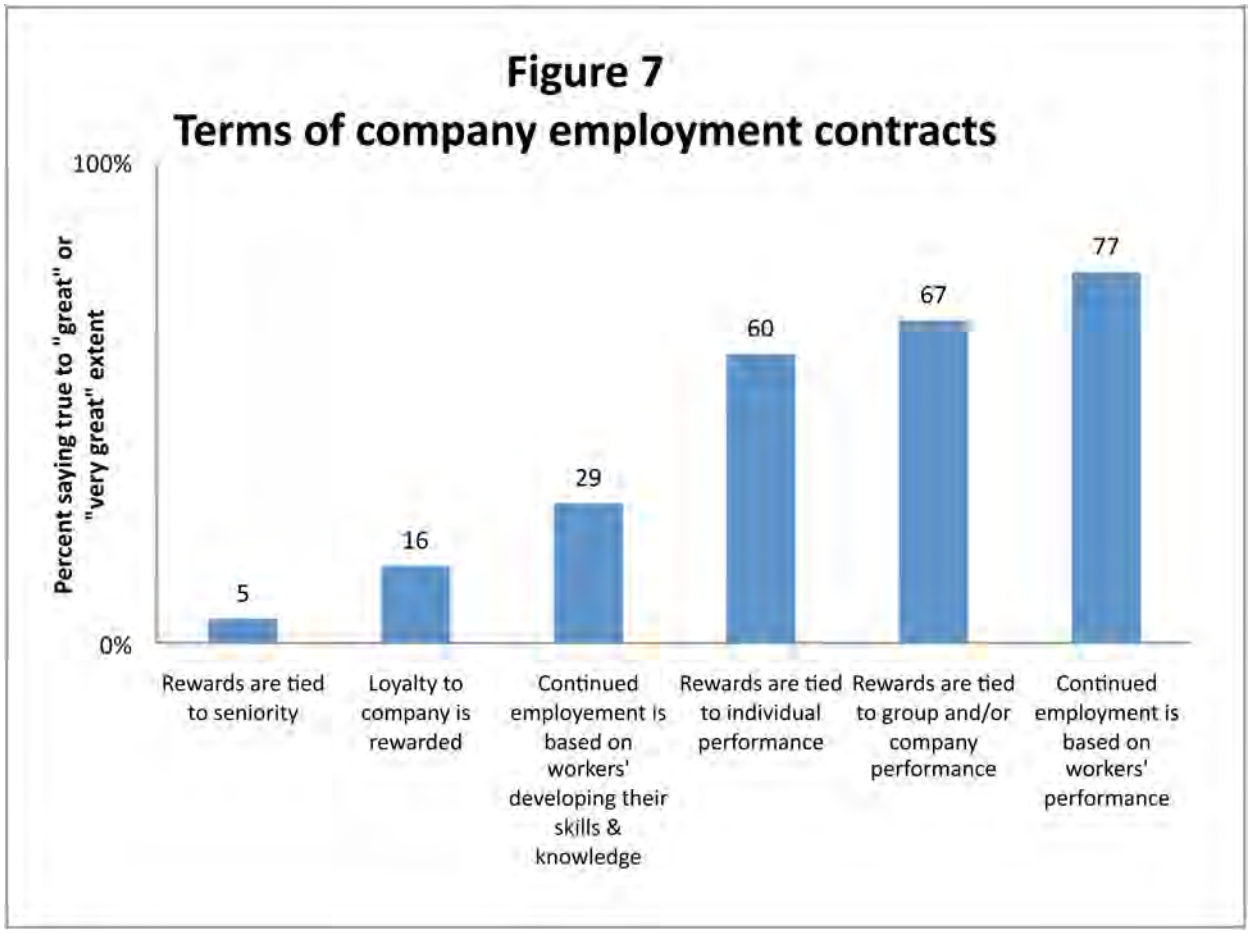
Clearly, the world in which people live and work is becoming both more complex and more demanding. That is not always a bad thing. As Figure 3 shows, jobs that are more challenging also tend to be more personally satisfying. In 1977, only 28 percent of workers strongly agreed that "the work I do is meaningful to me," but by 2002 the figure had swelled to 66 percent.

At the same time, however, because of changes in corporate and government policies, individuals now shoulder a greater burden of risk and responsibility for their personal well-being. Three intersecting spheres illustrate the trend: job security, health care, and financial planning.

Job security

In today's knowledge and service economy, many companies have recognized that human capital is their greatest asset. Ironically, that has translated into *less* job security than in the past. "As the capacity to make rapid change has become increasingly central to the survival of corporations, loyalty is giving way to contingency at the heart of relationships companies have with their employees," write O'Toole and Lawler. Today, companies "recruit employees who are willing to learn, reward them with pay increases for learning new skills, bring in new talent if the existing workforce can't be upgraded, and dismiss those who are unwilling to, or cannot, learn the skills that the organization needs in order to compete effectively."[75]

For example, a late 1980s Conference Board survey found that 56 percent of corporate managers agreed with the statement, "employees who are loyal to the company and further its business goals deserve an assurance of continued employment." But only a decade later, that percentage had plummeted to 6 percent.[76] As Figure 7 shows, the days are long gone when an employee could expect to have a job for life if he or she remained loyal to a company. Twice as many companies say that employment is contingent on developing necessary skills. But even that is not enough: The overwhelming majority of companies—more than three quarters—say that continued employment is based on performance.

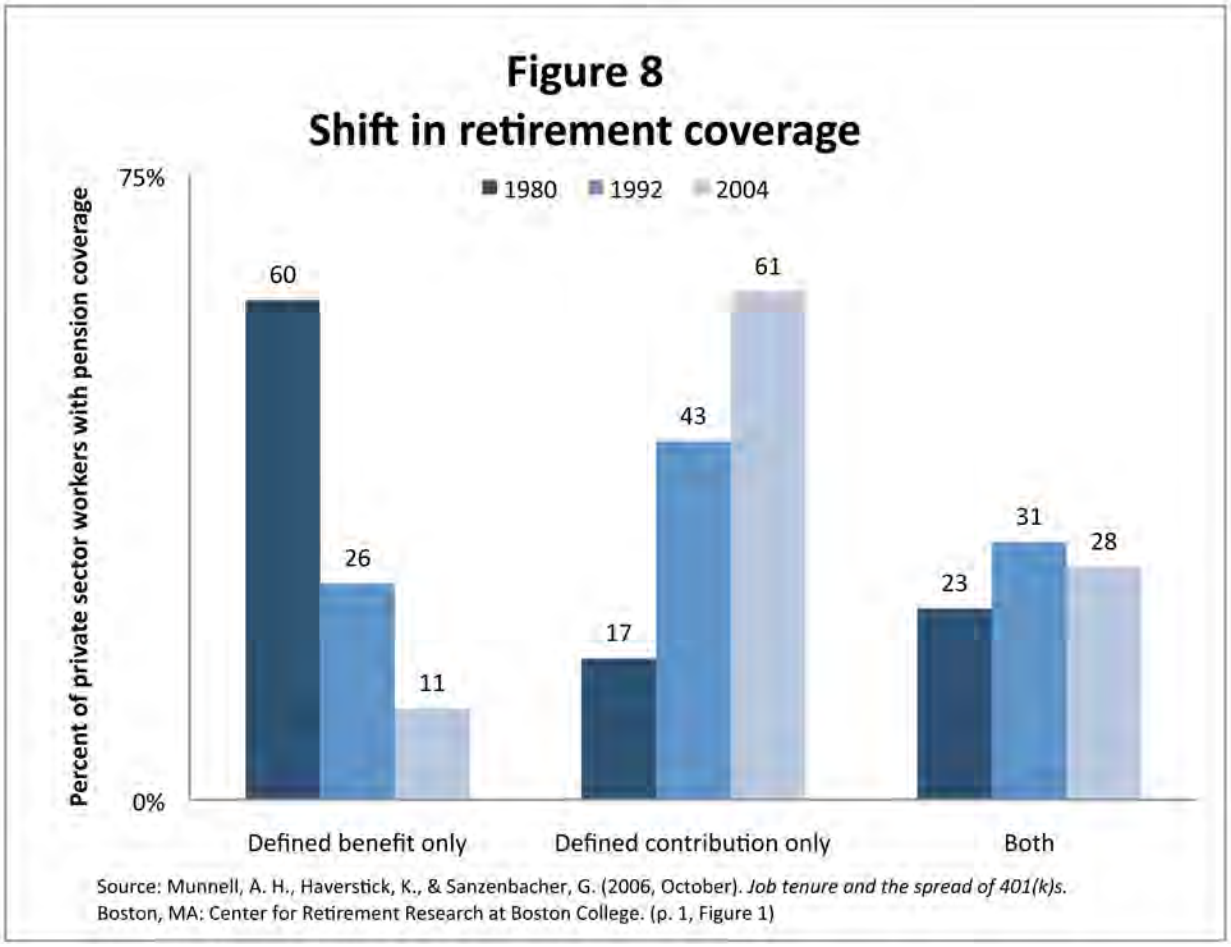


Unlike several decades ago, today's graduates face a corporate world in which loyalty and seniority are no longer greatly valued and continuing employment depends on performance.

Financial planning

Several decades ago, many workers could expect to receive a pension when they retired. The amount would be defined by how long they had worked for a company and what their final salary was. Long-term employees could look forward to monthly checks that, while paying less than they made when they worked, provided a roughly "comparable" lifestyle.

Today we call such arrangements "defined-benefit" plans, and they have been all but replaced with "defined contribution" plans such as Individual Retirement Accounts and 401(k)s. In fact, between 1980 and 2004, the percentage of covered private sector employees who only have a defined benefit plan dropped from 60 to 11 percent while the percentage with only a defined-contribution plan rose from 17 to 61 percent.[77] (Figure 8) Today, only one in four employers even offers any kind of defined or guaranteed pension plan.[78] Under defined *contribution* plans, employees are responsible—at least to some extent—for deciding how the contributions will be invested, and the amount of retirement income they can depend on is determined by how well those investments work out.



Over the past few decades, companies have shifted away from defined-benefit plans that offer a set amount upon retirement and toward defined-contribution plans that pay out according to how well an individual's investments pay off.

"Over the past 30 years, individuals have had to become increasingly responsible for their own financial security following retirement," writes Annamaria Lusardi, a professor of economics at Dartmouth College.[79] In other words, retirement was once something that workers did not have to think a lot about. Today, they do have to think about it, and *how well they think about it* can have huge consequences for their future well-being.

Health care

A similar trend is occurring in health care. According to a 2007 study published in *Medical Care Research and Review:*

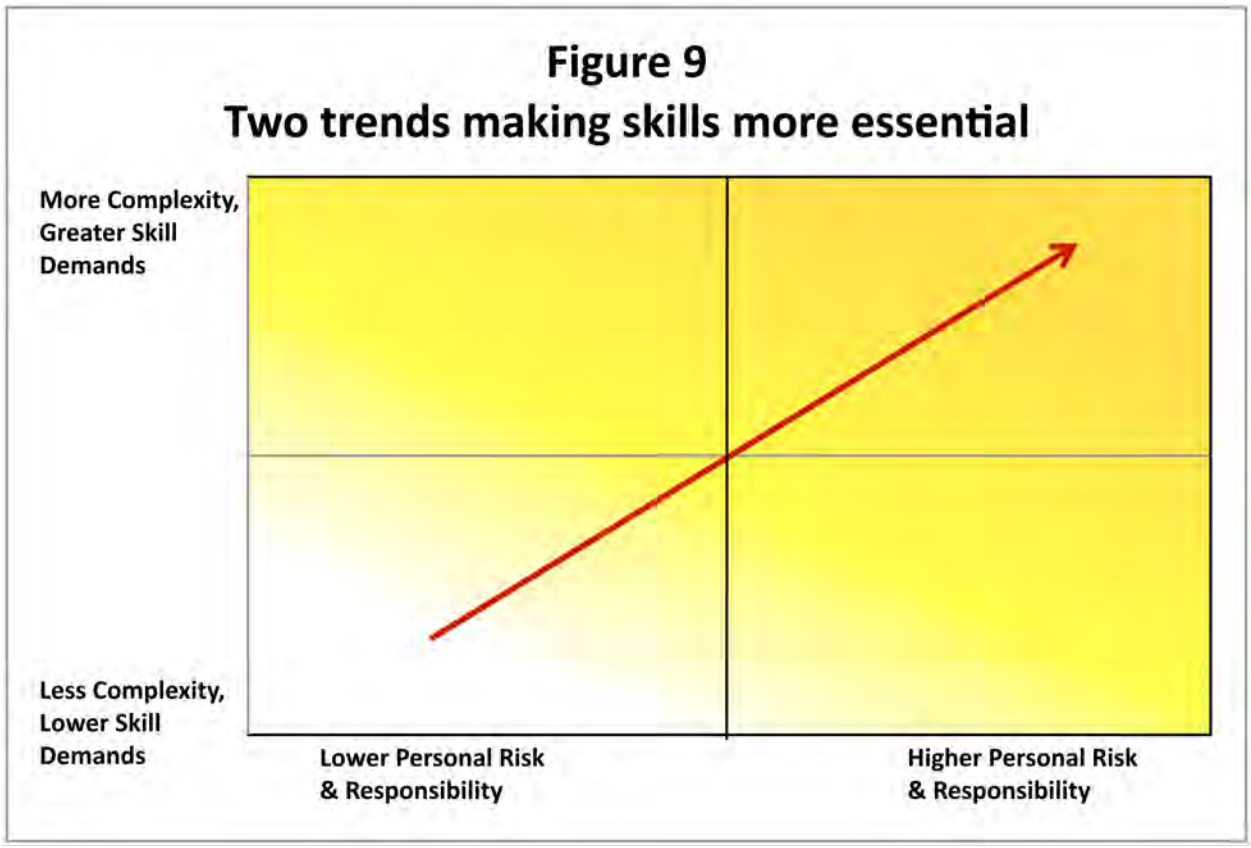
> The direction of current health policy places a greater reliance on consumers to be part of the solution to health care cost and quality problems. By providing consumers with accurate and timely information, the expectation is that consumers will make more appropriate and cost-effective choices. […] At the same time, coverage choices are becoming more complicated and varied, health delivery systems more complex, and evidence of provider quality

> and treatment efficacy more transparent. *Consumers therefore require more knowledge and greater skill to take full advantage of new sources of information and to make appropriate choices.80* [emphasis added]

Moreover, patients also are being asked to shoulder a greater share of medical expenses.[81] As a result, Americans face increasing risk—both financial and physical—when it comes to their health care. And their "performance" in choosing plans and treatments can literally be a matter of life and death.

Taken together, all of these trends have created twin forces that are changing what it takes to thrive in the adult world: First, the environment that people live in is becoming more complex and demanding, while, second, individuals are being asked to take on greater responsibility in their work and personal lives. (Figure 9) As economists Anthony Carnevale and Donna Desrochers frame the challenge in a recent article on math education, "It appears that the requirement for mathematical literacy in labor markets (and by implication in society) is one of an ascending ability to use basic mathematical operations with increasing independence and in situations of increasing complexity. This suggests that the way we teach mathematics may not be aligned with the uses we make of mathematics in most jobs."[82]

Students will need strong skills to navigate a world where personal choices are fraught with greater risk. At the very least, they will need strong math and reading skills to understand the information necessary to understand their options. And they will need to be able to use what they learn in school to understand critical information—including numerical health and financial information—in order to make sound decisions that ensure their well-being.



Changes in the workplace, the larger economy, and society as a whole are increasing the complexity of the environment people live in and demanding greater skills of them. At the same time, people are being asked to shoulder a greater burden of personal risk and responsibility for navigating that environment, both on the job and in personal spheres like health care and financial planning.

2. What specific kinds of knowledge and skills will be most important in the 21st century?

As we saw in the first section, a number of major trends are changing the world in ways that have been and will continue to impact skill demands. To summarize,

Computer technology in the work place has led to the **automation** of many job tasks that humans once performed, primarily "routine" tasks that require following directions—something computers can do better, faster, and more cheaply than humans. At the same time, human workers are increasingly called on to tackle thinking tasks that computers cannot (yet) handle, particularly those that require solving unpredictable problems and interacting with other humans—along with the strong foundation in math, reading, and writing that forms a foundation for such thinking work.

Technological and political changes have contributed to **globalization** of the economy. As a result, many more Americans are competing for jobs with a huge number of foreigners in an increasingly global labor market and—just as significantly—collaborating with workers in other countries when they do land a job. So far the impact of globalization has resembled that of automation, reducing demand for less-skilled labor. However, some economists predict that highly skilled workers in other countries will increasingly compete for more intellectually demanding and higher paying jobs, which will force Americans to offer not only strong traditional skills but also high levels of creativity and innovation in order to stay competitive.

Because of technology, globalization, and other competitive forces, **companies have radically restructured** how work gets done. Many companies are now "flatter" organizations with less hierarchy and lighter supervision where workers experience greater autonomy and personal responsibility for the work they do. Work also has become much more collaborative, with self-managing work teams increasingly responsible for tackling major projects. Increasingly, such work teams are global in nature, which much of the interaction taking place electronically. Jobs have become less predictable and stable. From project to project and from year to year, employees must adapt to new challenges and demands. Workers need strong foundational skills as well as the ability to think independently, identify and solve problems on their own, work collaboratively, and learn new knowledge and skills as necessary.

U.S. **demographics** are changing rapidly as the population becomes both older and more diverse. The 65 and older population is expected to more than double between 2008 and 2050 (while the 85 and older population is expected to more than triple), and so-called "minorities" will constitute the majority of schoolchildren by 2023, of working-age Americans by 2039, and of all Americans by 2042. That creates a two-fold challenge for schools: First, they will need to be able to teach a more diverse group of students. Second, they will need to prepare those students to collaborate in diverse job settings and function in a diverse society.

Individuals increasingly shoulder a greater burden of **risk and responsibility** for their personal well-being when it comes to things like job security, health care, and financial planning. As a result, students will need strong reading and math skills to make sense of information that can inform their decisionmaking. Students will need to be able to use what they learn in school to understand critical information—including numerical health and financial information—in order to make sound decisions that ensure their well-being.

We now turn to the specific skills that are important in the 21st century, either because they *continue* to be important or because they are becoming more important due to the trends described above.

Broadly speaking, five major lessons emerge from the expert research and opinion on what kinds of knowledge and skills will most benefit students in the future:

1. Students who obtain more education will be at a great advantage; increasingly, some postsecondary education or technical training is essential for an opportunity to support a family or secure a middle-class lifestyle.

2. The need for traditional knowledge and skills in school subjects like math, language arts, and science is not being "displaced" by a new set of skills; in fact, students who take more advanced math courses and master higher math skills, for example, will have a distinct advantage over their peers.

3. At the same time, for success both on the job and in their personal lives, students must also better learn how to *apply* what they learn in those subjects to deal with real world challenges, rather than simply "reproduce" the information on tests.

