National Assessment Governing Board

Ad Hoc Committee on
Measures of Postsecondary Preparedness

Thursday, November 16, 2017
1:45 – 3:45 pm

AGENDA

1:45 – 2:00 pm	Welcome and Agenda Overview *Terry Mazany, Chair* *Bill Bushaw, Executive Director*	
2:00 – 3:00 pm	Discussion of the Proposed Approach for the Ad Hoc Committee on Measures of Postsecondary Preparedness *Terry Mazany*	Attachment A
3:00 – 3:45 pm	Discussion on the Workforce of the Future *Terry Mazany*	Attachment B

Proposed Approach for the Ad Hoc Committee on Measures of Postsecondary Preparedness

Overview of the Ad Hoc Committee

On August 3, 2017, National Assessment Governing Board Chair Terry Mazany established an Ad Hoc Committee on Measures of Postsecondary Preparedness. To support this initiative, the Governing Board's Executive Committee established the following charge:

1. The Ad Hoc Committee on Measures of Postsecondary Preparedness shall review existing research, collect expert testimony, and prepare recommendations for the Governing Board's consideration to achieve Strategic Vision priority #10.[1]

2. While the current legislation guiding the National Assessment of Educational Progress (P.L. 107-279) should provide parameters for the approaches to accomplish this priority, the Ad Hoc Committee on Measures of Postsecondary Preparedness may consider options that could require amendments to current legislation.

3. The Ad Hoc Committee on Measures of Postsecondary Preparedness will report its recommendations to the Governing Board no later than the November 2018 Board meeting.

The members of the Ad Hoc Committee on Measures of Postsecondary Preparedness are:

- Terry Mazany, Chair
- Alberto Carvalho
- Jim Geringer
- Carol Jago
- Tonya Matthews
- Dale Nowlin
- Alice Peisch
- Fielding Rolston
- Linda Rosen
- Ken Wagner
- Chasidy White

The work of the Ad Hoc Committee will be supported by Governing Board staff and its contractors.

Potential Research Questions for the Ad Hoc Committee

This is not the Governing Board's first effort to explore postsecondary preparedness. After a decade of research and over 30 studies, the Board successfully established a link between 12th

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[1] Strategic Vision priority #10: "Develop new approaches to measure the complex skills required for transition to postsecondary education and career."

grade students' reading and mathematics scores on the National Assessment of Educational Progress to their placement into non-remedial college coursework. This was an important breakthrough, but it left the Governing Board wanting to explore ways to address the question—are high school seniors prepared for life after high school, regardless of which postsecondary pathway(s) they select?

To make headway on addressing this question, the Governing Board will need to widen its lens and consider the broader context of a changing world by examining, as best it can, trends that most likely will shape the future, the nature of skills, and the utility of existing and new measures. In considering its approach, the Ad Hoc Committee may review existing research and collect expert testimony to answer three questions to develop its recommendations to the Board:

1. ***Workforce of the future (readiness for what?):*** What are we, as a nation, preparing students for? Changes in the workplace are not only inevitable, but are accelerating, driven by technological advances, demographics, and social changes. Self-driving vehicles, robots, and artificial intelligence are signs of existing innovations poised to dramatically change the jobs available to young Americans. Young Americans hold different expectations about work, and the ways in which people connect and communicate with each other are all changing. How will the workplace change given these emerging technologies? How will our communities change given these trends?

2. ***Requisite skills for future work (skills for what?):*** With a better understanding of the future workplace, we can better understand the skills that young Americans will need to succeed. But should we consider more than just workplace skills? What about skills like citizenship and financial literacy? How do these skills factor into the question of measuring postsecondary preparedness?

3. ***Measures of preparedness (measures for what?):*** Finally, what metrics exist to measure the skills that young Americans will need in the workplace, their roles in community, and in their personal lives? Should these metrics be limited to tests? Could they include data from other sources? Additionally, what metrics don't exist but are needed to help the nation better understand if students are prepared as they exit high school, regardless of which paths they take—through college or other postsecondary learning experiences or directly to the workforce?