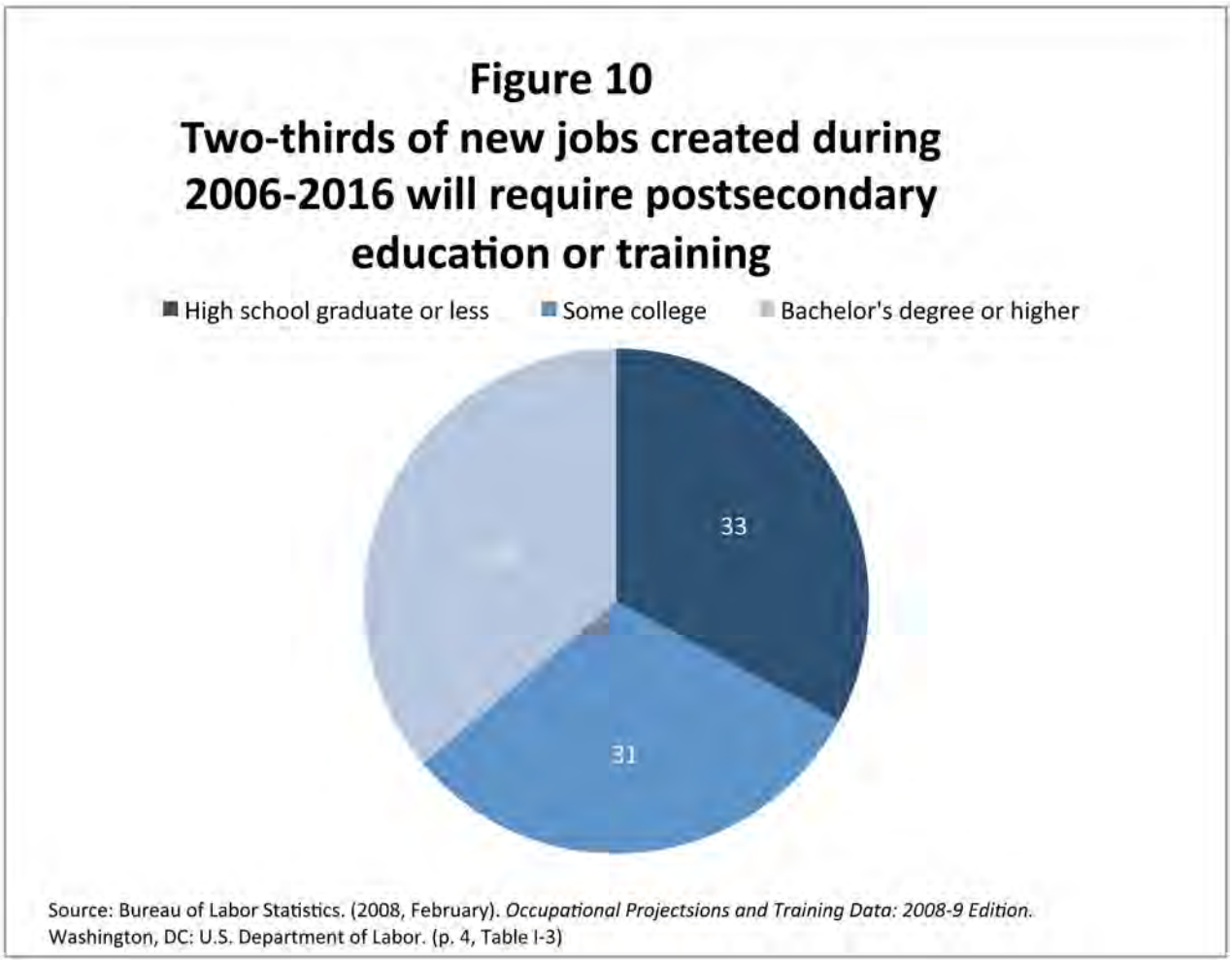
4. Students who develop an even broader set of in-demand competencies—the ability to think critically about information, solve novel problems, communicate and collaborate, create new products and processes, and adapt to change—will be at an even greater advantage in work and life.

5. Applied skills and competencies can best be taught in the context of the academic curriculum, not as a replacement for it or "add on" to it; in fact, cognitive research suggests that some competencies like critical thinking and problem solving are highly dependent on deep content knowledge and cannot be taught in isolation.

Educational Attainment

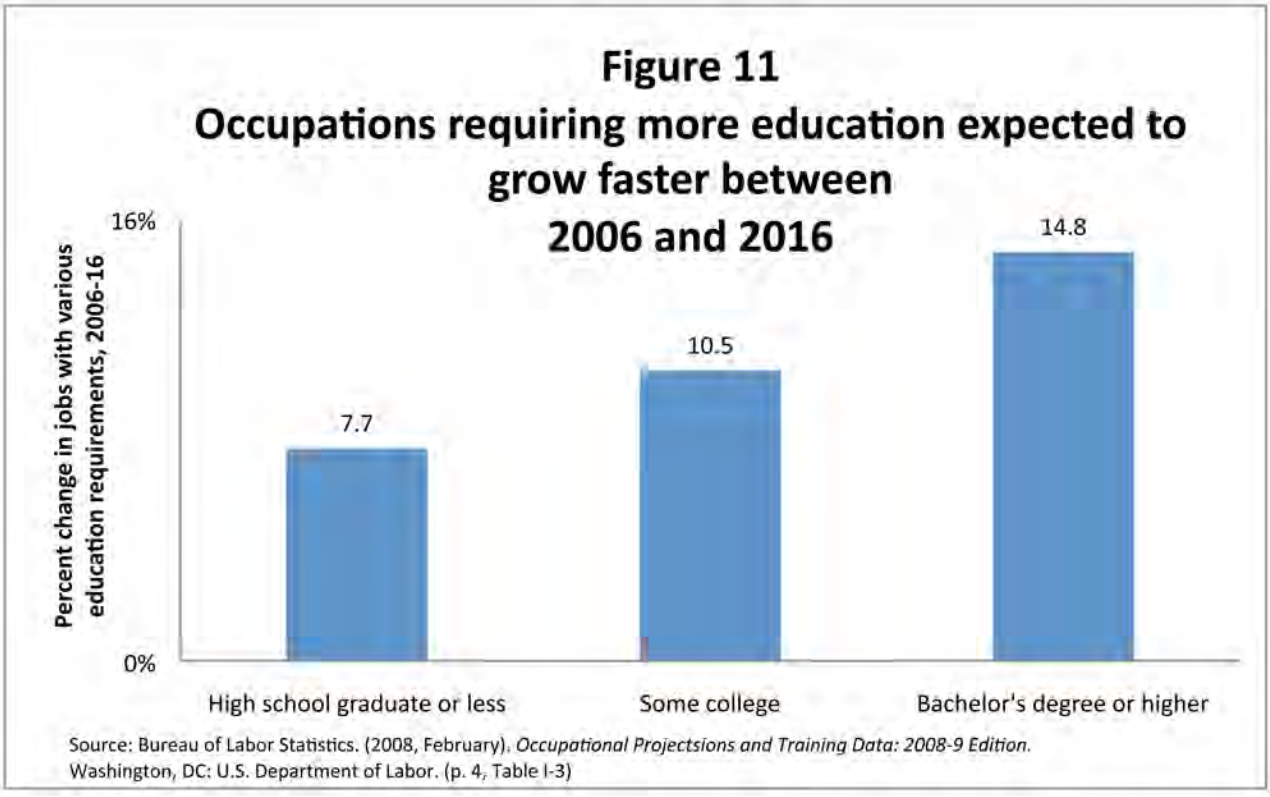
Before considering what skills are necessary for success in the 21st century, it is important to recognize that how much education one attains is important of itself. According to Harvard University economists Claudia Goldin and Lawrence Katz in their new book *The Race Between Education and Technology,* from 1980 to 2005, the college wage premium—the amount of additional money earned by those with a college degree—increased by "an astonishing 25 percent." The rate of return for each year of college education now stands at about 13 to 14 percent.[83]

According to the most recent 10-year occupational growth projections by the U.S. Department of Labor's Bureau of Labor Statistics (BLS), the demand for more educated workers should continue. "In the next decade," says U.S. Secretary of Labor Elaine Chao, "nearly two-thirds of the estimated 15.6 million net new jobs created in our country will be in occupations that require postsecondary education or considerable on-the-job training."[84] (See Figure 10)



The Department of Labor estimates that two out of every three new jobs created between 2006 and 2016 will require education or training beyond a high school diploma.

Moreover, occupations that require a bachelor's degree will grow twice as fast as occupations that require only a high school diploma. (Figure 11) Professional occupations are expected to add 5 million jobs, more than any other major category, and also to share the fastest growth rate. Within that category, health care practitioners and technical occupations are projected to add the most new jobs (1.4 million), while computer and mathematical occupations are expected to grow the most quickly—at a nearly 25 percent rate. By 2016 there will be jobs for nearly 3 million new healthcare professionals and 950,000 engineers, including aerospace, biomedical, civil, computer software, and environmental engineers. Health services, professional services, and business services now account for nearly one-fifth of total employment in the U.S., and those occupational areas will account for more than half of U.S. employment growth from 2006-2016. [86]



Among occupations that the Department of Labor expects to grow fastest between 2006 and 2016, those requiring and bachelor's degree will outnumber those requiring only a high school diploma by two-to-one.

Of course, service sector jobs will be growing too, including lower-wage service jobs. As the Baby Boom generation ages, for example, there will be greater demand for elderly care workers. As discussed above, such jobs cannot be automated. However, high-wage work will increasingly require more education, and the retirement of older workers also increases the demand for skilled workers to replace many of them. Of the 7.4 million new jobs in occupations expected to experience above-average growth *and also to pay above-average wages*, more than 5.5 million (76 percent) will require either some college or a bachelor's degree. In 2006, those occupations paid an average median wage of $55,911. (An additional 6.25 percent are in a category where requirements are more flexible but often entail a vocational or bachelor's degree.)

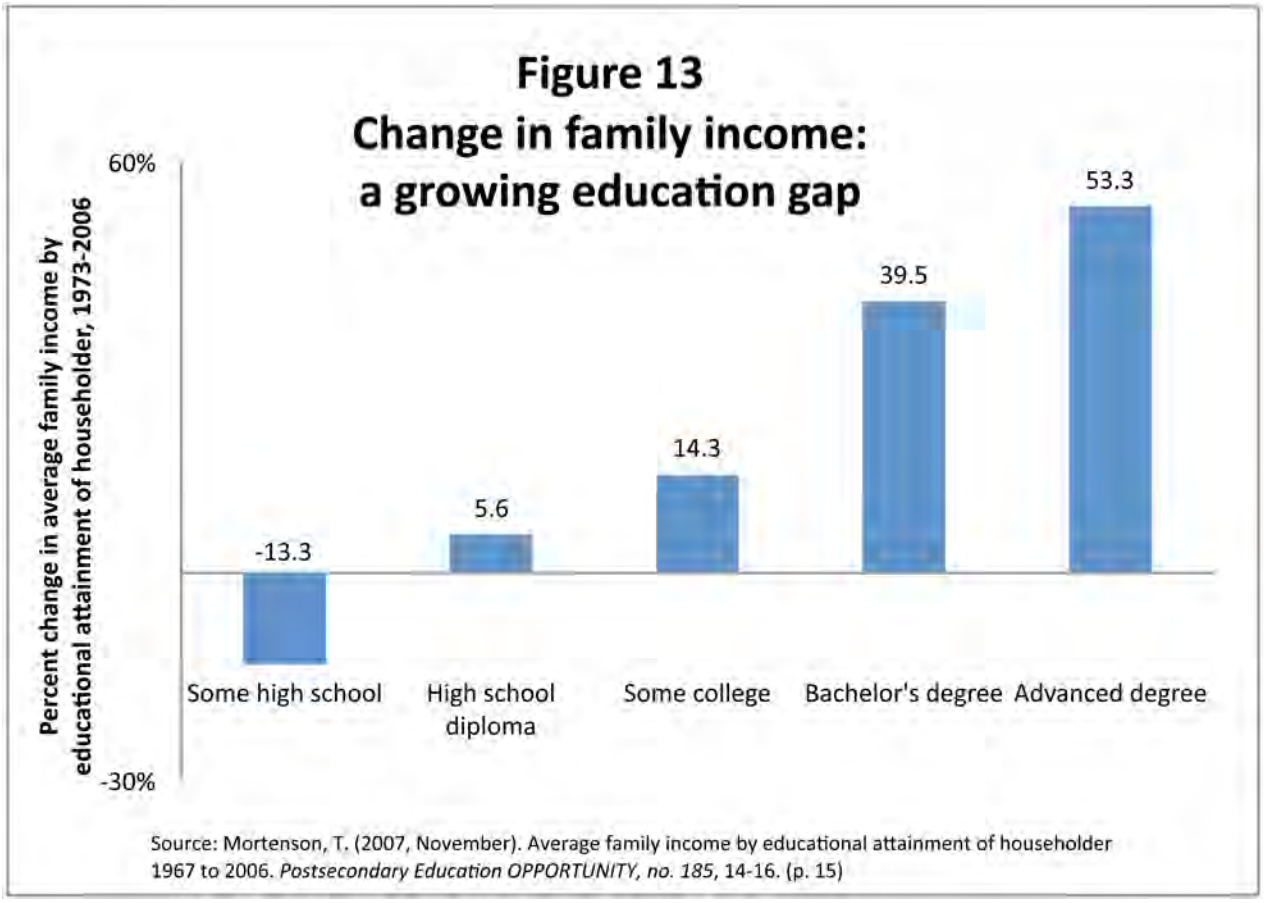
Figure 12
Which occupations will see great growth between 2006 and 2016?

Twenty occupations with the fastest rate of growth	Twenty occupations that will add the most jobs
Network systems and data communications analysts	Registered nurses
Personal and home care aides	Retail salespersons
Home health aides	Customer service representatives
Computer software engineers, applications	Combined food preparation and serving workers
Personal financial advisors	Office clerks, general
Veterinary technologists and technicians	Personal and home care aides
Makeup artists, theatrical and performance	Home health aides
Medical assistants	Postsecondary teachers
Veterinarians	Janitors and cleaners, except maids and housekeeping cleaners
Substance abuse and behavioral disorder counselors	Nursing aides, orderlies, and attendants
Skin care specialists	Bookkeeping, accounting, and auditing clerks
Financial analysts	Waiters and waitresses
Social and human service assistants	Child care workers
Gaming surveillance officers and gaming investigators	Executive secretaries and administrative assistants
Physical therapist assistants	Computer software engineers, applications
Pharmacy technicians	Accountants and auditors
Forensic science technicians	Landscaping and groundskeeping workers
Dental hygienists	Elementary school teachers, except special education
Mental health counselors	Receptionists and information clerks
Mental health and substance abuse social workers	Truck drivers, heavy and tractor-trailer

Source: Dohm, A. & Shniper, L. (2007, November). Employment outlook: 2006–16. Washington, DC: Bureau of Labor Statistics. (pp. 95-98, Tables 2 & 3)

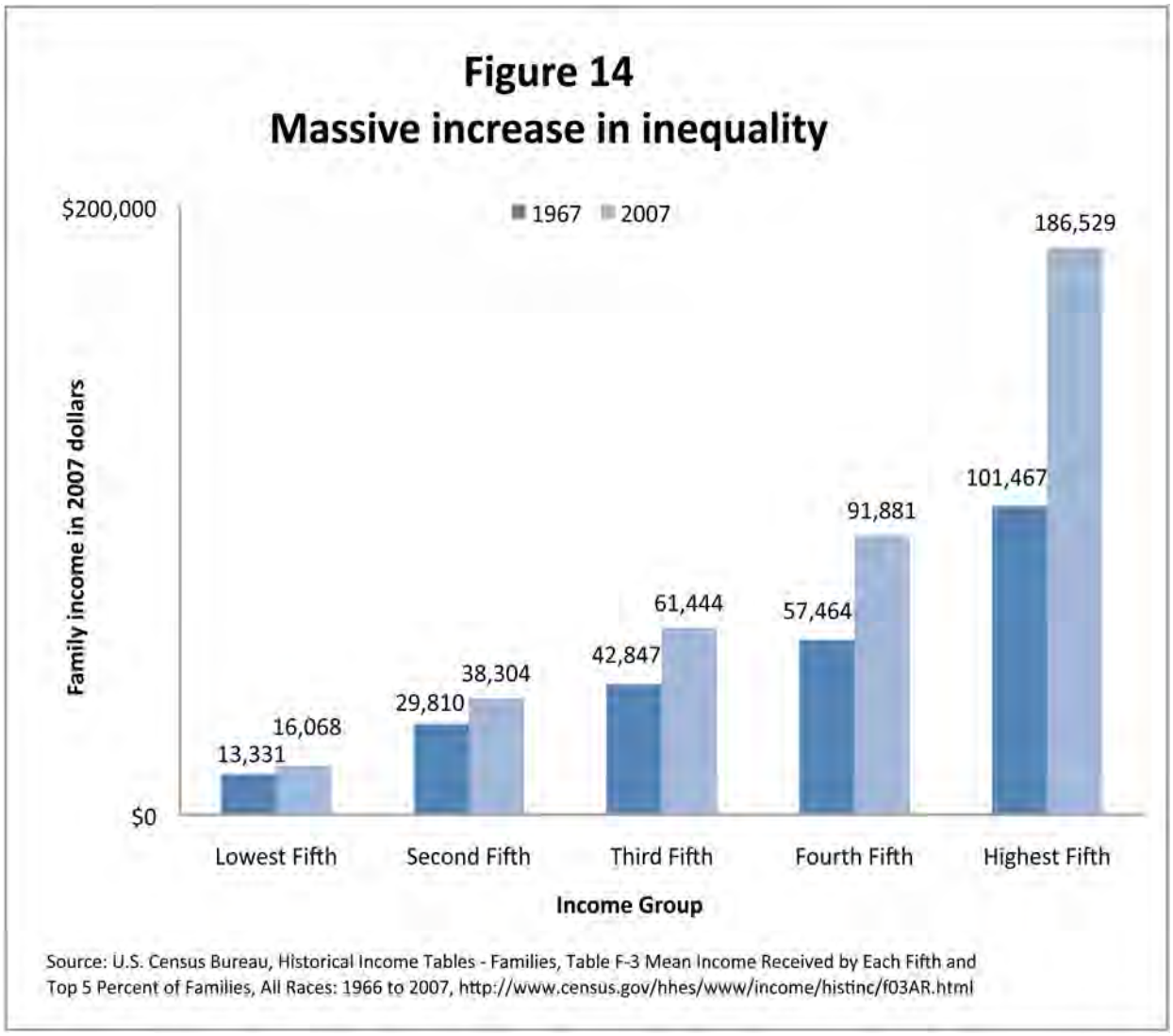
This table shows the occupations expected to grow at the fastest rate between 2006 and 2016 and the occupations expected to add the largest number of jobs on an absolute basis.

That means demand for educated workers will continue to be high, and those who obtain postsecondary education or training can continue to expect to earn a premium while those who do not will have far fewer opportunities to earn a living wage. Family income for households headed by someone with a college degree grew by nearly 40 percent from 1973 to 2006, compared with less than 6 percent for families headed by someone with only a high school diploma.[89] (Figure 13)



Between 1973 and 2006, the income of families headed by a high school dropout dropped after taking into account inflation, while family income of college graduates rose greatly.

In fact, according Goldin and Katz, the failure of educational attainment to keep up with technology-driven skill demands has been a major factor behind the massive surge in income inequality in the United States over the past several decades.[90] (Figure 14) "Education has not kept pace," says Katz. "In the early 20th century, we created almost universal access to high school. We have not done the same with college, which essentially we would need to have done to [keep] widespread prosperity present."[91]

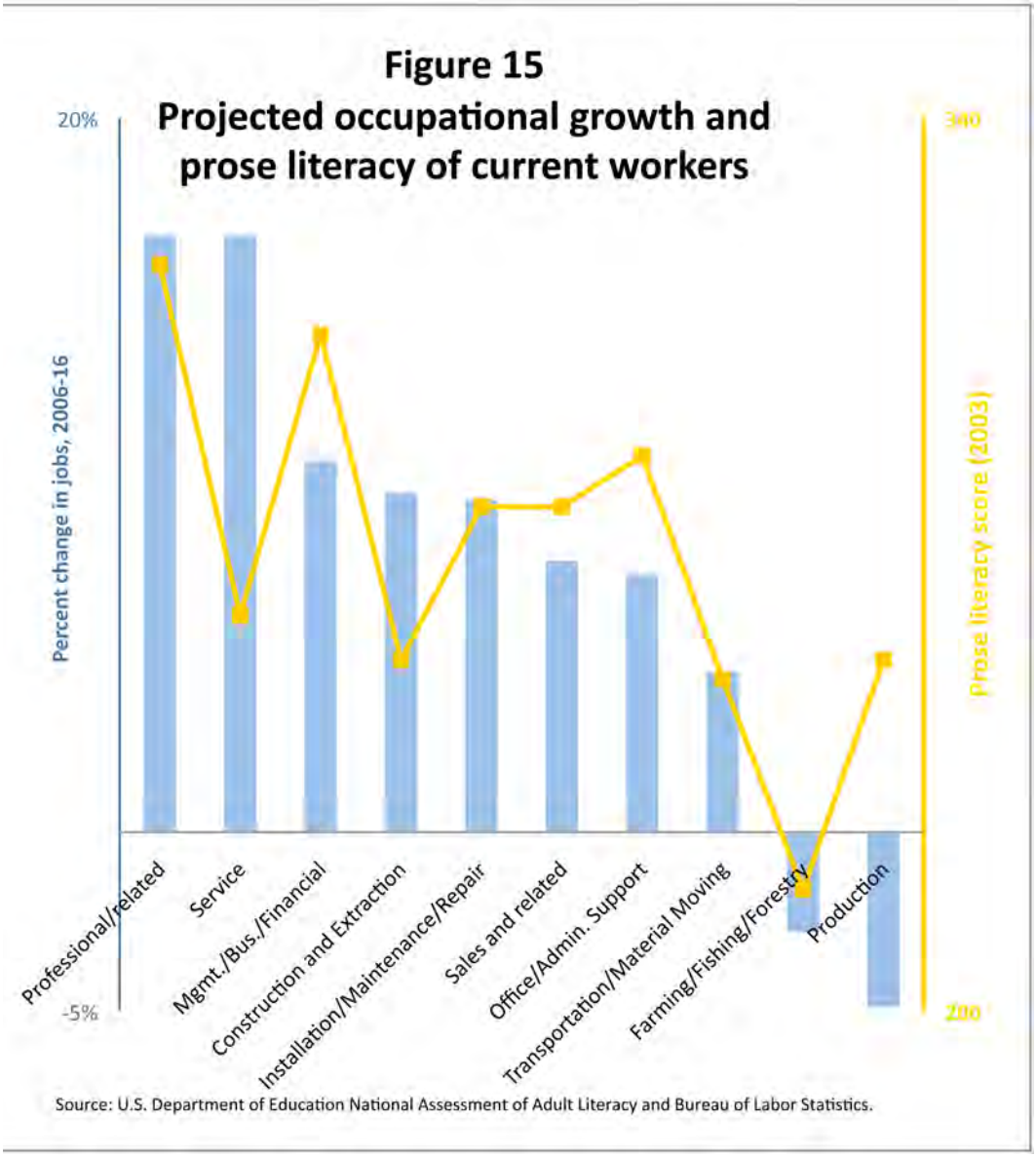


Between 1967 and 2007, the annual income of the wealthiest American families nearly doubled, while the earnings of the poorest grew very little.