Reviewing Research and Collecting Testimony

The work of the Ad Hoc Committee is to seek, gather, and make sense of the thinking and research of others. Its task is not to conduct primary research, but to assemble and integrate the wide-ranging work of others across diverse domains of research and practice.

To explore these research questions, the Ad Hoc Committee has several avenues to inform its work. In addition to the Board staff and partners at NCES, the Ad Hoc Committee will be able to utilize the Board's technical support contractor as a thought partner in this work. The resources available to the Ad Hoc Committee during its commission include:

- *Expert Speakers* – The Board staff could arrange for expert speaker(s) to present to the Ad Hoc Committee at its in-person meetings or via video-conferences.
- *Literature Reviews* – The Ad Hoc Committee could request a literature review to identify, critique, and synthesize existing research and/or best practices on a specified topic. The resulting report would be approximately 25-30 pages, with a short executive summary for general audiences, and is anticipated to take 2-3 months to complete. The Ad Hoc Committee may identify multiple literature review topics to inform its work.
- *Expert Panel Meetings* – The Ad Hoc Committee could request an expert panel(s) be convened to engage in deep discussion on the technical feasibility of an identified topic(s). Expert panels typically involve six to eight expert consultants for an in-person panel meeting lasting two days. The Ad Hoc Committee would not be expected to attend the panel discussion, but would receive the resulting summary report.
- *White Papers* – The Ad Hoc Committee could also commission white papers from experts who participate in the panel meeting(s), similar to the thought papers the Board commissioned to further the Board's Long-Term Trend discussion.
- *Technical Memos* – The Ad Hoc Committee could request technical memos to provide advice or recommendations on topics related to its work. The resulting technical memo would be approximately 15-20 pages and include a short executive summary. Technical memos could be requested to examine issues, such as: the nature and definition of relevant skills in a future defined by radically different demands and conditions for work; existing metrics for work and adult skills; non-traditional measures of these types of skills; and options for exploring the feasibility of a new approach to using NAEP as an indicator of preparedness for postsecondary endeavors.

Proposed Timeline Leading to Recommendations

The Ad Hoc Committee on Measures of Postsecondary Preparedness is charged to develop recommendations for the Governing Board's consideration to achieve Strategic Vision priority #10 and will report those recommendations to the Governing Board *no later than* the November 2018 Board meeting.

If the Ad Hoc Committee agrees with the three proposed domains for research questions, then a natural progression emerges as the findings from each question inform the work of the next question. Therefore, the approach of dedicating each Ad Hoc Committee meeting to one of the research questions is one way to approach the work (see table below). However, it is assumed that the Ad Hoc Committee may discuss all aspects of its charge at any given meeting and follow-up on previous discussions will be necessary. The Ad Hoc Committee, with support from staff and the technical support contractor, will need to determine what the desired research and expert consultation is, when it can occur or be completed, and the impact of that on the work plan timeline.

This proposed timeline focuses on in-person Ad Hoc Committee meetings scheduled to occur on the Thursday afternoon of Board meetings. It may be determined that additional in-person or teleconference meeting time is needed between Board meetings. Ad Hoc Committee meetings may include outside experts, as necessary.

Board Meeting Date	**Ad Hoc Committee meets in person for ~2 hours at the Board meeting to:**
November 16, 2017	*Kick-off* • Review the charge • Confirm the research questions to pursue • Discuss the work plan timeline and resources needed (Introduce new technical support contractor) *Discuss the future of the workforce (Q#1)* • React to materials sent in advance
March 1, 2018	*Discuss the requisite skills for future work (Q#2)* • What are the requisite skills of the future workforce? • What other skills are needed for postsecondary preparedness?
May 17, 2018	*Discuss the measures of requisite skills (Q#3)* • What are the measures of the skills identified in Q#2 • Which measures exist already, which do not?
August 2, 2018	*Develop recommendations for the Board*
November 2018 — Present the Ad Hoc Committee's final recommendations to the Board	

At its first meeting on November 16, 2017, the Ad Hoc Committee will begin its discussion on the "workforce of the future" and the associated requisite skills. The following video and attached reports were provided to Ad Hoc Committee members in September 2017, and are included in these meeting materials as background to help prompt discussion on this topic.