Even so, says Katz, "there has been much more growth of inequality among college graduates than among noncollege workers." Why? "Only some people are coming out of college with the high-level abstract-reasoning skills that fully complement the new information technologies and command high salaries."[92] Indeed, other recent economic studies have found that skills are not just at least as important as degrees, they are even more important.

According to a research review by Patte Barth, now director of the Center for Public Education, "There is considerable pay off in today's job market for those with more years of education. But it's not just paper credentials that count. Researchers have shown that individuals with highly developed skills gain greater advantages in the workplace over those with similar educational credentials but with less developed skills. Simply, the more you know, the more you earn."[93]

A very broad look at occupational growth projections and literacy levels supports the idea that higher growth will occur in occupations demanding higher skills. Figure 15 compares the amount by which each occupational category is expected to grow between 2006 and 2016 with the average "prose literacy" of workers in that occupation. Other than two exceptions—service and construction jobs--the overall trend is toward greater demand for higher skills; the correlation between occupational growth and literacy scores is 0.66, which is considered relatively high. Literacy demands might also increase because of "up-skilling" occurring within occupational categories, which the chart cannot show. For example, although construction workers currently have lower literacy levels, many construction trades are requiring higher levels of learning. (See the example in Figure 16 on page 31 of algebra questions on a screening test for potential electricians.)



This chart graphs occupational growth projects (left hand axis and grey bars) on top of the literacy level of workers in that occupation according to the 2003 National Assessment of Adult Literacy (right hand axis and blue line). In general, the higher the expected occupational growth, the higher the literacy level, with two exceptions: services and construction.

Recent research at the national level confirms the critical importance of skills as opposed to educational credentials. Hanushek and his colleagues found that each additional year of schooling attained by a country's population increased its 40-year growth rate in GDP by about 0.37 percentage points—much less than the boost from improving test scores. Moreover, once test scores are added to the equation, the boost from years of schooling dwindles even further.[94]

That is not to say that educational credentials are meaningless: In the absence of direct measures of skill, they signal to employers that job candidates are more likely to have developed desirable skills—perhaps because they need them to get into college or perhaps because they develop them in college—or have the ability to learn new skills. But while getting an education is just as important or more important than it has ever been, simply "getting an education" is no longer enough. What matters most is the quality of that education defined by level of knowledge and skills students attain during it.

Foundational knowledge and skills

Along with the rhetoric about "21st century skills," a myth has spread in some circles that students will no longer need to learn the academic content traditionally taught in the school curriculum.[95] After all, why do you need to know "that stuff" if you can look it up on Google? Can't your cell phone or Blackberry perform all the math problems you'll ever need to do? After they teach students how to read, shouldn't schools then just focus on teaching them "how to think" and how to use technology to learn on their own?

But such beliefs are wrong for many reasons. First, cognitive scientists have found that a broad vocabulary and sufficient background knowledge about the world—the kind of things students learn in science and social studies classes, for example—are hugely important for strong reading comprehension. One study demonstrated that poor readers knowledgeable about baseball scored better in comprehending a text about that subject than good readers who knew little about baseball. The more you know, the easier it is to learn new things by reading about them.[96]

Second, according to Levy and Murnane, research shows that higher-paying companies that invest heavily in training their workers are particularly likely to screen their applicants for basic reading and math skills because they deem them necessary to success in such training.[97] As noted above, even trade unions have begun to develop screening tests for potential apprentices. Figure 16 shows some sample questions from an apprentice screening test developed by the International Brotherhood of Electrical Workers. Since "the basics" are necessary for good jobs that require further training, schools can hardly abandon them without putting students at a great disadvantage.

Figure 16

Sample Algebra and Functions

This is a test of your ability to solve problems using algebra.

1. Consider the following formula: A = B + 3 (4 - C)
If B equals 5 and C equals 2, what is the value of A?

A.7
B.11
C.12
D.17

2. Consider the following formula: y = 3 (x + 5) (x - 2)
Which of the following formulas is equivalent to this one?

A. y=3x2+9x-30
B. y=x2+3x-lO
C. y=3x2+3x-lO
D. y=3x2+3x-30

3. Consider the following pattern of numbers: 110, 112, 107, 109, 104
What is the next number in the pattern?

A.97
B. 99
C. 106
D.109

4. Consider the following formula: a = 1/2 b - 4
Which of the following statements is true for this formula?

A. When the value of b is less than 8, a is negative.
B. When the value of b is greater than 8, a is negative.
C. When the value of b is less than 8, a is positive.
D. When the value of b is greater than 4, a is positive.

Source: National Joint Partnership and Training Committee for the ElectricalCionstruction and Maintenance Industry, www.njatc.org/training/apprenticeship/sample/sample_test.html

These are sample questions from a test that is used by apprenticeship programs to screen prospective electricians, work that is well-paying but does not require a college degree.

Third, subject matter knowledge and basic skills are important building blocks for the broader competencies gaining value in the 21st century. As discussed below, being able to think critically about a topic or solve a problem in a particular domain demands sufficient background knowledge about it. And an important aspect of creativity is making connections across domains of knowledge—something that is impossible unless someone knows enough in different domains to make such a connection.

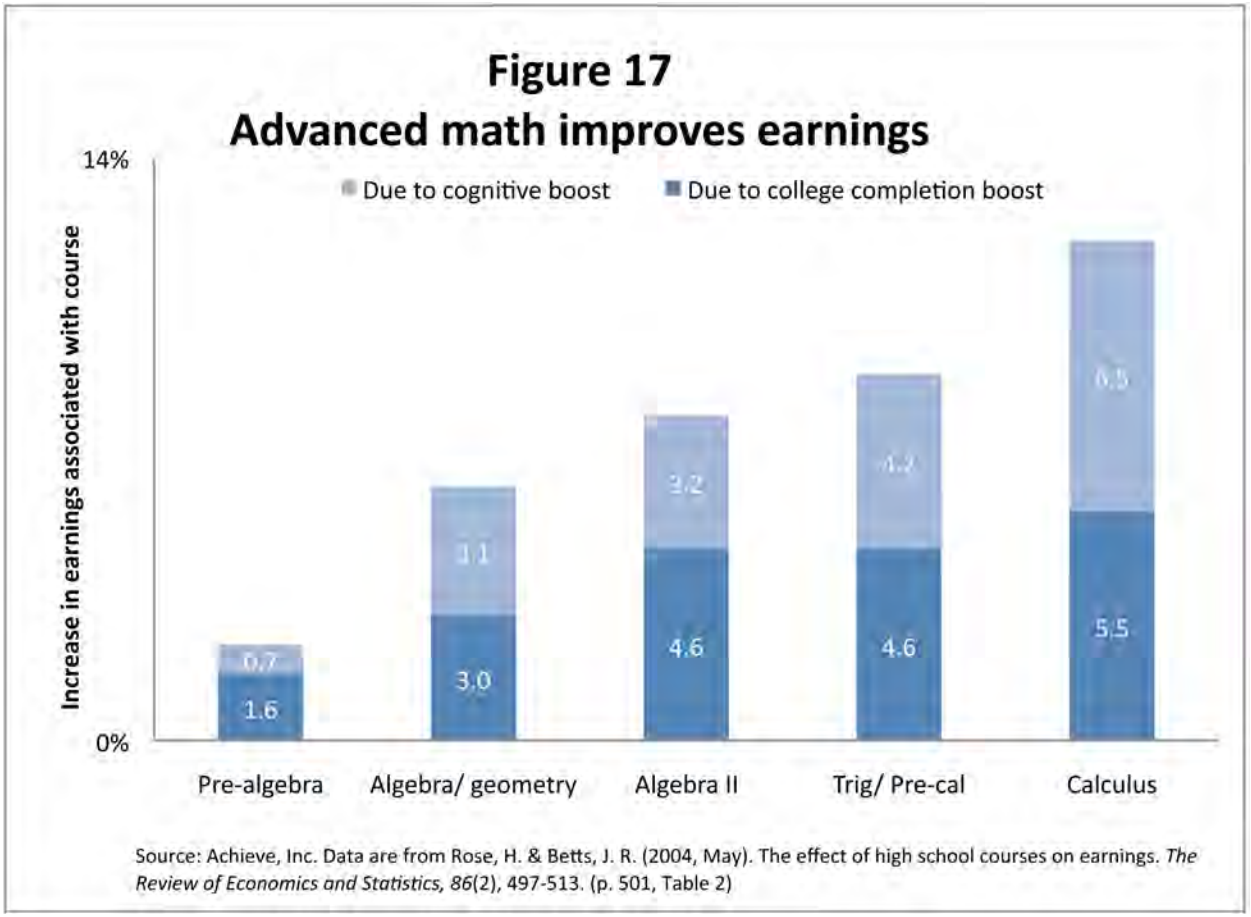
Fourth, some executives recognize its importance for workers who need to be adaptable and able to "learn to learn." "Learning how to learn is a trait we will always value," then-CEO of UPS Michael Askew told a conference in 2005. "One of the great attributes of a liberal arts education is preparing people to learn how to learn. So we absolutely believe that traditional liberal arts educations will still have an important role to play in American society."[98]

Finally, the traditional subjects continue to be important on their own. For example, researchers have found that taking higher level math courses and developing better math skills leads to greater success in both in higher education and the labor market:

Completing advanced math courses in high school has a greater influence on whether students will graduate from college than any other factor, including family background; students who take math beyond Algebra II double their chances of earning a bachelor's degree.[99]

Just taking advanced math has a direct impact on future earnings, apart from any other factors; students who take advanced math have higher incomes ten years after graduating—regardless of family background, grades and college degrees.[100] (Figure 17)

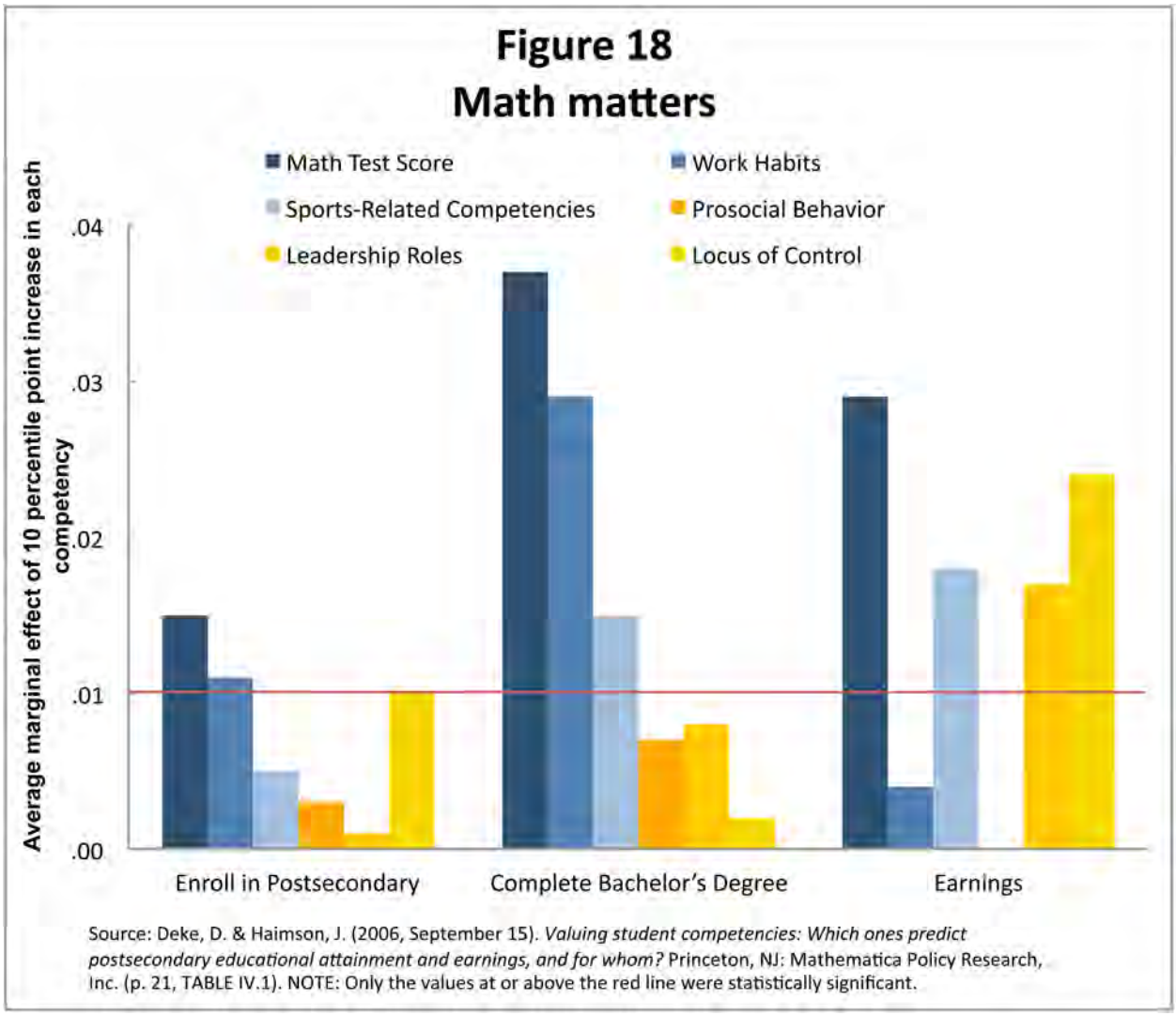
Taken together, several recent studies suggest that higher math performance at the end of high school translates into substantially higher future earnings; an increase of one standard deviation in math scores translates into a 12 percent boost in wages.[101]



Researchers Rose and Betts found that students who take higher level math courses during high school have higher earnings later on, other factors being equal. Part of the reason is that such students are more likely to earn a college degree, which itself greatly boost earnings. But some of the earnings advantage seems to come from what they learn in advanced math class regardless of whether they later attend college—a "cognitive" boost.

Indeed, a study by the research group Mathematica found that having stronger math skills was a better predictor of future success than having good work habits, leadership skills, teamwork and other sports-related skills, and positive beliefs about whether luck or effort determine success in life (a trait psychologists call "locus of control").

The researchers pointed out that for students who already have strong math skills, developing other personality traits they are weak in would be a more effective strategy. Nevertheless, "if policymakers are only able to focus on improving a single competency for all students, then that competency should be math ability," they concluded. "Math test score has a greater effect on postsecondary enrollment, completion of a bachelor's degree, and earnings than any other competency." (Figure 18)



While other competencies matter too, better math skills are consistently related to greater success in postsecondary education and the labor market.

The subjects matter

According to a 2004 report by the American Diploma Project (ADP) in 2004, all students, whether heading to college or pursuing a well-paying career, need the same level of knowledge in the "foundational subjects" of English and mathematics. That conclusion was based on what leading economists thought necessary for promising jobs that would pay enough to support a family and offer career advancement, as well as what postsecondary leaders considered to be prerequisite knowledge and skills for success in entry-level, credit-bearing courses in English, mathematics, the sciences, the social sciences and humanities. For example, ADP concluded that in math, all students need to master the content typically taught in Algebra I, Algebra II and Geometry, as well as Data Analysis and Statistics.

However, based on its analysis of labor market data, the recent Skills Commission concluded that students should go beyond mastery in English and math. "The O*NET data show that high earnings are not just associated with people who have high technical skills. In fact mastery of the arts and humanities is just as closely correlated with high earnings, and, according to our analysis, that will continue to be true," the commission wrote in its final report. "History, music, drawing and painting, and economics will give our students an edge just as surely as math and science will."

Building on the Foundation

Many experts say that today's world also rewards a broader set of skills than what the "average student" typically learned through the school curriculum. Indeed, the ADP project developed a set of benchmark standards reflecting the notion that all students need a curriculum that is rigorous not only in the level of content studied but also in the *kinds of skills* demanded: "The ADP benchmarks are ambitious. […] The English benchmarks demand strong oral and written communication skills because these skills are staples in college classrooms and most 21st century jobs. They also contain analytic and reasoning skills that formerly were associated with advanced or honors courses in high school."

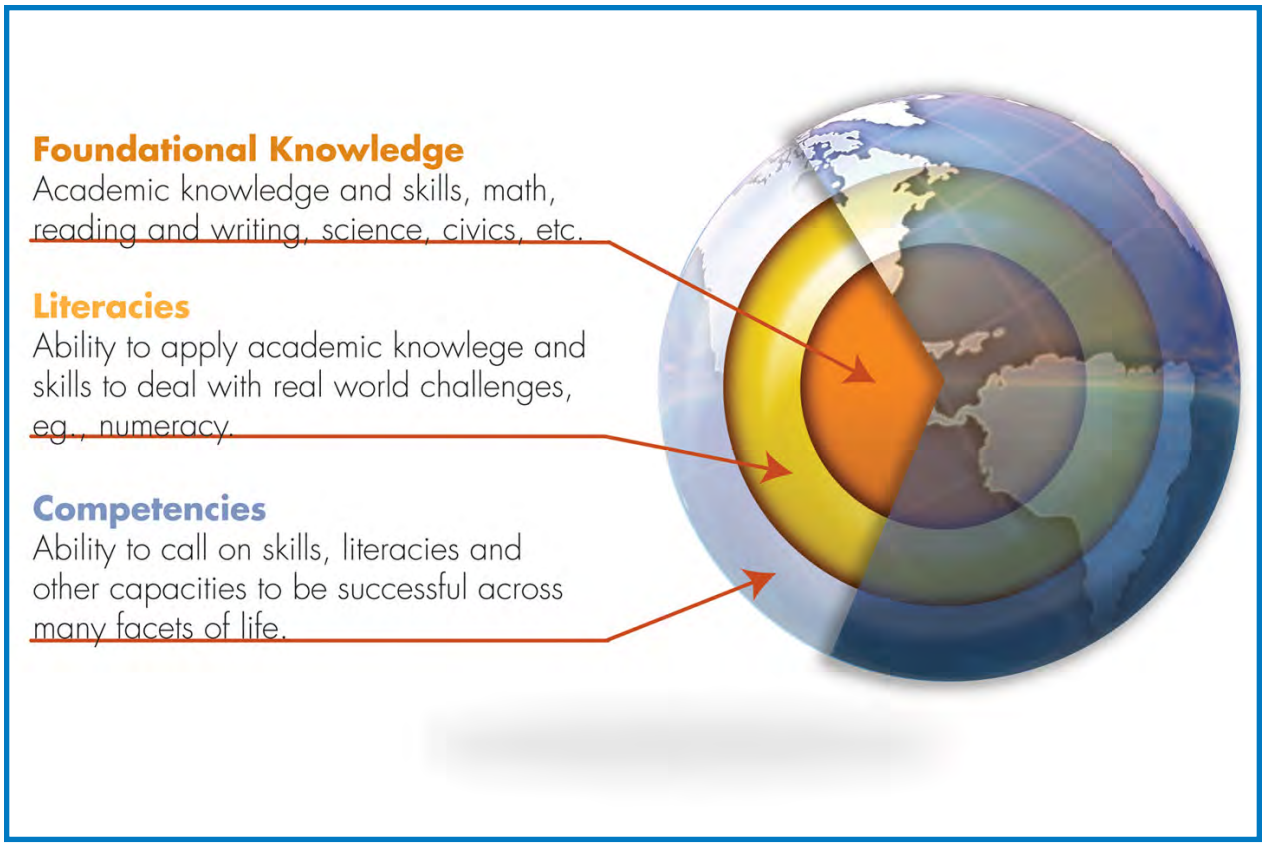
Others stress an even broader set of skills. After analyzing the U.S. Department of Labor's O*NET database, along with the trends in automation and globalization described above, the Skills Commission concluded that securing the economic future of the United States will depend on whether students can master a wide range of practical literacies and competencies. That is because many workers in other countries are beginning to offer competitive skills for low wages. "If all we can do is match our low-cost competitors in these core subjects in the traditional curriculum, then, in time, all we will qualify for is their wages."