1. McAfee, Andrew, "What will future jobs look like?" (2013) https://www.ted.com/talks/andrew_mcafee_what_will_future_jobs_look_like.

2. KnowledgeWorks, "The Future of Learning: Redefining Readiness from the Inside Out." (2017)

3. National Research Council, "Education for Life and Work: Developing Transferable Knowledge and Skills in the 21st Century." (2012)

4. University of Chicago Consortium on Chicago School Research, "Teaching adolescents to become learners. The role of noncognitive factors in shaping school performance: A critical literature review." (2012)

KnowledgeWorks Forecast

The Future of Learning: **Redefining Readiness from the Inside Out**

Katherine Prince • Andrea Saveri • Jason Swanson

KnowledgeWorks

Executive Summary

Work is changing rapidly as we enter a new era fueled by exponential advances in digital technologies. In particular, the rise of smart machines and the decline of the full-time employee are reshaping the ways people work and are creating significant uncertainty about what readiness for further learning, career, and life will look like in 2040.

To help all learners prepare for the new employment landscape, this paper forecasts key characteristics of future work and proposes a framework for redefining readiness. As depicted below, that new foundation for readiness focuses on core social-emotional skills and foundational cognitive and metacognitive practices.

The paper goes on to explore how this new foundation for readiness might help people navigate new employment landscapes. These scenarios illustrate different ways in which two critical uncertainties could affect readiness by 2040:

- Will there be high or low technological displacement of human workers?
- Will the societal response be systemic and intentional or market driven?

The paper concludes by highlighting strategic opportunities for K-12 and post-secondary education to begin acting today to ensure that all learners have an equitable chance of being ready for further learning, career, and life in 2040. In addition, a discussion guide offers ways of beginning to make sense of the changing nature of work and readiness in your context.

We owe it to current and future students to reframe our approaches to readiness. This is the most urgent issue on the horizon for learning.

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Redefining Readiness
for the Era of Partners in Code

Work is changing rapidly as we enter a new era fueled by exponential advances in digital technologies. As we described in *The Future of Learning: Education in the Era of Partners in Code*,[1] these technologies are combining with cultural, economic, and institutional shifts to create an era of partners in code in which we can expect to be developing new uses for and new relationships with machines that are increasingly wearable, connected, and smart. We called this era one of partners in code because we forecast that our lives will become inextricably linked to the code in our digital devices as we increasingly use them to navigate, make sense of, and contribute to the world around us. We are already seeing shifts in this direction and anticipate that society will be reconfigured as advances in digital technologies continue to accelerate. While people have used and worked alongside various kinds of machines for centuries, the defining characteristic of the new era is that our machine partners will be increasingly capable of cognition.

One impact of this era shift is the need to redefine readiness to help all learners prepare for the new employment landscape. As we wrote in the forecast:

The changing nature of work will bring to the fore a societal debate about the role of people in the workplace and what it means to be career-ready. Reflecting this debate, the K-12 sector will no longer push students toward post-secondary options that might not adequately prepare them for the new world of work. Instead, education at all levels will prepare learners continually to reskill and upskill and to know how to partner constructively with machines.

EDUCATION AND THE ECONOMY

Readiness for college, career, and life is one of the central purposes of education at all levels. Education systems have historically followed economic eras. Those eras' dominant paradigms of production have traditionally shaped the ways people have organized teaching and learning. For much of the 20th century, mastering content guided teaching, curricula and classroom structures, as students learned to follow instructions and produce output according to criteria set by teachers, much like the expectations of factory work. In the late 20th century, education stakeholders increasingly questioned this focus on content acquisition as higher-order skills such as creativity, communication and critical thinking came to be seen as essential. In its place, thinking and doing emerged as increasingly important organizing principles. Many schools shifted their teaching to focus on project-based work and other ways of cultivating inquiry, analytical thinking, problem solving and other complex cognitive practices. Despite this pattern, the relatively slow pace of change in education can make it difficult for K-12 schools and postsecondary institutions to adapt as quickly as the economy.