The Commission concluded that America and its workers will need to offer something more: strong analytical skills, flexibility and adaptability, the ability to collaborate, and, most important, creativity and innovation.

One way to understand how academic knowledge and skills, practical literacies, and broader competencies fit together is to think of them as forming a sphere comprised of layers (Figure 19) Competencies, or "outer layer," often draw upon literacies, and literacies always draw upon foundational or "core," knowledge and skills. On an individual basis, to survive in a world that has become increasingly complex and demanding at the same time individuals are being asked to take greater responsibility for their own well-being, students need to be able to *apply* what they have learned in school to deal with real world challenges. In this paper, we refer to such skills as "literacies." For example, simply knowing how to calculate a percentage on a piece of paper is not enough to understand and interpret the massive amount of numerical information available for making important decisions in life. Nor is it sufficient to solve a novel problem as a member of a project team in the workplace, even if part of the solution involves calculating percentages. In this paper we use the word "competencies" to refer to broader skills like problem solving and teamwork that are not attached to a particular domain.

Figure 19

Skills and Knowledge Work Together



A solid education today demands not only a strong foundation or "core," in content knowledge but also the ability to apply it to the real world, and both are essential to develop broader competencies like critical thinking and problem solving.

As an example of how they fit together in a real life situation, consider the Toyota plant scenario described on this page. The workers involved could not have tackled the challenge if they did not have knowledge and skills related to algebra and geometry. In fact, according to Bob Tribble, Team Leader for Toyota Paint Operations, "Good math skills will improve your chances of getting a job with Toyota, improve your chances of getting a higher-paying job, improve your chances of being successful on the job and improve your chances of moving up in the company."

However, if the team members weren't mathematically *literate* or "numerate," that is, able to apply their math skills to a real-world situation, those math skills would not have done much good. As discussed below, even students who graduate with strong math skills on paper often have trouble when it comes to put them to use in the real world. Finally, the team could not have tackled the challenge if its members were not able to work together collaboratively, communicate with each other effectively, and solve problems creatively. All of those competencies had to work together with practical mathematical literacy and discrete kinds of math skills in order for the team to be successful.

Teamwork, Problem Solving, Creativity, Practical Numeracy, and Math Skills on the Toyota Assembly Line

The goal was to build a hood opener with a lift arm to hold the hood in place while a technician installs a stabilizing monster jig—the device that keeps the hood in the correct position—prior to painting. The hood opener needed to follow along with the car, complete its task and return to home position in less than a minute. And it needed to operate safely more than a thousand times a day and last for at least 10 years—a long time frame that would allow the hood opener to be adaptable to subsequent model changes and new car designs.

The hood opener design team consisted of a group of skilled employees who had expertise in welding, machining and electronics—but were not engineers. During the initial design phase, they needed to outline the function the hood opener would perform and determine how it would be powered.

They determined that the hood opener would be suspended from a track above the production line and follow the car as it neared completion. The lift arm would extend and contract to grab and raise the hood, and then it would release the hood once the monster jig was in place. The team compared the advantages and disadvantages of using electricity, hydraulics or pneumatics to propel the hood opener. They decided against using an electric motor because it would be heavy and cumbersome and could emit sparks. They eliminated hydraulics due to the potential mess and danger if a leak developed. Pneumatics—the choice of the team—are explosion proof and, provided the pressurized air is kept clean and proper lubrication is added, they have a long service life.

Coordinating the actions of the pneumatic arms required the design team to refer back to the formula for the proportionality of theoretical torque. By determining the torque that corresponds to motor displacement—and knowing the fluid density and gravitational acceleration—the design team determined the difference in hydrostatic pressure due to the weight of the fluid and built a motor for a smoothly operating yet durable lift arm.

After working through the mechanics of pneumatic arms, the design team next wanted to ensure that the hood opener would have the latest safety controls installed. Electrical circuitry would guarantee the well-being of technicians on the production line if the switches used were both efficient and fully operational. Together, the team checked the control circuits employed in the design of the lift arm using truth tables based on Boolean algebra to analyze their logical behavior and ensure that power would be delivered accurately and efficiently to specific parts of the circuit.

After running through the electronics, the team turned to measurements. How long was the hood? Where was the lip of the hood relative to the hinge? If the lift arm did not extend far enough, it would not connect to the hood properly. If the hood was raised too high, it could cause a premature release. If the hood was not raised high enough, team members would not be able to perform their job properly, and the hood could be damaged when released.

Basic right-triangle trigonometry was essential to the task of designing the lift arm, but the calculations were complicated by the fact that car hoods are not perfectly straight like the side of a triangle — and different hoods open to different angles. By considering several different locations for the hood opener, the team determined where to anchor the lift arm relative to a car as it traveled down the production line. The team created an all-purpose schematic so that, once the size of the hood was known, the length of the lift arm could be calculated. Its length depends on the initial and final angle of the hood as well as the position of the lift arm in the ceiling mount and is designed to allow the hood opener to work with any type of car.

Source: Achieve, Inc. (2008). *Mathematics at work: Manufacturing*. Washington, DC: Author. www.achieve.org

Practical Literacies

The term "literate" originally was used to describe someone who could read and write. Later it was used to describe someone with knowledge of a particular area: musically literate, computer literate, etc. More recently, the term has begun to mean someone who not only "knows" a lot about a topic but who also can *apply* that knowledge outside the classroom to successfully tackle real world challenges.

For example, at the prompting of its member nations, the Organization for Economic Cooperation and Development (OECD) created a new international assessment to measure practical "literacy" in three subject areas: math, science, and reading. The OECD describes how its Program for International Student Assessment (PISA) is different from other more traditional assessments:

> While it assesses students' knowledge, PISA also examines their ability to reflect, and to apply their knowledge to and experience to real world problems. For example, in order to understand and evaluate advice on food safety an adult would need not only to know some basic facts about the composition of nutrients, but also to be able to apply that information. The term "literacy" is used to encapsulate this broader concept of knowledge and skills [to] solve problems and apply ideas and understanding to situations encountered in life.[108]

A student might be able to read a short story during class and fill in a worksheet about the plot, but will she later be able to read, understand, and apply a technical manual—one that includes diagrams as well as text—to fix a piece of machinery on the job? Another student might be able to select the right multiple-choice answers to a set of math problems like "½ ÷ 4 =___," but will he later be able to quickly change a recipe if a catering client tells him to expect fewer guests at a reception?

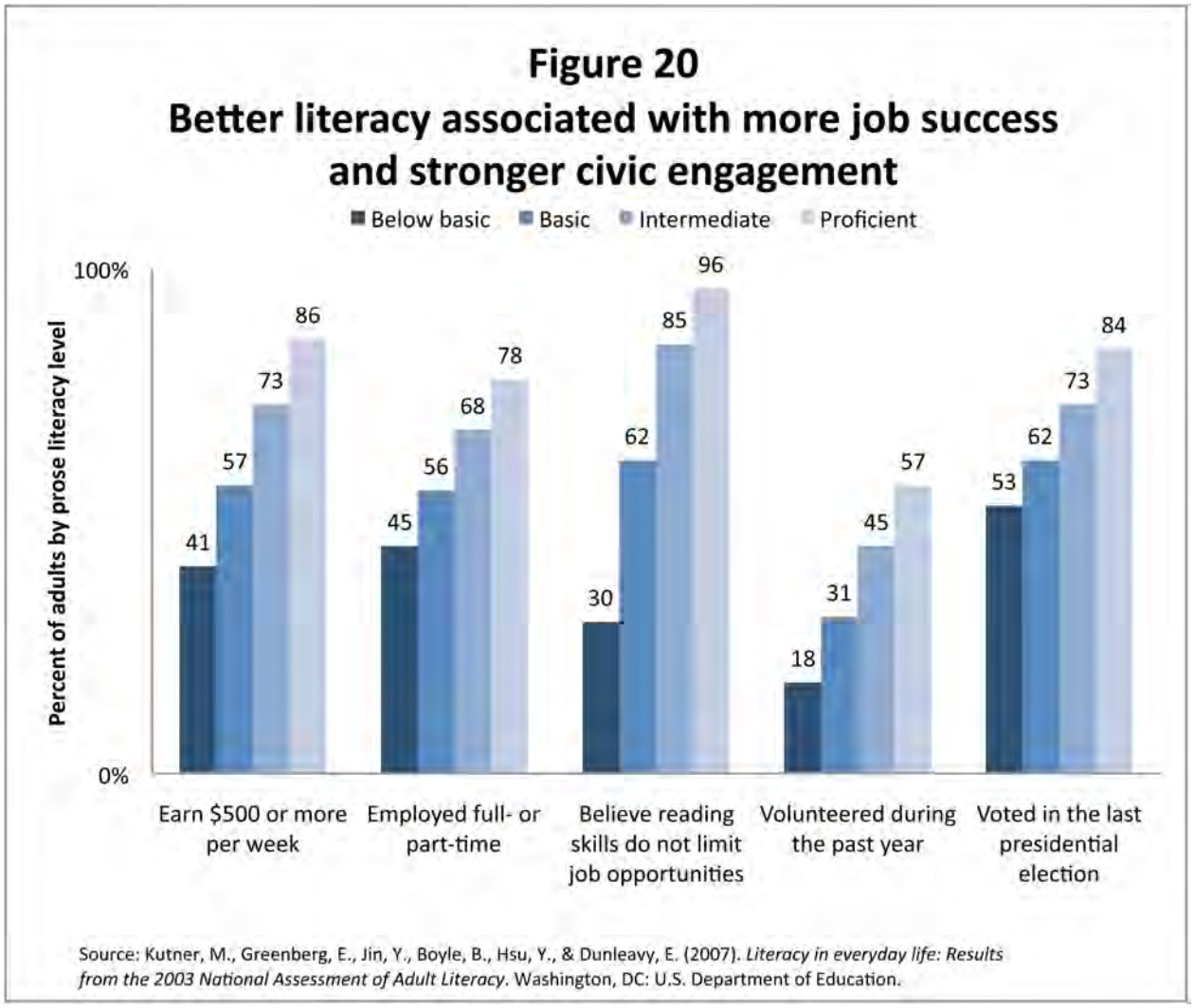
Reading literacy

Think of the difference between learning to read and reading to learn. Reading literacy means more than being able to decode words in a text as young children are taught to do. In complex modern societies, adults must be able to understand many kinds of documents to carry out all kinds of tasks, from getting a drivers' license to voting to learning how to operate a new piece of equipment at work or home. A number of national and international assessments have looked at teenage and adult literacy. All have employed a definition close to this: "Using printed and written information to function in society, to achieve one's goals, and to develop one's knowledge and potential."[109]

That also means adults must be able to interpret a wide range of documents. For example, the National Assessment of Adult Literacy (NAAL) distinguishes between "prose literacy" and "document literacy." The former involves "the knowledge and skills needed to search, comprehend, and use information from continuous texts. Prose examples include editorials, news stories, brochures, and instructional materials." The latter, however, requires participants to interpret a kind of document seldom seen in English classrooms: "non-continuous" ones that include other symbols in addition to letters, such as payroll forms, transportation schedules, maps, tables, and drug and food labels. The PISA reading literacy assessment uses charts and graphs, tables, diagrams, maps, forms, information sheets, persuasive documents like advertisements or political flyers, vouchers, and various kinds of certificates.

In the modern world, literacy is critical for success in many spheres of life. The 2003 NAAL found that adults with stronger literacy skills are more likely to be employed, to have higher-status jobs, and to earn significantly more income. They were less likely to receive public assistance (of if they had, did so for a shorter period of time) and less likely to say their reading and computer skills limited their limited their job opportunities. But the advantages extended well beyond the labor market. Parents with stronger literacy skills were more likely to read to their children and to have preschool children who already knew the

alphabet, to talk to their children each day about what they had learned in school, and to help their children with homework. Finally, adults with weaker literacy scores were less likely to vote, less likely to get information about current events from a variety of print and non-print sources, and less likely to volunteer in their communities.[110] (Figure 20)



Adults who have stronger literacy skills have greater success earning a living, and they also are much more civically engaged.

From an economic perspective, it is important to understand that strong reading skills have become even *more* important in the technology-driven information age. Levy and Murnane point to auto mechanics: "Twenty-five years ago, auto mechanics did not have to read to learn their jobs—they could learn by watching other mechanics." But automobiles are now much more sophisticated electronic as well as mechanical machines with many invisible parts. "As a result," they say, "a mechanic can no longer function without the ability to read, to work with computerized testing equipment, and to construct mental models of a problem."[111] In fact, when the Conference Board surveyed employers about the most important

skills for entry level employers several years ago, "reading comprehension" ranked above technology skills for every educational group.[112]

Being able to communicate both verbally and in writing also has become increasingly important. The corporate shift toward horizontal teamwork has increased demand for strong written communication skills—especially since much collaboration takes place over a distance. Moreover, as the pace of change accelerates, companies are asking employees to document their approaches, processes and solutions to problems for colleagues so they can be shared throughout the organization.[113] Part of the reason is that information has become too diffuse and complex for one person to know everything necessary to do a job. "In today's competitive environment, sharing information and expertise can be critical in driving both individual and organizational success," says the IBM Corporation.[114]

Mathematical literacy, or "numeracy"

Many experts say that the in the 21st century, it has become just as important to be able to apply what you learn in math class once you leave school. Mathematical literacy, which is sometimes called "quantitative literacy" and sometimes "numeracy," means something different than just being able to get the right answer to problems on a worksheet or test given in math class. Studies show that even highly educated people who took a lot of math in school can be innumerate when it comes to understanding real life quantitative information and applying math in practical ways.[115] Indeed, when the 2003 NAAL assessment, which included questions to measure quantitative as well as prose and document literacy, was given to a sample of college students, many could not perform tasks such as understanding credit card offers or comparing the cost per ounce of food.[116]

Some believe that must change. "The world is awash in numbers," says Lynn Steen, a professor of mathematics at St. Olaf Collage, who points out that "the roles played by numbers and data in contemporary society are virtually endless."[117] Steen provides examples from a wide range of occupations:

> Farmers use computers to find markets, analyze soil, and deliver controlled amounts of seeds and nutrients; nurses use unit conversions to verify accuracy of drug dosages; sociologists draw inferences from data to understand human behavior; biologists develop computer algorithms to map the human genome; factory supervisors use "six-sigma" strategies to ensure quality control; entrepreneurs project markets and costs using computer spreadsheets; lawyers use statistical evidence and arguments involving probabilities to convince jurors.[118]

The benefits of numeracy extend well beyond careers. "Virtually every major public issue—from health care to social security, from international economics to welfare reform—depends on data, projections, inferences, and the kind of systematic thinking that is at the heart of quantitative literacy," says Steen.[119] At the local level, for example, voters need to understand quantitative information in pamphlets and on the Web to make informed decisions about important issues like school budgets and tax proposals. Indeed, the 2003 NAAL results support the argument that numeracy is just as important as literacy both for individuals and for the communities in which they live: Adults who scored higher on "quantitative literacy" were more likely to be better earners, better parents, and better citizens.[120]

At the same time, a growing chorus of experts is raising the alarm about the dangers of innumeracy in the 21st century. Those who cannot make sense of and make use of numbers in their daily lives are at increasing risk the modern world. Take the trends in health care and personal finance discussed in the first section. As individuals are forced to shoulder more risk and responsibility for their own well being in areas like health care and financial planning, they are encountering more numerical information than ever before. And their quantitative literacy skills can have a huge impact on the financial and physical well being of them and their families.

Recent research has found that lower numeracy results in poorer health outcomes, less accurate perceptions of health risks, and poorer decisions about health issues.[121] "Much of the information provided to patients in written and electronic health communication is quantitative—information such as medication schedules, nutrition information, laboratory values, and risks and benefits of therapies," observed Jessica Ancker and David Kaufman of Columbia University. "A growing literature attests to an awareness that many patients get lost in numbers, unable to fully comprehend or use this information."[122]

For example, recent studies have found that patients with lower math literacy:

- Had worse understanding of risks and made worse decisions about the benefits of mammography and experimental cancer treatments[123];
- Had a harder time taking prescribed medications (inhaled steroids, anticoagulation drugs) and as a result worse health outcomes and more hospitalizations[124];
- Had a harder time comprehending nutrition labels important for patients with chronic illnesses like hypertension and diabetes[125];
- Had a harder time comprehending information about health coverage options and made less informed choices about health plans[126]; and
- Chose lower quality hospitals than more numerate patients when both were given information on medical outcomes.[127]

As such studies accumulate, experts in the field have coined the term "health numeracy" to signal a growing public health concern. In some cases researchers are investigating how doctors can assess patients' numeracy skills; a group of medical experts recently tested a *Diabetes Numeracy Test*, for example.[128] One expert, Dr. Valerie Reyna, who directs Cornell University's Center for Behavioral Economics and Decision Research, served on the National Mathematics Advisory Panel recently convened by the U.S. Department of Education. "Increased emphasis on patient-centered decisionmaking and on disease prevention has shifted responsibility to patients, who need to understand health-related numerical information," she and a colleague wrote in an article published last year. "Understanding numerical information about risks and outcomes of medical treatments, for instance, is literally a matter of life and death."[129]

Concern about numeracy also has risen due to the shift towards greater individual risk and responsibility for financial planning. According to Annamaria Lusardi of Dartmouth College, "most individuals cannot perform simple economic calculations and lack knowledge of basic financial concepts, such as the working of interest compounding, the difference between nominal and real values, and the basics of risk diversification." She adds, "Knowledge of more complex concepts, such as the difference between bonds and stocks, the working of mutual funds, and basic asset pricing is even scarcer."[130]

According to Lusardi and other experts, financial innumeracy has a significant negative impact on retirement planning and borrowing behavior. Indeed, the current mortgage foreclosure crisis has revealed that many borrowers failed to accurately estimate whether they would be able to afford secondary expenses such as condominium fees, property taxes, and maintenance costs in addition to monthly mortgage payments.

Other recent studies suggest numeracy is important for making *any* kind of decisions involving quantitative information, especially decisions that involve assessment of risk. According to University of Oregon researcher Ellen Peters, "highly numerate people appear to pay more attention to numbers, better comprehend them, translate them into meaningful information, and ultimately use them in decisions." On the other hand, she says, "Decisions of the less numerate are informed less by numbers and more by other non-numeric sources of information, such as their emotions, mood states, and trust or distrust in science, the government, and experts."[131] Examining the results of four recent studies, she and several colleagues concluded that, "the effect of numeracy was not due to general intelligence. Numerical ability appears to matter to judgments and decisions in important ways."[132]

At a basic level, numeracy means understanding quantitative information. At a more sophisticated level, it means being able to apply math to solve challenging problems in the real world. The OECD's PISA assessment of mathematical literacy focuses on that kind of problem solving, of which Figure 21 provides an example. According to the OECD, numerate students who are good at solving such problems are not just good at using formulas and algorithms, they are good at "mathematizing" a real world situation to recognize when math is called for and to decide which specific formulas and algorithms can be useful in any given situation.[133] First they build a mental model of the situation, then they understand it mathematically and apply the appropriate procedures (formulas, algorithms) as necessary, and finally they translate the result back into the real world.

Figure 21

Measuring "Mathematical Literacy"

This sample problem shows how the Program for International Student Assessment, a test administered every three years in more than 60 nations, measures mathematical literacy. Students must not only be able to perform mathematical calculations, but also apply that ability in order to tackle practical, real world challenges presented by the assessment.

SKATEBOARD

Eric is a great skateboard fan. He visits a shop named SKATERS to check some prices.

At this shop you can buy a complete board. Or you can buy a deck, a set of 4 wheels, a set of 2 trucks and a set of hardware, and assemble your own board.

The prices for the shop's products are:

Product	*Price in zeds*	
Complete skateboard	82 or 84	
Deck	40, 60 or 65	
One set of 4 wheels	14 or 36	
One set of 2 trucks	16	
One set of hardware (bearings, rubber pads, bolts and nuts)	10 or 20	

The shop offers three different decks, two different sets of wheels and two different sets of hardware. There is only one choice for a set of trucks.

How many different skateboards can Eric construct?

A. 6 *C. 10*

B. 8 *D. 12*

Eric has 120 zeds to spend and wants to buy the most expensive skateboard he can afford.

How much money can Eric afford to spend on each of the 4 parts? Put your answer in the table below.

Part	Amount (zeds)
Deck	
Wheels	
Trucks	
Hardware	

Eric wants to assemble his own skateboard. What is the minimum price and the maximum price in this shop for self-assembled skateboards?

(a) Minimum price: .....zeds. *(b) Maximum price: .....zeds.*

Source: Organization for Economic Cooperation and Development, *PISA Released Items — Mathematics,* December 2006

Scientific literacy

Many K-12 students will not become scientists, but experts say that in the 21st century all adults need to better understand and apply science-related information. "Today, faced with national issues that are increasingly acquiring scientific and technological dimensions," Nobel-prize winning scientist James Trefil writes in a new book, educators must "turn to the question of how to go about providing average citizens with enough scientific knowledge to allow them to participate in public debates in a meaningful way."[134]

Trefil and others lament that Americans seem to know so little about scientific issues at the forefront of public life and political affairs. For example, according to the National Science Foundation, two-thirds of Americans do not adequately understand DNA, which is increasingly used in legal trials and other spheres, and half believe that antibiotics kill viruses.[135] On the other hand, the general public seems too ready to believe in pseudoscience. According to the NSF, more than one in three 18-24-year-olds (39 percent) think astrology is at least "sort of scientific," and an additional 5 percent say they don't know.[136]

Experts agree that several different kinds of knowledge are important for scientific literacy. The first is knowledge *about* important scientific topics. For example the OECD's PISA science literacy assessment examines knowledge of physical systems, living systems, earth and space, and technology. The second is knowledge about *how* science works, the scientific "method" and mindset that distinguishes it from other domains. Boiled down to its basics, according to Trefil, that means a firm understanding of observation and testing. More recently, experts have added a third kind of knowledge for science literacy—the ways that science and technology can and do have an impact on the physical world and human society, for good or ill. The OECD's definition of science literacy for PISA emphasizes all of those areas and also includes a fourth dimension related to attitudes and engagement:

- Scientific knowledge and use of that knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related issues;
- Understanding of the characteristic features of science as a form of human knowledge and enquiry;
- Awareness of how science and technology shape our material, intellectual, and cultural environments; and
- Willingness to engage in science-related issues and with the ideas of science, as a reflective citizen.[137]

Civic literacy

The most recent definitions of civic literacy also incorporate skills and dispositions along with knowledge. According to Judith Torney-Purta, a University of Maryland expert on human development who has helped design and analyze international assessments in civics, there are three "strands" of civic competency or literacy that schools can help students develop:

- Civic-related *knowledge*, such as understanding the structure and mechanics of constitutional government, and knowing who the local political actors are and how democratic institutions function;
- Cognitive and participative *skills*, such as the ability to understand and analyze data about government and local issues, and skills that help negotiate and resolve conflict in responsible ways; and

- Core civic *dispositions*, or attitudes and values, which can include support for justice and equality, a sense of personal responsibility, and a willingness to participate in civic life.[138]

For example, voters need to know about the role of elections and how they work, they need to be able to thoughtfully evaluate and interpret information on candidates and proposals, and they need the motivation to show up and cast their vote on Election Day. The same is true for jury duty and many other kinds of civic participation. Fortunately, this is one area where the United States is ahead of the rest of the world. Not only did American ninth-graders score well above average on the 1999 Civic Education Study (ranking sixth out of 28 countries overall), U.S. students ranked first in the world in their ability to critically interpret political materials.[139] In addition, the U.S. was one of only two countries whose students scored above average not only in civics content, but also on measures of positive civic engagement and attitudes.[140]

However, some argue that in the digital age, information and media messages are proliferating at such a rate that adults will find it difficult to make sense of and act on them unless schools specifically develop another set of literacies often called "media literacy" and "information literacy." In some cases, experts have advocated that schools pay attention to those as separate kinds of literacies. Taken together, the Partnership for 21st Century Skills defines "media literacy" and "information literacy" as follows:

- Accessing information efficiently and effectively, evaluating information critically and competently and using information accurately and creatively for the issue or problem at hand;
- Understanding how media messages are constructed, for what purposes and using which tools, characteristics and conventions;
- Examining how individuals interpret messages differently, how values and points of view are included or excluded and how media can influence beliefs and behaviors; and
- Possessing a fundamental understanding of the ethical/legal issues surrounding the access and use of information.[141]

Current trends seem to support the notion that such skills are becoming vital in today's society—particularly in the civic arena. At the very least, adults need to be able to know how to separate fact from opinion. The boom in blogs and cable news shows have increased information about politics and public affairs but also have helped fuel a blurring of the traditional distinction between news and opinion in the media. In 2007 the Washington Bureau Chief of the *Associated Press* provoked debate by calling for more opinion and "emotive language" in the outlet's political news coverage.[142]

Moreover, as the presidential primaries wound down last spring, nearly half of all Americans (46 percent) reported using the internet to get news about candidates, share their views, or mobilize others. Months before the general election, nearly one in three Americans had gone online to gather "unfiltered" material directly from the campaigns.[143] Obviously, voters now have a wealth of information about candidates at their fingertips. However, more than three in five internet users agreed with the statement, "The internet is full of misinformation and propaganda that too many voters believe is accurate."[144]

Technology, or "ICT," literacy

When the Conference Board asked employers which skills they expected to become more important for entry level employees over the next five years, "information technology application" ranked second—just below critical thinking and problem solving.[145] According to a 2008 survey by the Pew Internet and

American Life Project, nearly two in three (62 percent) employed Americans can be considered "Networked Workers" who use the internet or email at their workplace; more than half of them also use information technologies to work from home.[146]

Information and communications technology (ICT) also is increasingly important in people's personal lives. A recent Pew survey found that, in general, more people turn to the internet than any other source of information and support when they face a major life problem, including experts and family members. Between January 2002 and March 2005, the number of adults who said the internet played a major role as they helped another person cope with a major illness grew by 54 percent. Pew estimates that by the end of 2007, about 80 percent of Americans had searched for health-related information online.

Clearly, technological literacy (or "digital competence" as it is known in Europe) is an increasingly important skill for everyday life. However, that does not mean schools need to teach students the *mechanics* of using technology. First, the specific tools and applications change too rapidly. Second, children and teens are way ahead of many adults in technological fluency anyway. In 2007 Pew found that, of the 93 percent of 12- to 17-year-olds who now use the Internet, *nearly two-thirds* use it not just to access information but also to create it and share it—uploading their own digital creations, writing blogs, or maintaining personal Web pages. More than a quarter of online teens have created a blog, a word they could not even have looked up in a Webster's dictionary before 2005.

In fact, some observers refer to school-age children as "digital natives" because they have grown up in a wired world, as opposed to adults who have had to acclimate themselves to it. "Reared on social media, always on Internet connections, cell-phone cameras, Machinima, and YouTube, digital natives live on the same planet as digital immigrants, but inhabit a very different universe," says Jeff Howe of *Wired* magazine. "They can concentrate on multiple projects simultaneously, they collaborate seamlessly and spontaneously with people they've never met, and most important, they create media with the same avidity that previous generations consumed it.

Experts agree that what schools can do is help young people learn how to use information technology more responsibly, reflectively, and effectively in different areas of life. They can also help students link their use of technology to what they are learning in school. For example, a Pew study published last year found that 85 percent of all 12- to 17-year-olds engage at least occasionally in some form of electronic personal communication—from text messaging to emailing to instant messaging to posting comments on social networking sites—but far less than half of them (40 percent) actually think of these activities as "writing"!

Broader Competencies

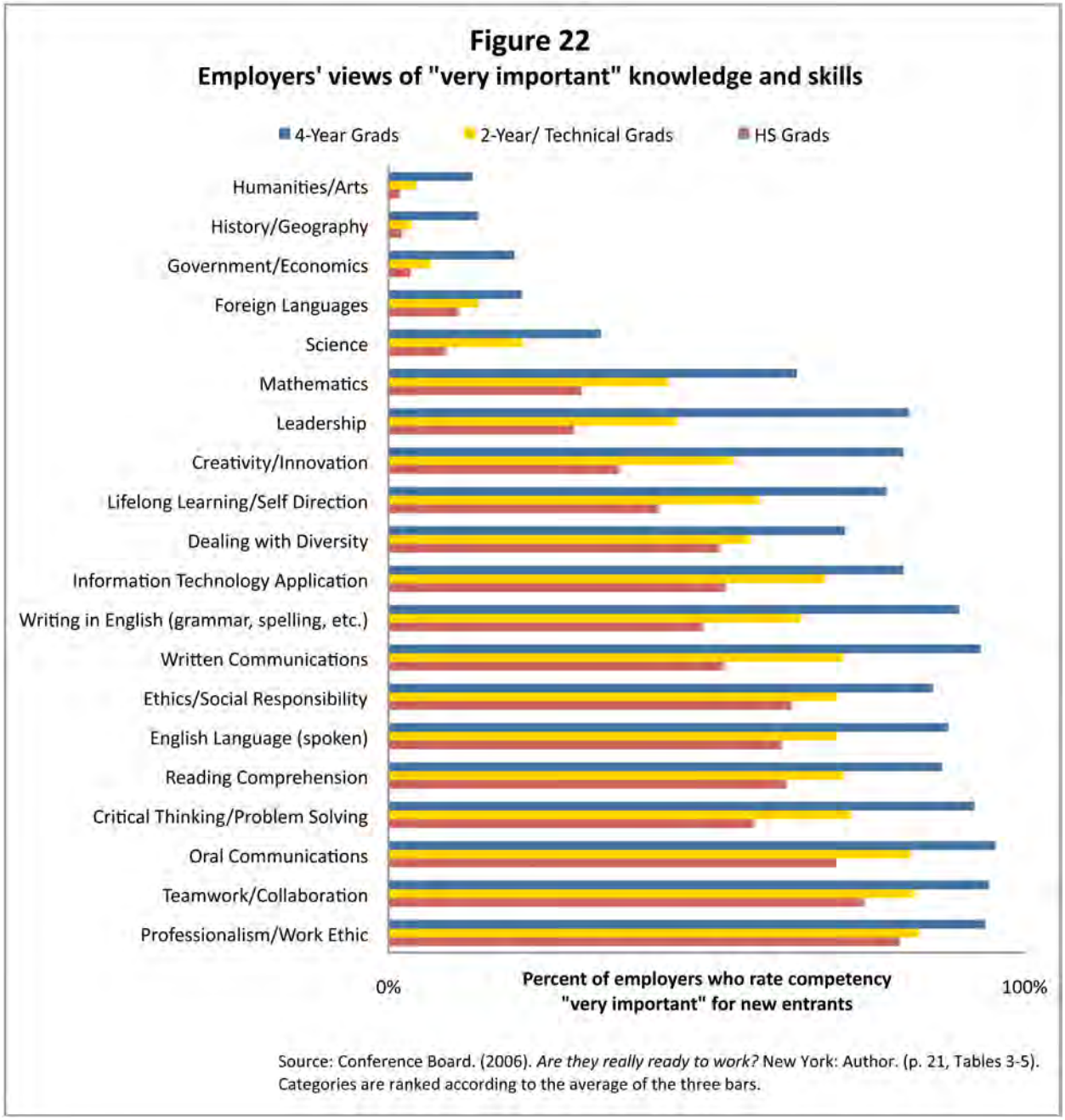
Along with foundational knowledge and applied literacy skills, experts point to a set of broader "competencies" that are increasingly important. These are sometimes called "generic" or "cross-disciplinary" because they are not dependent on a particular domain of knowledge. For example, the Skills Commission concluded that to obtain the good jobs in the future, in addition to strong foundational knowledge and skills in traditional school subjects, "candidates will have to be comfortable with ideas and abstractions, good at both analysis and synthesis, creative and innovative, self-disciplined and well organized, able to learn very quickly and work well as a member of a team and have the flexibility to adapt quickly to frequent changes in the labor market as the shifts in the economy become ever faster and more dramatic."[153]

That notion also has gained widespread attention due to Daniel Pink's popular 2005 book, *A Whole New Mind*. Pink argued that the information age, which favored "left brain" cognitive skills, is giving way to a

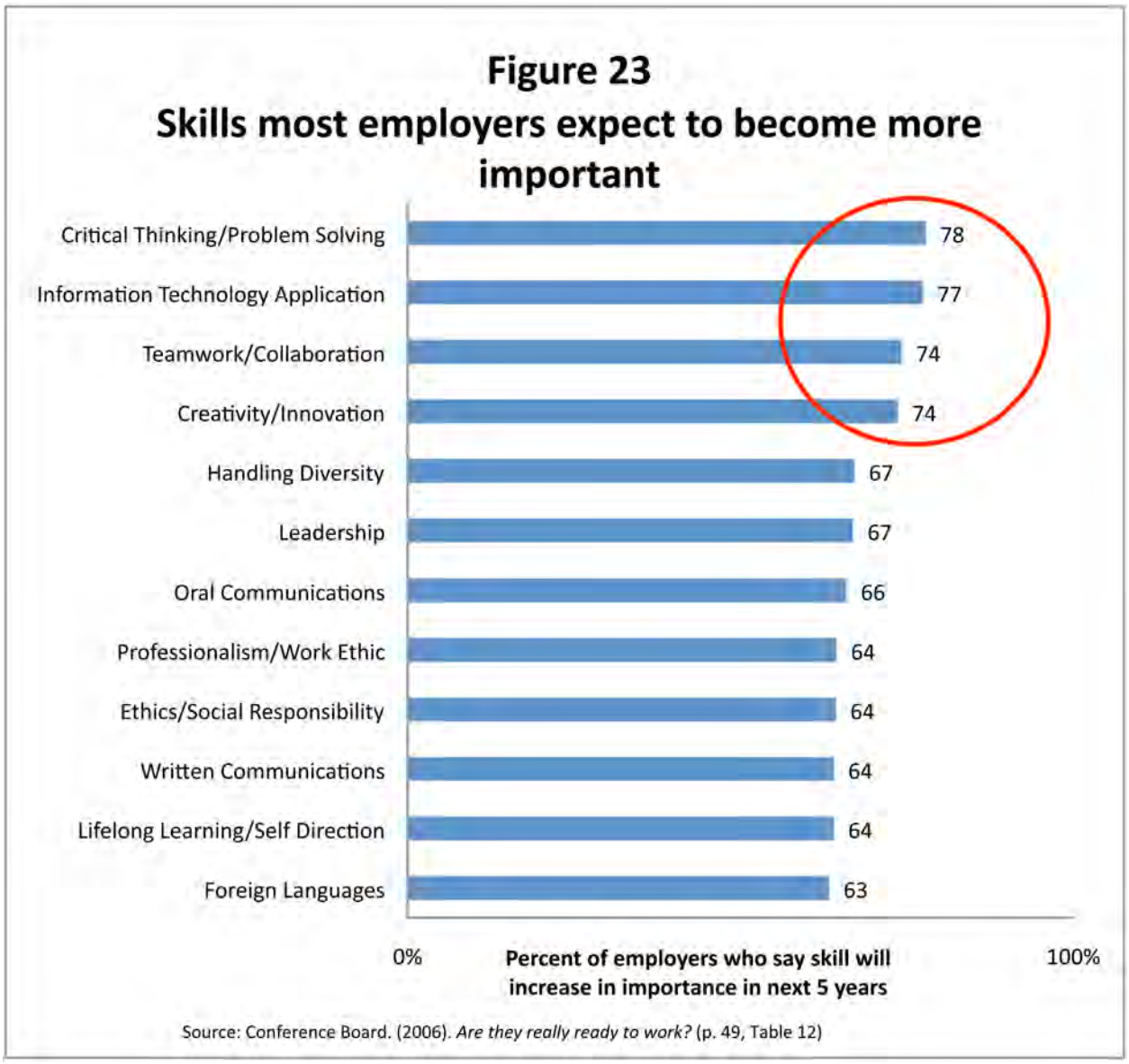
"conceptual age" because of the forces of offshoring and outsourcing, automation, and material abundance. "The future belongs to a very different kind of person with a very different kind of mind," claimed Pink," creators and empathizers, pattern recognizers, and meaning makers."[154]

Clearly, the major trends described in the first section, from automation to globalization and corporate change, all point in various ways to an increasing need for broader competencies to thrive in today's workplace. Another source of evidence comes from recent surveys of employers themselves.

In 2006, the Conference Board surveyed 431 employers about the skills they believed most important for new entrants to succeed in the workplace. The survey asked about "basic skills" related to school subjects like reading, math, science, and social studies as well as "applied skills that enable new entrants to use the basic knowledge acquired in school to perform in the workplace."[155] The results showed that while employers still view basic skills like reading comprehension to be fundamental to success on the job, some broader competencies—such as the ability to communicate, collaborate, thinking critically, and solve problems—are considered even more valuable. (Figure 22) In addition, when the survey asked employers to look into the near future, four applied skills topped the list by a comfortable margin—critical thinking and problem solving; applying information technology; teamwork and collaboration; and creativity and innovation.[156] (Figure 23)



From an employer's perspective, broader competencies such as collaboration, communication, and problem solving are very important for success on the job.



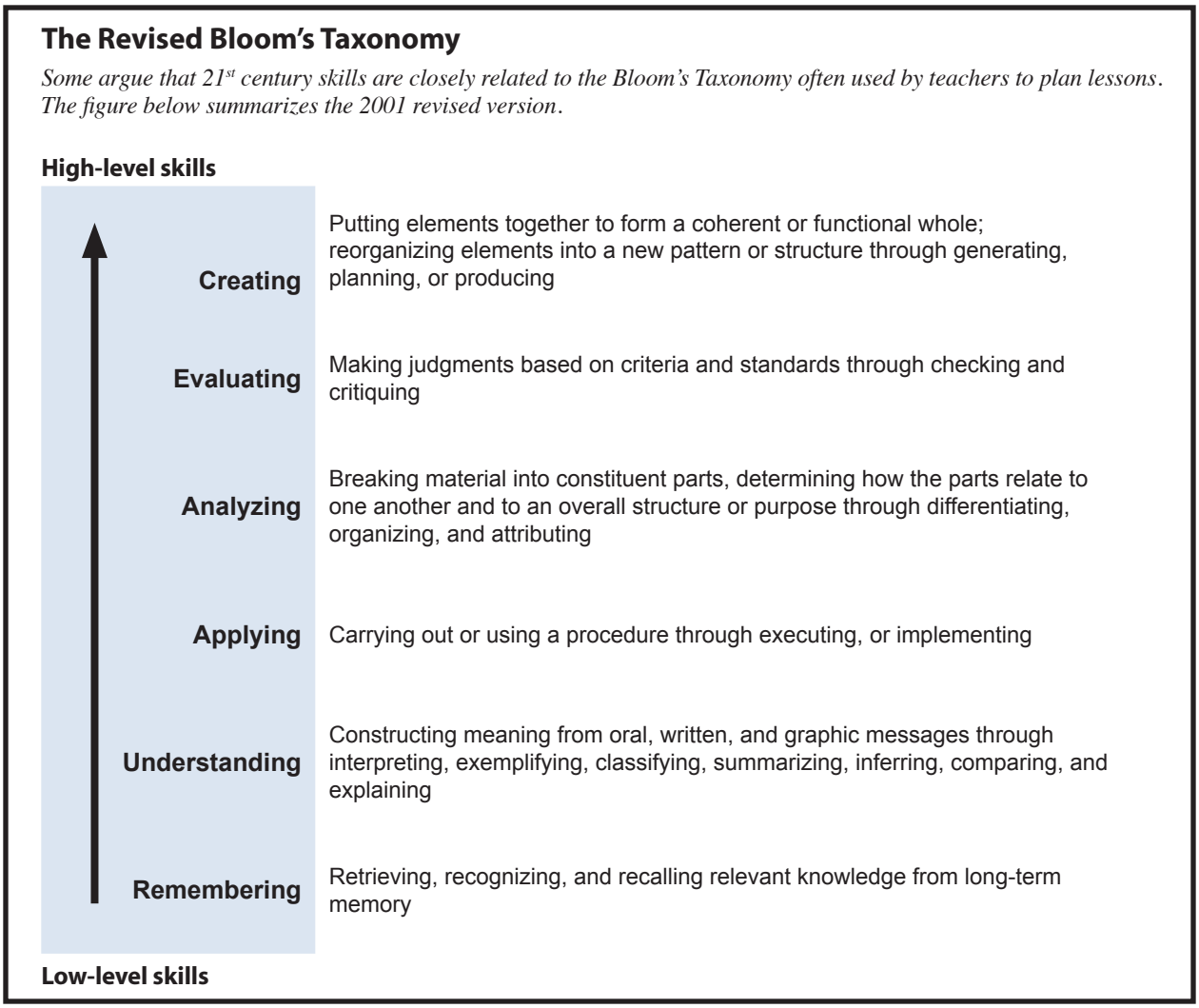
Three out of four employers predict that broad competencies like critical thinking, collaboration, and creativity will become even more important for job success in the near future.

Reflecting the demand among employers for such competencies, seven states have developed a "National Work Readiness Credential" and an aligned computer-based assessment. To earn a Work Readiness Credential, candidates must demonstrate skills in the following areas:

- Communication skills—Speak so others can understand, listen actively, read with understanding, observe critically;
- Interpersonal skills—Cooperate with others, resolve conflict and negotiate;
- Decision making skills—Solve problems and make decisions, use math to solve problems and communicate; and
- Lifelong learning skills: Take responsibility for learning, use information and communications technology.

Are these really new, "21st century" demands? In a recent paper for Education Sector, Elena Silva pointed out that teachers should not be completely unfamiliar with some aspects of these particular 21st century skills. Most teachers have been trained to use Bloom's taxonomy, which organizes types of learning according to the level of cognitive sophistication. "The attributes that business and higher education leaders are calling for in young people—that they be independent thinkers, problem-solvers, and decision-makers—are captured by the advanced skills in the revised Bloom's taxonomy, the ability to analyze, evaluate, and create," argues Silva. (Figure 24)

Figure 24



Source: Anderson, L.W. & Krathwohl, D.R. (eds.) (2001). A taxonomy of learning, teaching, and assessment: A revision of Bloom's taxonomy of educational objectives. New York: Longman.

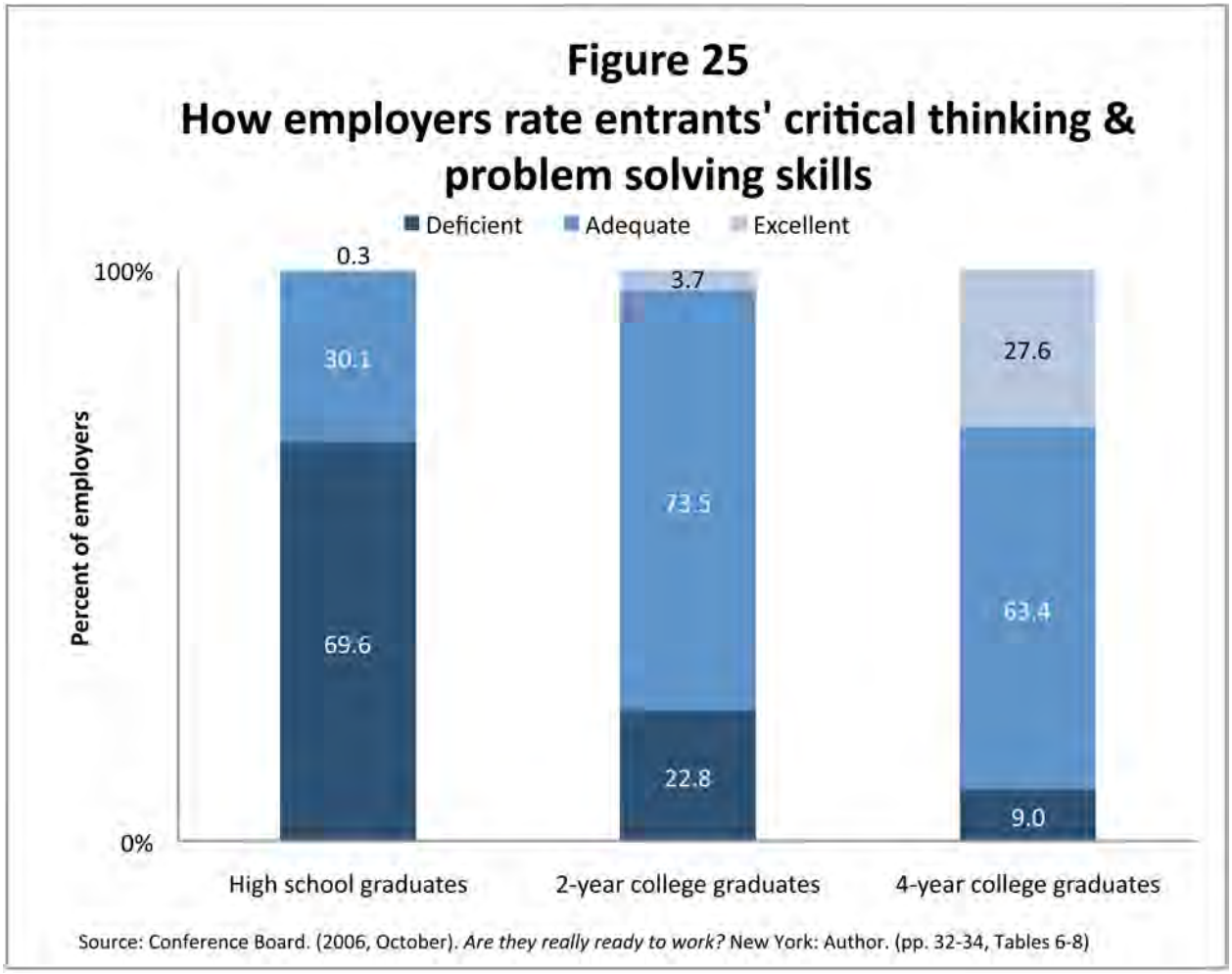
However, the taxonomy does not include the kind of interpersonal skills highly desired by employers. Those are often called "soft skills" precisely because they rely on non-cognitive attributes, such as the ability to empathize and relate to others as well as manage one's own emotions, in addition to formal thinking skills. Moreover, as experts and organizations around the world have sought to define key competencies, they have concluded that personal motivation, beliefs, and attitudes also play a key role.[159]

Experts also emphasize that competencies are different from skills in that they are broader in nature. "From a strictly, conceptual viewpoint, competence has a broader meaning than skill and many analysts consider a competence to include several skills, observes Alejandro Tiana, who analyzed efforts to define key competencies at the request of UNESCO's International Bureau of Education. "If we accept that distinction, then the concept of competence should be considered as broader, more general and a higher level of cognition and complexity than the concept skill."[160] Being able to divide fractions is a skill. Being able to solve a challenging new problem at work by applying that skill and other thinking skills—along with non-cognitive skills such as confidence and persistence—is a competency. Indeed, neither Bloom nor those who recently revised his taxonomy could fit competencies like "problem solving" and "critical thinking" into it because they are too broad.

Critical thinking and problem solving

Employers rank critical thinking/problem solving as the number one competency they expect to become more important for new entrants over the next five years, which is not surprising given Levy and Murnane's research showing the steady rise in workplace tasks demanding such skills. (Figure 2) Moreover, because of the up-skilling of many jobs due to technology and the flattening of corporate hierarchies, such competencies are no longer only the province of college-educated employees in white collar professions.

For example, nearly 60 percent of employers rate critical thinking and problem solving as "very important" for *high school graduates* entering the workforce, yet 70 percent of employers rated such entrants as "deficient" in that area.[161] (Figure 25) In another study, the Conference Board found that while 73 percent of school superintendents considered high school graduates to meet or exceed expectations for problem solving, only 45 percent of employers did so.[162]



While employers believe that few college graduates lack the critical thinking and problem solving skills necessary to succeed on the job, they say that a very large proportion of high school graduates—nearly seven in ten—are deficient in such competencies.

"For our production and crafts staff, the hourly workers, we need self-directed people who either have problem-solving skills or can easily be trained to think on their feet and find creative solutions to some very tough, challenging problems," says Mark Maddox of Unilever Foods North America. "We no longer have supervisors who take control," he explains, "and so we look at a different employee than a few years ago: one with critical thinking, creativity, mechanical aptitude, and a passion to embrace new ideas."[163]

Karen Bruett of Dell says it is just as important for front-line workers in the high-tech sector. "Teams have to figure out the best way to get there—the solution is not prescribed," she explains. "And so the biggest challenge for our front-line employees is having the critical-thinking and problem-solving skills they need to be effective in their teams—because nobody is there telling them exactly what to do."[164]

Of course, critical thinking and problem solving are both important outside of the workplace too. Students will need such skills to participate in solving local, national, and global problems that threaten our collective well-being. They also need them to participate effectively in many aspects of civic life, from

voting to school board deliberations to jury duty. Indeed, a study of 180 jurors serving in the Kings County, New York, court system found that jurors' measurable skills in argument—an aspect of critical thinking having to do with reasoning and evidence used to make a claim—are related to how well jurors consider possible verdict choices.[165]

But is it possible to teach students "how to think"? And beyond broad generalizations, what does that even mean? Teaching something well requires a clear idea of exactly what you want to teach and how you propose to teach it. Therefore, the first challenge facing educators is to figure out precisely what "critical thinking" and "problem solving" actually mean. The second challenge is to figure out whether and how such skills can actually be taught.

Attempts to assess these competencies can offer one source of information, since formal assessment requires that you first precisely define or "operationalize" what you want to measure. Recently several serious attempts have been made to assess critical thinking in an educational context. The most prominent U.S. example is probably an assessment developed by the Council for Aid to Education and the Rand Corporation for use in higher education, the Collegiate Learning Assessment (CLA). (Its developers have created a high-school version, the College Work and Readiness Assessment, but so far it is used in only a handful of schools.[166]) The CLA measures "a student's demonstrated ability to evaluate and analyze source information, and subsequently to draw conclusions and present an argument based upon that analysis." Helpfully, the developers have identified a specific set of sub-skills underlying that competence. (Figure 26)

Figure 26

Defining Critical Thinking: The Collegiate Learning Assessment (CLA)

The Collegiate Learning Assessment (CLA) was developed by the Council for Aid to Education and the Rand Corporation to assess the learning of college students. Here is how the CLA defines critical thinking and problem solving, the primary competencies it assesses:

Applied in combination, critical thinking, analytic reasoning and problem solving skills are required to perform well on CLA tasks. We define these skills as a student's demonstrated ability to evaluate and analyze source information, and subsequently to draw conclusions and present an argument based upon that analysis. We specifically consider the following items to be important aspects of these skills and attend to scoring those items that apply to a given task.

1. Evaluation of evidence: How well does the student assess the quality and relevance of evidence, including:
   a. Determining what information is or is not pertinent to the task at hand;
   b. Distinguishing between rational claims and emotional ones, fact from opinion;
   c. Recognizing the ways in which the evidence might be limited or compromised;
   d. Spotting deception and holes in the arguments of others; and
   e. Considering all sources of evidence?

2. Analysis and synthesis of evidence: How well does the student analyze and synthesize data and information, including:
   a. Presenting his/her own analysis of the data or information (rather than "as is");
   b. Committing or failing to recognize logical flaws (e.g., distinguishing correlation from causation);
   c. Breaking down the evidence into its component parts;
   d. Drawing connections between discrete sources of data and information; and
   e. Attending to contradictory, inadequate or ambiguous information?

3. Drawing conclusions: How well does the student form a conclusion from their analysis, including:
   a. Constructing cogent arguments rooted in data/information rather than speculation/opinion;
   b. Selecting the strongest set of supporting data;
   c. Prioritizing components of the argument;
   d. Avoiding overstated or understated conclusions; and
   e. Identifying holes in the evidence and subsequently suggesting additional information that might resolve the issue?

4. Acknowledging alternative explanations/viewpoints: How well does the student consider other options and acknowledge that their answer is not the only perspective, including:
   a. Recognizing that the problem is complex with no clear answer;
   b. Proposing other options and weighing them in the decision;
   c. Considering all stakeholders or affected parties in suggesting a course of action; and
   d. Qualifying responses and acknowledging the need for additional information in making an absolute determination?

Source: Council for Aid to Education. (No date). Collegiate learning assessment (CLA) critical thinking, analytic reasoning, problem solving, and writing skills: Definitions and scoring criteria. New York: Author.

Source: Council for Aid to Education, Collegiate Learning Assessment (CLA) Common Scoring Rubric. www.cae.org/content/pdf/CLA_Scoring_Criteria_(Jan%202008).pdf

The OECD conducted a special stand-alone assessment of real-world problem solving in 2003 to complement its triennial assessments in reading literacy, math literacy, and science literacy. The test focused on three kinds of thinking tasks: *making decisions* under constraints; *evaluating and designing systems* for a particular situation; and *trouble-shooting* a malfunctioning device or system based on a set of symptoms. Specific tasks included reading movie show times and coordinating schedules with two friends for a visit to the cinema; using a map to plan a trip that includes overnight stays; using a subway map and information about fares and schedules to figure out the best way to get from one part of a city to another; designing a bunking arrangement at a children's summer camp; creating a plan to complete a set of technical training courses over a three-year period; and diagnosing problems in an irrigation system and a freezer unit.[168]

The OECD test illustrates how the kind of problem solving called for in real life is *very* different from the traditional meaning of the term "problem solving" in education. "While every one agrees that children need problem-solving skills, 'problem-solving skills' have often been taught by focusing only on problems with rules-based solutions. Algebra is an example. Solutions using rules are easy to test," say Levy and Murnane. "But because, as we now know, a problem that can be solved by rules can also be programmed on a computer, rules-based problem solving has little value in the labor market."[169] Perhaps that kind of definitional disagreement is why less than half (45 percent) of employers think high school graduates are able to solve problems, compared with nearly three quarters (73 percent) of school superintendents.[170]

Those seeking a clearer definition of critical thinking and problem solving can also look to cognitive psychology for inspiration, since researchers in that field have been studying human thinking for decades. According to Daniel Willingham, a psychologist at the University of Virginia, cognitive scientists consider what educators might call "critical thinking" to consist of three distinct types of thinking—***reasoning***, ***making judgments and decisions***, and ***problem solving***. However, since people "think" in those ways every day, it is not sufficient to ask students to complete simplistic tasks calling for those types of thought. Willingham says cognitive scientists look for thinking that is

- "***Effective*** in that it avoids common pitfalls, such as seeing only one side of an issue, discounting new evidence that disconfirms your ideas, reasoning from passion rather than logic, failing to support statements with evidence, and so on.

- "***Novel*** in that you don't simply remember a solution or a situation that is similar enough to guide you. For example, solving a complex but familiar physics problem by applying a multi-step algorithm isn't critical thinking because you are really drawing on memory to solve the problem. But devising a new algorithm is critical thinking.

- "***Self-directed*** in that the thinker must be calling the shots: We wouldn't give a student much credit for critical thinking if the teacher were prompting each step he took."[171]

At one point cognitive scientists thought reasoning and problem solving must come down to some set of general-purpose strategies or steps that, once learned, could be applied to any situation. If so, it would be easy to teach students those tactics and make them "sound thinkers" and "creative problem solvers." Indeed, programs designed to teach abstract thinking skills sprang up around this belief, and many of those are still in use today.

But it turns out that assumption was mistaken. Experiments showed that reasoning and problem solving are not generic skills like being able to ride a bike or being able to divide fractions. Instead, as the National Research Council summarized, "Research on expertise in areas such as chess, history, science, and mathematics demonstrate that experts' abilities to think and solve problems depend strongly on a rich body

of knowledge about subject matter."[172] That is why Levy and Murnane used the term "expert thinking" rather than words like "critical thinking" and "problem solving" to describe the kinds of work tasks humans can do and computers cannot. Experts, by definition, know a lot about a subject, and it is that knowledge which helps them think critically and solve problems in their area of expertise.

In fact, for anyone who wants to help students reason and solve problems more effectively, it is *absolutely essential* to understand what research has discovered about expert thinking.

First, experts do not just know a lot of disconnected facts about a topic. They understand how those facts are linked together by concepts—the underlying "big ideas" in a field. If facts are the "what," those concepts are the "why" and the "how." Doctors would hardly become good at diagnosing illnesses if they only memorized the parts of the body in medical school. They also develop a deep understanding of how those parts are related and how they function together to make the body "work." In a high school science class, students might be able to remember that arteries are more elastic than veins to get the answer right on a multiple choice test. But do they learn *why* arteries are elastic? Cognitive scientists use the word "schema" to talk about that kind of rich knowledge base.

Schemas are what make effective reasoning and problem solving possible because they facilitate the second element of expert thinking: Pattern recognition. Because they work from a detailed and highly organized knowledge base, experts are able to connect new information about an issue or problem with what they already know. That allows them to see things about that new information that non-experts simply cannot. A physicist will recognize that a problem involving river currents is similar to a problem involving tailwinds; they both involve mathematical principals like relative velocities.[173] In contrast, non-experts get stuck on the surface features. To them, it seems like two completely unrelated problems. So far computers are not good at that kind of very complex pattern recognition, which is why you cannot obtain an accurate diagnosis over the internet like you can obtain an airline ticket.

That is also why students who memorize a lot of facts in a subject do not become good critical thinkers and problem solvers. The issue is not that they didn't memorize and practice some set of generic "thinking skills." The problem is that they do not really understand the subject because they lack the big ideas and deep concepts—how and why "things work" in that subject area—that allow them to recognize patterns and see relationships. "A student can learn to fill in a map by memorizing states, cities, countries, etc., and can complete that the task with a high level of accuracy," explains the National Research Council. But what if the boundaries are removed? "An expert who understands that borders often developed because natural phenomena (like mountains or water bodies) separated people, and that large cities often arose in locations that allowed for trade (along rivers, large lakes, and at coastal ports) will easily outperform the novice."[174]

Finally, many experts also are good at "metacognition," thinking about one's own thinking—another distinctly human ability that (so far) computers cannot be programmed to perform. And here is where strategy can make a difference. Students can be taught how to monitor their thinking and taught to avoid common pitfalls in thinking. But according to Daniel Willingham, a cognitive psychologist at the University of Virginia, metacognitive strategies can only take you so far. "You may know that you ought not accept the first reasonable-sounding solution to a problem, but that doesn't mean you know how to come up with alternative solutions or weigh how reasonable each one is," says Willingham. "That requires domain knowledge and practice in putting that knowledge to work." Similarly, students might learn that they should look at both sides of an issue, but doing so in any meaningful way requires a good deal of knowledge and understanding about the subject in question.[175]

To that end, Levy and Murnane caution that school districts should not discard the traditional academic subjects and try to substitute generic thinking strategies in their place. They cite two reasons: "First,

literacy and math are critical skills necessary to acquire the knowledge to be an expert thinker in any field. Second, the skills needed to be good at complex communication and expert thinking can be taught in any subject area and need not compete for space in the curriculum. What the changes in the economy make increasingly important is that students learn to use their reading, math, and communication skills to develop and express a deep understanding of the subject matter the are studying." (Figure 27)

Figure 27

"Expert Thinking" in History Class

Labor economists Frank Levy and Richard Murnane argue that rather than doing away with the traditional academic subjects, "the challenge posed by a changing economy is to teach the subjects currently in the curriculum in a way that enables all students to develop the type of understanding and communication skills illustrated by the second student's response" in the following example:

Student 1

Q: What was the date of battle of the Spanish Armada?
A: 1588.
Q: How do you know this?
A: It was one of the dates I memorized for the exam.
Q: Why is the event important?
A: I don't know.

Student 2

Q: What was the date of battle of the Spanish Armada?
A: It must have been around 1590.
Q: How do you know this?
A: I know the English began to settle in Virginia just after 1600, although I'm not sure of the exact date. They wouldn't have dared start overseas explorations if Spain still had control of the seas. It would have taken a little while to get expeditions organized, so England must have gained naval supremacy somewhere in the late 1500s.
Q: Why is the event important?
A: It marks a turning point in the relative importance of England and Spain as European powers and colonizers of the New World.

Source: Levy, F. & Murnane, R. J. (2006, Summer). Why the changing American economy calls for twenty-first century learning: Answers to educators' questions. *New Directions for Youth Development, 10*, 53-62. The example is drawn from Pellegrino, J., Chudowsky, N., & Glazer, R. (Eds.). (2001). *Knowing what students know: The science and design of educational assessment*. Washington, DC: National Academy Press.

Willingham is adamant on this question. "These 21st-century skills require deep understanding of subject matter," he wrote recently on his blog. "Shallow understanding requires knowing some facts. Deep understanding requires knowing the facts *and* knowing how they fit together, seeing the whole." Therefore, calls to stop teaching facts and instead "teach thinking" are deeply misguided and potentially disastrous. "If you don't think that most of our students are gaining very deep knowledge of core subjects—and you shouldn't—then there is not much point in calling for more emphasis on analysis and critical thinking unless you take the content problem seriously. You can't have one without the other," he argues.[177]

Communication and collaboration

Employers rank "teamwork/collaboration" second only to "professionalism" when asked which skills are currently very important for new entrants in the workforce, and they rank it third when asked which skills they expect to become more important over the next five years. That should not be surprising given the flattening of corporations and the trend toward horizontal collaboration described earlier.

As the information-service sector of the economy expands and evolves, this competency will only become more important. Indeed, some research suggests that even highly technical occupations are become more collaborative and interactive. According to Asaf Darr, in the rapidly growing "techo-service" sector of the economy, technical workers like engineers now interact much more frequently with customers and clients in order to create custom-designed solutions. As a result, he says, social and interactive skills are now intertwined with technical skills in jobs like software engineering that used to take place far from the front lines.[178]

It's not just corporate jobs that are becoming more collaborative either, but many kinds of work. "The last two decades have seen a significant increase in scientific collaborations that span fields, institutions, sectors, and countries," say researchers John Walsh and Nancy Maloney. "As scientific work becomes increasingly collaborative, scientists are facing the problems that come with organizing a group of workers into a team." According to Walsh and Maloney, the percentage of scientific papers with multiple authors increased from 48 to 62 percent between 1988 and 2001; those resulting from international collaborations rose from 9 percent to 22 percent between 1983 and 2001, approaching 40 percent in physcs.

Employers rank another interpersonal skill, "oral communications," very high—placing it second for high school and 2-year college graduates and first for 4-year college graduates. Indeed, this broad competency is best thought of not in terms of some broad concept like "collaboration" but rather as a *cluster* of related "interpersonal skills" that give one the power to interact effectively with others to accomplish a wide variety of aims in the workplace and in life. The Conference Board survey looked at five applied interpersonal skills—"teamwork/collaboration," "oral communications," "written communications," "leadership," and "ability to handle diversity."

The OECD's DeSeCo project outlined an even more comprehensive range of cognitive and non-cognitive sub-skills necessary for effective interactions. That definition is also helpful because it clearly illustrates how critical thinking and problem solving overlap with effective collaboration. (Figure 28) For example, the OECD definition includes skills like negotiation and managing and resolving conflicts. As Levy and Murnane observe, "the growing complexity of work has made uncertainty and disagreement far more prevalent in the workplace. As a result, negotiation is a far more valuable skill." But such skills require strong analytical skills in order to identify sources of disagreement and the reasoning behind different opinions, for example, not just affective skills like empathy.

Figure 28

Defining Teamwork & Collaboration: OECD's DeSeCo Project

A number of industrialized nations worked with the Organization for Economic Cooperation and Development (OECD) to define "key competencies" for a successful life in the 21st century. Here is how that project, entitled Definition and Selection of Competencies (DeSeCo), described interpersonal competencies:

"The Ability to Interact in Heterogeneous Groups"

1. The ability to ***relate well to others***
    a) Empathy, or taking the role of the other person and imagining the situation from his or her perspective
    b) Effective management of one's own emotions

2. The ability to ***cooperate***
    a) The ability to present ideas and listen to those of others
    b) The ability to understand the dynamics of debate and following an agenda
    c) The ability to construct tactical or sustainable alliances
    d) The ability to negotiate
    e) The capacity to make decisions that allow for different shades of opinion

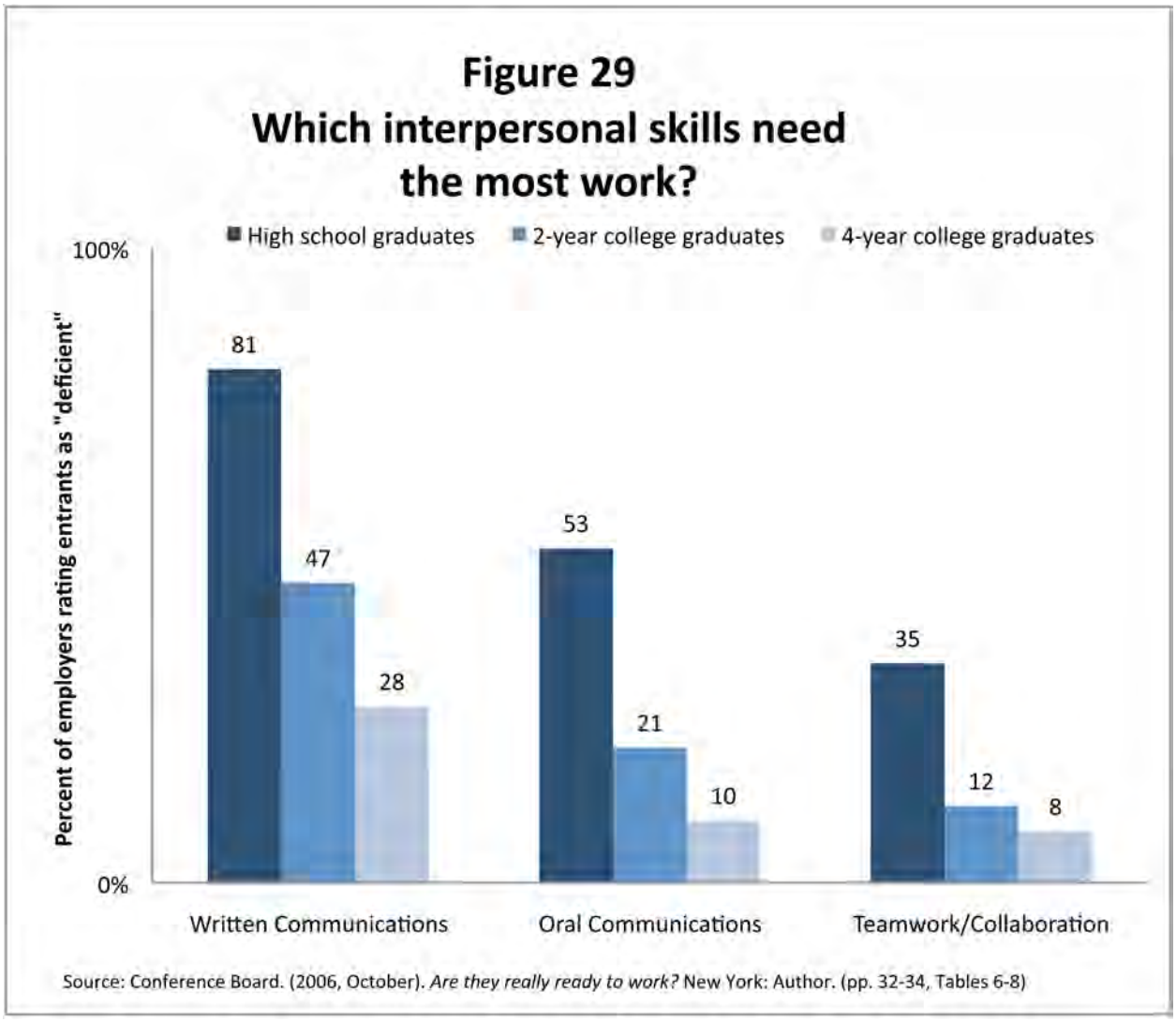
3. The ability to **manage and resolve conflicts**
    a) The ability to analyze the issues and interests at stake (e.g. power, recognition of merit, division of work, equity), the origins of the conflict and the reasoning of all sides, recognizing that there are different possible positions
    b) The ability to identify areas of agreement and disagreement
    c) The ability to reframe the problem
    d) The ability to prioritize needs and goals, deciding what you are willing to give up and under what circumstances

Source: Organization for Economic Cooperation and Development. (2005). The *definition and selection of key competencies: Executive summary*. Paris, France: Author. (pp. 12-13) Available at http://www.oecd.org/dataoecd/47/61/35070367.pdf

Levy and Murnane's research on what computers still *cannot* do and humans can provides additional insights. They call this broad competency "complex communication." So far computers cannot substitute for complex forms of communication because they require the ability to interpret information within a context. Think, for example, of how much information is conveyed through intonation and body language. The only way to know if client is being serious or a colleague honest is to interpret the verbal information they provide within the context of additional cues such as facial gestures and voice inflections. Today's computers simply cannot process that kind of information very well, nor do they have the extensive contextual or "tacit" knowledge necessary to make sense of it.

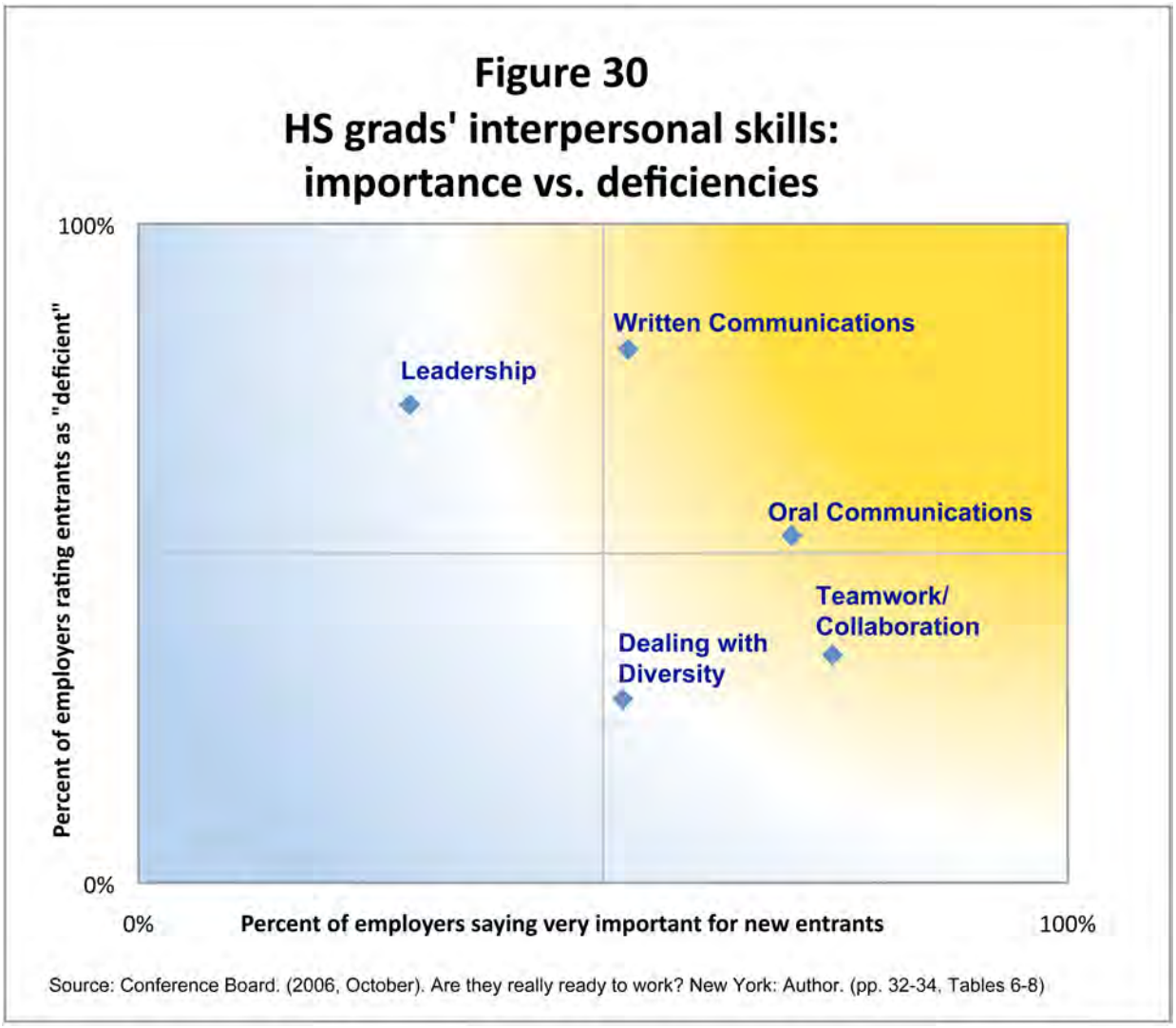
But what are school systems to make of this complex cluster of skills and sub-skills, some of which are clearly non-cognitive in nature? When considering where to invest resources, school districts might consider the results of the Conference Board's follow-up questions about whether employers think entrants possess specific interpersonal skills. Perhaps surprisingly, entrants earned "deficient" ratings in collaboration/teamwork from only a minority of employers—ranging from about a third for high school

graduates to less than ten percent for 4-year college graduates. But employers rated entrants much worse on oral communications, and their written communication skills received some of the worst ratings of all. (Figure 29)



According to employers, new entrants to the work force are much more deficient in written and oral communications, skills closely related to the language arts curriculum, than in teamwork or collaboration per se.

Figure 30 adds the other interpersonal skills like leadership and dealing with diversity to the mix and then assess the full set of skills along two dimensions: how highly employers rated the importance of each skill and also how well they rated high school graduates on each skill. Once again, oral and written communications would seem to be the highest priority: They are the only skills where more than half of employers say the skill is very important *and* more than half say high school graduates are deficient in it. In contrast, leadership ranks high on deficiency but relatively low in importance, while the reverse can be said for diversity and for teamwork/collaboration. (Figure 30)



This chart compares interpersonal skills on two dimensions, the percentage of employers who say the skill is very important and the percentage who say that recent high school graduates are deficient in it. Written and oral communications are the only two skills to score over 50 percent on both dimensions.

Therefore, within the cluster of interpersonal skills, schools should give just as much attention to skills like oral and written communications as they do to collaboration and teamwork. "We are routinely surprised at the difficulty some young people have in communicating: verbal skills, written skills, presentation skills," says Mike Summers, vice president of global talent management at Dell Computers. "They have difficulty being clear and concise; it's hard for them to create focus, energy, and passion around the points they want to make." He provides an example: "You're talking to an exec, and the first thing you'll get asked if you haven't made it perfectly clear in the first sixty seconds of your presentation is, 'What do you want me to take away from this meeting?' They don't know how to answer that question."[180]

That is not to imply that "softer" skills like leadership and teamwork are unimportant. In fact, economists Peter Kuhn and Catherine Weinberger recently found that, "controlling for cognitive skills, […] men who occupied leadership positions in high school earn more as adults. The pure leadership-wage effect

varies, depending on definitions and time period, from 4% to 33%.[181] The Mathematica study summarized in Figure 18 earlier clearly shows the significant impact of leadership and teamwork (sports-related competencies) on later earnings; while math had the biggest impact of any individual skill, the *combined* impact of leadership and teamwork was actually greater.

But those studies also suggest that classroom teachers should not bear the entire burden of developing those skills. The Mathematica study measured leadership and sports-related competencies by *participation* in such extracurricular activities during high school. Kuhn and Weinberger found evidence that leadership is not just a natural talent, but one that can be developed by participation in extracurricular activities: "At least some component of leadership skill is fostered by occupying leadership positions during high school."[182] A 2008 study by Christy Lleras reached a similar conclusion: Students who participated in sports and other extracurricular activities during high school activities had higher earnings 10 years later, even after controlling for cognitive skills as measured by test scores.[183]

Obviously, classroom teachers can and do help students develop those skills; they can certainly help them understand and practice the analytical skills that underlie collaboration in the DeSeCo definition. But extracurricular activities clearly should play a role too. Therefore, instead of simply adding those skills to the long list of teaching goals that classroom teachers already are responsible for, it might make sense to first ensure that district policy provides opportunities for *all students* to actively participate in extracurricular activities. Also, there is no reason why extracurricular activities cannot be evaluated to determine whether they offer all participants explicit opportunities to develop leadership and teamwork skills.

Creativity

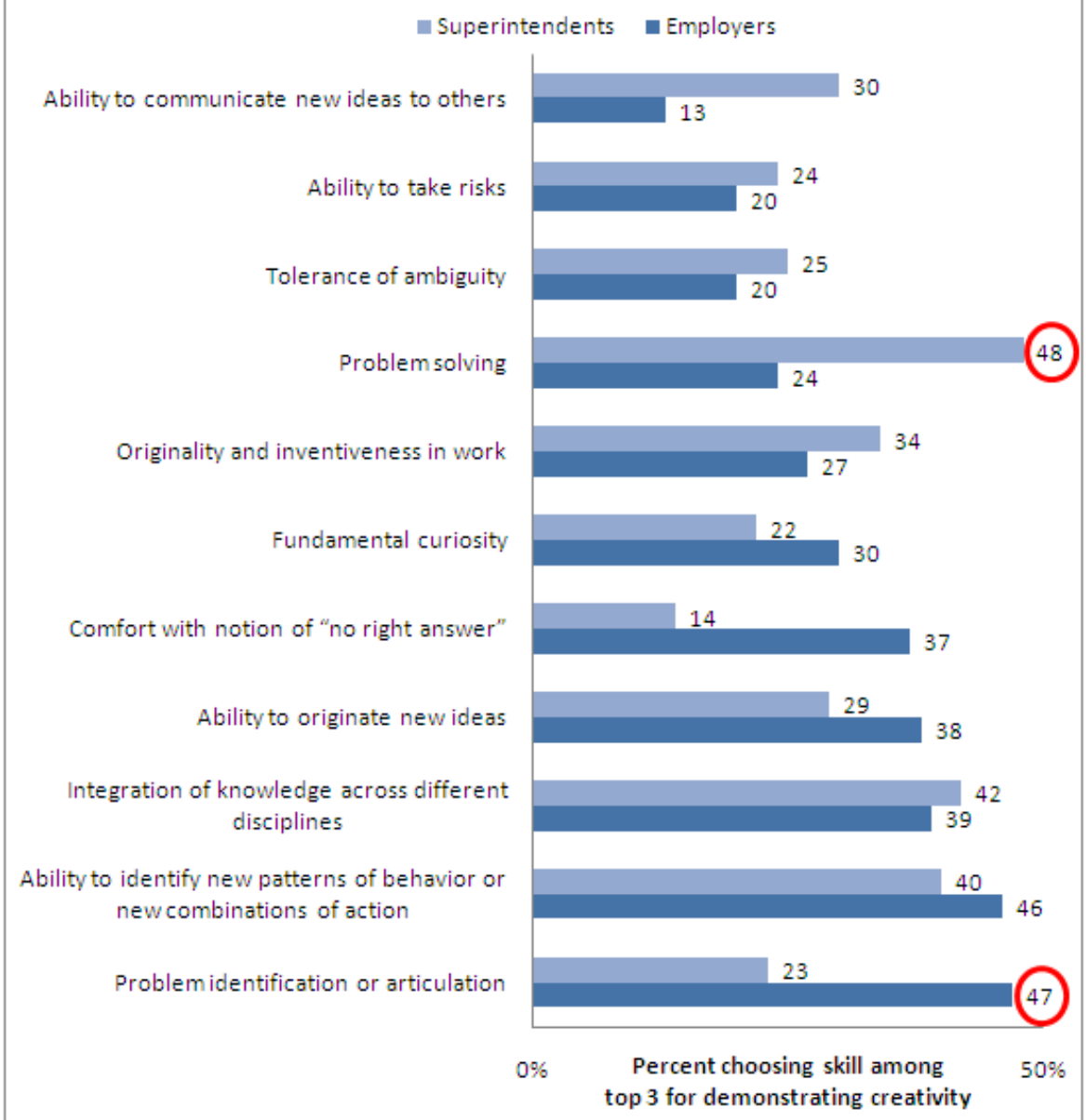
After reviewing extensive research and data on workforce and global economic trends, the new Skills Commission concluded that academic knowledge and skills, applied literacies, and critical thinking will not be sufficient for the U.S. to maintain its competitive edge in the global economy. "The crucial new factor, the one that alone can justify higher wages in this country than in other countries with similar levels of cognitive skills, is creativity and innovation."[184] Indeed, employers in the Conference Board survey ranked creativity third among skills they expect to increase in importance over the next half decade. (Figure 21)

According to employers, the two most important factors driving the need for creativity are consumer demand for customized products and services and the rise in consumer power—even more than by globalization or the need for continuous innovation. Indeed, nearly 80 percent pointed to "demand for customized products and services"—far more than any other factor.[185] Today, with so many similar products and services available to consumers, companies can only stay ahead by providing customized or uniquely designed versions.

But what exactly *is* creativity? That might sound like a silly question. Doesn't everybody know what creativity is and can't you recognize it when you see it? But it turns out that, just as with critical thinking and collaboration, getting the definition right is important if school districts want to be sure they are focused on the right thing.

In fall 2007, the Conference Board worked with the American Association of School Administrators (AASA) on a second survey to find out whether employers and school leaders are aligned in their beliefs about creativity. First they looked at how the two groups define creativity by asking respondents to choose which skills best exemplify it. The number one choice among superintendents was "problem solving," while the number one choice among employers was "problem identification or articulation." In fact, superintendents were twice as likely as employers to rank problem solving in the top three creativity skills, while the reverse was true for problem identification![186] (Figure 31)

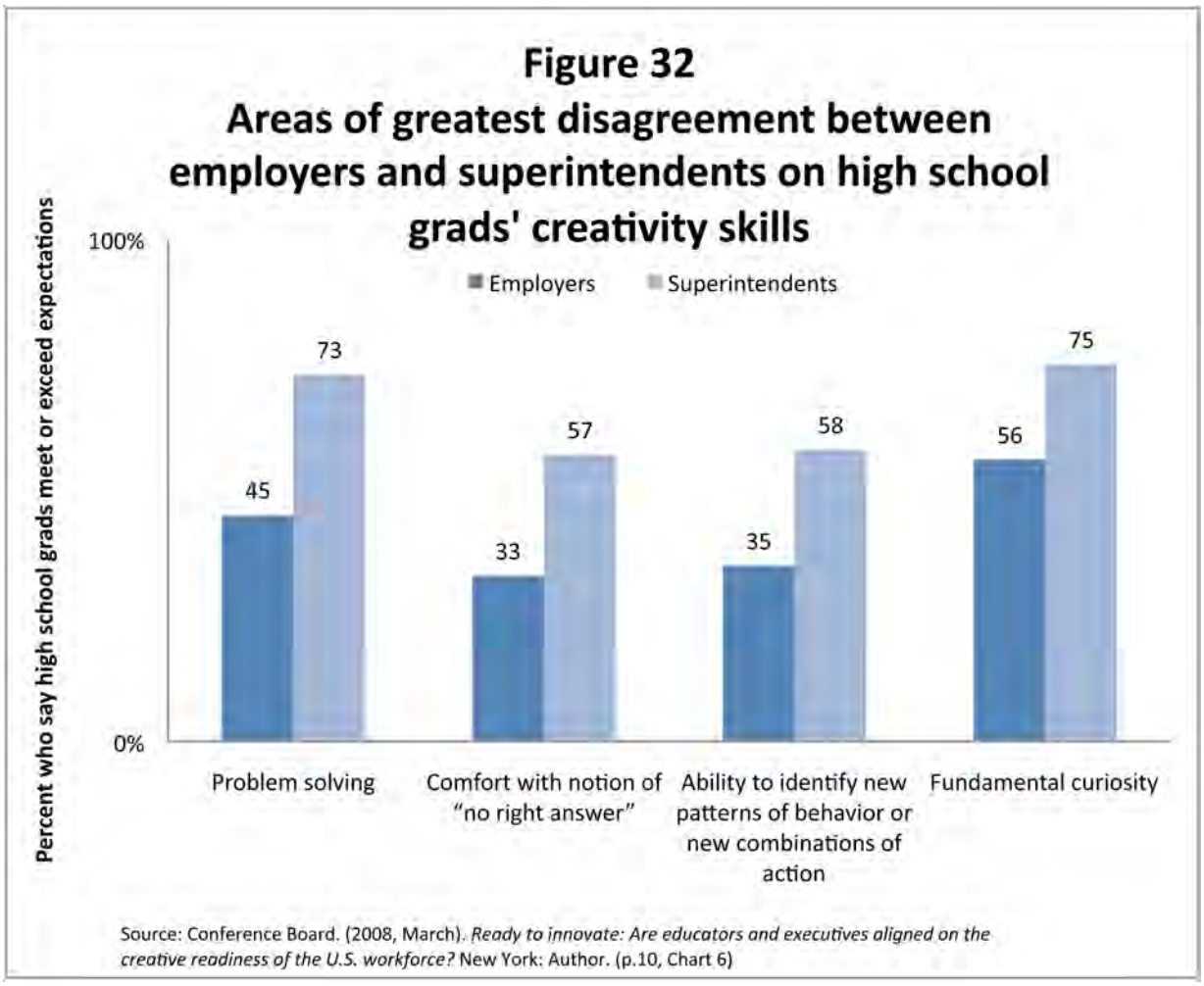
Figure 31
Employers and superintendents define "creativity" differently



Source: Conference Board. (2008, March). *Ready to innovate: Are educators and executives aligned on the creative readiness of the U.S. workforce?* New York: Author. (p.7)

When asked which attributes best define creativity, superintendents tend to point to "problem solving" while employers point to "problem identification or articulation."

Employers and superintendents also disagreed on the "comfort with 'no right answer.'" Employers ranked it fifth in importance, but by such a small margin that it was virtually tied for third, while superintendents ranked it eleventh—dead last. The survey also revealed a substantial gap in how well employers and superintendents rated new entrants on that dimension. (Figure 32) These differences might reflect the low priority given less structured and more open ended problems in school curricula and assessments—not just standardized tests but classroom assessments as well. Traditionally, education has focused on equipping students to "find the right answer" to a set of predictable, well-defined problems.



Superintendents are far more likely than employers to rate high school graduates as acceptable when it comes to their ability to solve problems, their comfort with challenges that have no single correct answer, their ability to identify new patterns, and their level of curiosity.

But that is not the kind of creativity adults need in today's workplace, where problems workers encounter are unfamiliar, ill-structured, and often have no single right solution or even a good solution. As Levy and Murnane point out, if a workplace problem is well defined and has one or more "correct" or preferred solutions, the chances are good that programmers will find a way for computers to do the job—if they haven't done so already. Many experts endorse the idea that student should be challenged with more ill-

structured problems that require divergent rather than convergent thinking. "An unfortunate feature of much education today, as well as the assessment of educational progress, is its overwhelming emphasis on well-structured problems," laments Yale University psychologist Robrt Sternberg.

These distinctions are important because the ability to identify complex new problems and see patterns suggesting new opportunities gets to the heart of what employers are looking for and what they will reward. "People who've learned to ask great questions and have learned to be inquisitive are the ones who move fastest in our environment because they solve the biggest problems in ways that have the most impact on innovation," says Dell vice president Summers.

If superintendents have a tendency to "define down" creativity as an element in structured problem solving, there also is a danger in defining it up to such a degree that it seems unattainable. Often people think of creativity as a talent possessed by only a handful of "artistic geniuses" who experience effortless flashes of transcendent insight. But creative people often decide to create and put a lot of effort into the process, often making many mistaken attempts before they produce a valuable insight. Creativity isn't a lucky lightening strike. Indeed, when University of California psychologist Keith Simonton studied a large sample of creative innovators over time, he found that creative success is linked to the sheer quantity of productive output. The more ideas you have, the more likely you are to have a truly valuable creative insight; the more you produce, the likelier you are to creatively succeed.

What else does research say about encouraging and nurturing creativity? The new Skills Commission considered the topic so important that it commissioned a separate review of the topic. The review found that "creativity requires both deep and technical expertise with one area and very broad knowledge of many, apparently unrelated areas. It depends on being able to combine disparate elements in new ways that are appropriate for the task or challenge at hand. Thus, it relies heavily on synthesis, the ability to see patterns where others see only chaos." The review also found research on what kinds of environments support creativity: "It will happen only in circumstances in which the creator is allowed to fail many times in order to succeed only once. Those who are most successful respond very poorly to extrinsic motivation." (Figure 33)

Figure 33

Creativity: Sources and Supports

According to a review commissioned by The New Commission on the Skills of the American Workforce, the following five elements are important for encouraging creativity:

1. Knowledge
    a) Deep, extensive knowledge of the domain
    b) Broad knowledge of many different areas

2. Creative thinking skills
    a) Synthetic: Combining existing knowledge or understanding in new ways, often through many attempts of which only a few are successful
    b) Analytical: Ability to judge one's own ideas
    c) Practical: Ability to promote creative ideas

3. Motivation
    a) Curiosity
    b) Intrinsic interest
    c) Perseverance (delayed gratification)
    d) Willingness to take risks
    e) Comfort with and ambiguity

4. Metacognition
    a) Explicit decision to be creative
    b) Knowing about creativity (i.e., all of the above)

5. Environment
    a) Non-controlling (risk taking and unconventional solutions rewarded rather than sanctioned)
    b) Non-threatening (intrinsic incentives vs. extrinsic rewards or threats)

Source: Adams, K. (2005, September). *The sources of innovation and creativity*. Paper commissioned by the National Center on Education and the Economy for the New Commission on the Skills of the American Workforce. Washington, DC: National Center on Education and the Economy.

The knowledge dimension might seem surprising given the idea of the creative genius who experiences flashes of novel insights. After all, Einstein said that "Imagination is more important than knowledge." But today experts understand that creativity *requires* a certain amount of knowledge in the relevant domain. Think of a chef who must come up with a new dish based on fresh ingredients available at the market that morning. He or she will not just throw ingredients together randomly, but rather based on deep knowledge about the taste and texture of various kinds of foods.[191] Notice that creativity seems to call for the same kind of "pattern recognition" at the heart of critical thinking and problem solving. According to Robert Sternberg, insightful thinking involves several kinds of knowledge processing: telling relevant from irrelevant information; combining pieces of relevant knowledge in new ways; and connecting new information to old information in novel ways.[192]

Indeed, other experts have studied how creativity frequently involves breaking down the barriers between disciplines to make connections *across* different domains of knowledge. In his book *The Medici Effect*, Franz Johansson says that this aspect of creativity calls for striking a balance between depth and breadth of knowledge in order to maximize creative potential—deep knowledge in one area and broad knowledge of other areas.[193] Some have characterized that as a "T-shaped mind."[194] A study of the people who have solved problems posted by companies on the InnoCentive website found that they often solved problems outside of their own fields by recognizing underlying patterns and making connections across domains. One physicist created a solution for injecting fluoride into toothpaste that had stumped in-house chemists at Colgate-Palmolive.[195] Robert Sternberg cautions that when it comes to creativity, it is important that one's expertise in a particular area not result in a closed and entrenched perspective.[196]

Obviously, motivation is hugely important to creativity. In fact, Sternberg argues that creativity is as much a decision as it is a skill or talent: "Creativity, according to the investment theory, is in large part a decision," he says. "To be creative one must first decide to generate new ideas, analyze these ideas, and sell the ideas to others."[197] Attributes like persistence in the face of failure are also important.

One of the most important findings about creativity is that it cannot be mandated. "In fact, in our creativity research, my students, colleagues, and I have found so much evidence in favor of intrinsic motivation that we have articulated what we call the Intrinsic Motivation Principle of Creativity," says Harvard's Teresa Amabile. "People will be most creative when they feel motivated primarily by the interest, satisfaction, and challenge of the work itself—and not by external pressures."[198]

On the other hand, it is just as important to recognize that creativity is not some form of joyous, spontaneous burst of unexpected inspiration. Indeed, one of the most important recent insights about creativity has to do with how closely it is linked with conscious effort, hard work, and persistence. According to R. Keith Sawyer, who studies creativity at Washington University, "the scientific explanation of creativity shows us that formal training and conscious deliberation are essential to creativity."[199] Dean Keith Simonton, who conducted an analysis of great creators over time, found that artists and scientists reach creativity breakthroughs only after working in their respective fields for a number of years (long enough to develop deep enough knowledge and expertise in the field) and that their level of creativity is closely related to their productivity—the sheer quantity of their overall output in the field.[200]

Some experts also emphasize the collaborative nature of creativity. "A common but misleading myth is that the innovative economy is based on a few brilliant and creative inventors and entrepreneurs," says Sawyer. "When researchers and historians study the origins of the important innovations that change our world, they discover that they are never the isolated insight of a solitary individual; they always involve collaborative teams and complex organizations."[201] He urges educators to use activities that require disciplined but improvisational collaboration. Even an activity as commonplace as whole class discussion can provide such opportunities. "Decades of educational research have demonstrated that unstructured group discussion has the potential to teach students the sort of group creativity that the new economy demands," says Sawyer.[202]

In his 2006 book *Explaining Creativity: The Science of Human Innovation*, Sawyer takes care to dispel the many myths and misperceptions that cling to the topic. In fact, all of the following common beliefs have no basis in current scientific understandings of creativity—that it comes from the unconscious; that children are more creative than adults; that it represents a person's "inner spirit"; that it is a kind of therapeutic "self discovery"; that creativity comes from spontaneous inspiration; that it is the same as originality; and that fine art is more creative than practical craft.[203] That last myth often finds its way into discussions of how to teach creativity in schools via the belief that simply increasing the amount of arts education available will increase students' creativity. Rather than thinking of creativity as an attribute that can be nurtured and

expressed only through the fine arts, school leaders should consider ways to encourage creativity across the curriculum. Indeed, in his book Sawyer includes whole chapters on creativity in business and in sciences as well as in the arts.

Self-sufficiency

Many attempts to define "21st century skills" also list a range of what are often called "intrapersonal competencies" that come down to being able to take responsibility for one's own future and acting in self-directed, self-sufficient ways. The Partnership for 21st Century Skills calls them "life and career skills" and says they include the following: Flexibility & Adaptability; Initiative & Self-Direction; Social & Cross-Cultural Skills; Productivity & Accountability; and Leadership & Responsibility. The OECD's DeSeCo project gave a prominent place to intrapersonal competencies as well, arguing that to thrive in the complex modern world, individuals need to be able to "act within the big picture, form and conduct life plans and personal projects, and defend and assert rights, interests, limits and needs."[204]

Who could argue that such skills are important? The surprise in Figure 18 is not that Mathematica found that "locus of control" has a big impact on earnings, but rather that math skills had an even bigger impact. Is anyone surprised that employer surveys consistently rank attributes like "professionalism" at or near the top of valued competencies? (See Figure 22 page 47) Of course, educators might reasonably object that making them responsible for things like students' confidence and self-esteem, sense of personal accountability, and locus of control is taking the 21st century skills idea too far. Certainly there has been a lot less research on what teachers can actually do to improve such competencies.

However, some recent research suggests it might be possible to address some intrapersonal competencies in the context of math classes. An experimental study published in 2007 showed that middle school students' math grades improved after an intervention to change their beliefs about the role of innate ability (something they cannot control) and effort (something they can control) in learning math. The researchers applied interventions instructing students that the brain is like a muscle that gets stronger with effort and exercise.[205] The National Mathematics Panel recommended more widespread use of such strategies.

Given the rapid pace of technological change along with the disappearance of well-defined jobs and long-lived careers, many experts add another competency to the list: the ability to acquire new learning on one's own, often called "learning to learn." Again, beyond teaching students how to do independent research, little work has been done to operationalize what "learning to learn" means as an adult competency and how best it can be taught. However, because the Parliament and Council of the European Union included this competency in the framework they passed in 2006, some serious efforts to operationalize and measure it are taking place across the Atlantic.

At the behest of EU authorities, several agencies developed a formal assessment to measure "learning to learn" as a distinct competency, and eight countries (Spain, Portugal, France, Italy, Cyprus, Finland, and Slovenia) field tested the assessment the spring of 2008. Because the official definition includes non-cognitive aspects, the test did as well—and it incorporated the results into the final score. (Figure 34) However, the pilot indicated that additional research into the interdisciplinary nature of learning to learn is necessary; officials are deciding on next steps.[207]

Figure 34

How the European Union Defines "Learning to Learn" as a Key Competency

Several years ago the major governing bodies of the European Union adopted a framework of key competencies for today's learners that included "learning to learn" as a distinct competency, and last year several countries field tested an experimental assessment designed to measure that skill. Here is how Europe is defining "learning to learn":

Official Definition: "'Learning to learn' is the ability to pursue and persist in learning, to organize one's own learning, including through effective management of time and information, both individually and in groups. This competence includes awareness of one's learning process and needs, identifying available opportunities, and the ability to overcome obstacles in order to learn successfully. This competence means gaining, processing and assimilating new knowledge and skill as well as seeking and making use of guidance. Learning to learn engages learners to build on prior learning and life experiences in order to use and apply knowledge and skills in a variety of contexts: at home, at work, in education and training. Motivation and confidence are crucial to an individual's competence."

Source: European Parliament and the Council of the European Union. (2006, December 30). Recommendation of the European Parliament and of the Council of 18 December 2006 on key competences for lifelong learning. Official Journal of the European Union, L 394, 10-18.

Assessment Framework:

The ***affective*** dimension is comprised of three sub-dimensions:

- Learning motivation, learning strategies, and orientation towards change;
- Academic self-concept and self-esteem; and
- Learning environment.

The ***cognitive*** dimension is based on four sub-dimensions:

- Identifying a proposition;
- Using rules;
- Testing rules and propositions; and
- Using mental tools.

The ***meta-cognitive*** dimension comprises three sub-dimensions:

- Problem solving (metacognitive) monitoring tasks;
- Metacognitive accuracy; and
- Metacognitive confidence.

Source: Hoskins, B. & Fredriksson, U. (2008). Learning to learn: What is it and can it be measured? Luxembourg: Office for Official Publications of the European Communities. (p. 29, Figure 2)

Part 3. What are the implications for school districts?

First, it is clear that districts should aim to prepare all students for postsecondary education or advanced training. Beyond that, districts must do a better job attending the *application* of knowledge and skills, going beyond simply teaching students to "reproduce" what they are taught within familiar contexts. Teaching only to the state test will probably be insufficient until states develop more sophisticated assessments. Recently, a team of researchers was startled to find that math tests in 10 states included too few complex problem solving items to even measure whether there is a gender gap in such skills let alone whether students are being adequately prepared for real world work.[208]

Unfortunately, too many educators assume that doing well on less demanding multiple choice tests requires teaching *only* the factual knowledge and routine skills such tests assess. But research shows that to be false. For example, one team of researchers in Chicago conducted a large-scale study to answer the question, "What happens to students' scores on standardized tests of basic skills when urban teachers […] assign work that demands complex thinking and elaborated communication"? The answer, they found, is that such students gain more and score better than students who receive mostly lower-level, multiple-choice-type assignments.[209]

However, it is important to avoid simplistic "either or" thinking about 21st century skills. Factual knowledge, the ability to follow directions, knowing how to find a right answer when there is one—all of these things will still be important in the 21st century. The key is to develop a curriculum that teaches students those things *as well as* how to apply what they learn to solve real world problems *and* helps them to develop the broader competencies increasingly important for success in an ever more complex and demanding world. The right word is "and," not "or."

To that end, applied literacies and broader competencies are best taught within traditional disciplines. Cognitive scientists warn against efforts to teach critical thinking as isolated skills outside of content, and commercial programs that promise they can do so have little to no strong evidence backing them up. Therefore, districts should be especially wary of sales pitches that ask them to spend less time on traditional subjects in order to fit in stand alone lessons related to 21st century skills.

Of course, that raises the question of time: How can districts fit all of this into the schedule? Lessons from abroad provide one possible answer. Researchers have found that countries performing better on international assessments have a more focused curriculum that emphasizes a much slimmer set of concepts, each of which in turn can be taught in much greater depth. For example, popular U.S. math textbooks cover almost twice as many topics per grade as do Singapore's math textbooks. In fact, Singapore's expect students to complete about one thorough lesson on a single topic per week, while U.S. textbooks students are expected to complete about one lesson on a narrowly focused topic each day.[210] If districts want to teach 21st century skills, they must focus the curriculum, not narrow it.

Also, as discussed above, since research shows that some interpersonal skills are developed in athletics and extracurricular activities, it makes sense to ensure those programs provide ample opportunities to all students to develop 21st century skills. Teachers of academic subjects should not be asked to bear these new responsibilities on their own.

The advice to focus the curriculum also holds true when it comes to integrating broader competencies. As noted above, lists of recommended "21st Century Competencies" can be overwhelming. As *Washington Post* reporter Jay Mathews recently put it, "How in the name of every teacher who has ever contemplated suicide during the unit on fractions are we supposed to make those things happen?"[211] For example, the

term "critical thinking" is so loosely applied in education that it can mean virtually anything and often does. In order to teach something well, let alone consistently well across classrooms and schools, you need to define what the "it" is—the specific knowledge or skill that you want students to learn—or teachers will be working at cross purposes and it will be impossible to measure whether students are actually acquiring them.

There are two dangers if school districts skip the defining stage. The first, as we have seen, is that teachers might be teaching the wrong thing, spending lots of time and effort on teaching something not calibrated to the real world demands that have prompted greater attention on 21st century skills in the first place. The second is simply that teachers will not be teaching the *same* thing. That is important, too, because if they are not teaching the same thing they will not be able to collaborate on instructional approaches and share emerging best practices.

School districts should also consider whether the learning environment in their schools encourages open ended curiosity, comfort with "no right answer," creativity, taking personal responsibility for identifying and solving problems—in other words, whether it reflects the evolving workplace environment. According to the Skills Commission, "People who prefer conventional work environments are likely to see their jobs disappear. But those who are comfortable working in artistic, investigative, highly social, or entrepreneurial environments are likely to succeed," as U.S. companies strive to become high-performance environments focused on innovation. "Schools will have to learn how to simulate these environments in many ways if our students are to develop the abilities that will be so important to them."

School districts also should give thoughtful consideration to whether, when, and how to assess development of 21st century skills. Unfortunately, though researchers are making some progress developing more sophisticated assessments, not many tools exist that are easily adaptable to a K-12 setting. For inspiration, districts might look to such tools as River City, the British KS3 ICT assessment, the CLA and CWRA, and the PISA assessment frameworks and released items.

Finally, district leaders should work to inform and educate others about the need for 21st century skills while at the same time dispelling myths about what those skills are and how students can best master them. Key audiences include not only teachers, but also state and federal policymakers.

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