Today, rapidly transforming technologies and shifting employment structures are once again changing production paradigms, calling into question the role that people play in the workplace and the ways in which they organize and access work. As a result, there is an intensifying need for K-12 schools and postsecondary institutions to respond with how they educate learners.

As artificial intelligence and machine learning improve over the coming decades, there will be a need to redefine how people contribute in the workplace. Our collective choices about smart machine partnerships at work will influence what readiness looks like in the future. In this paper, we define readiness as the core skills and practices that are necessary for people to navigate and thrive across further learning, career, and life, throughout their lifetimes.

A **time horizon** is a point in the future that is being explored. This paper explores a time horizon of 2040, allowing us to develop current critical uncertainties into scenarios of the future that look different than our current reality and to reduce the temptation to frame the future as an extension of the present.

To help education stakeholders ensure that education systems and experiences support all learners in preparing for the world in which they will live and work in the year 2040, this paper takes a deep dive into the future of readiness. It combines insights from ethnographic research along with scenarios for the future of readiness to propose a new foundation for readiness and show how people might apply that foundation as critical uncertainties about the future play out. It also highlights opportunities for K-12 and postsecondary education to act today to ensure that all learners have an equitable chance of being ready for further learning, career, and life in 2040. As you read through this paper, consider what key skills someone being born today might need when they transition from school to their next stage in life, and what a portrait of a graduate might look like given the changes highlighted in this paper.

The Changing Nature of Work

As the era of partners in code emerges, work is being reshaped by two drivers of change: the rise of smart machines and the decline of the full-time employee. Those drivers of change are being made more pronounced by technological acceleration. While it is clear that these drivers of change are transforming work, there is significant uncertainty about what work will look like in 2040.

A **driver of change** is a major shift combining multiple trends to identify a broad pattern of change.

The Rise of Smart Machines

Advances in artificial intelligence, machine learning and robotics and other forms of automation are leading to the rise of smart machines that will increasingly be able to perform tasks that people carry out today. As smart machines develop further and get cheaper, they will alter or eliminate cognitive and manual routine tasks and will also increasingly impact the cognitive and manual non-routine tasks often associated with white-collar professions and knowledge work.

We know that the rise of smart machines will impact work. We do not yet know the extent and nature of that impact. Smart machines have the potential to augment the contributions of people in the workplace, creating new jobs; reconfiguring current work; and making many jobs safer, easier and more interesting. However, such technologies also have the potential to cause significant displacement of human workers, at least for a time. Signals of change point toward both possibilities.

A **signal of change** is an example, or early indicator, of how a future possibility is beginning to play out today.

Even today, people in a wide range of jobs use or work alongside smart machine partners. For example, robots such as one called Baxter now work alongside people on production lines and factory floors, learning and re-learning tasks with relative ease and affordability. Baxter learns programs when its hands are moved through the motions required to perform its assigned tasks.[2] Some doctors are using machine learning to help diagnose illness.[3] Chess players are partnering with smart machines to compete in advanced chess leagues.[4] Indeed, technologies that augment human intelligence are present in nearly every adult's life. Among them, smartphones and smart home assistants such as Amazon's Alexa[5] and Google Home[6] enable people to extend their short-term memories by looking things up and getting reminders. GPS-enabled devices not only help people find their way, but can also recommend shorter routes as traffic conditions change. In addition, programs such as Skype's real-time language translator[7] allow people to bridge language barriers instantly. These examples illustrate the potential for smart machines to augment human intelligence.

At the same time, we are also seeing signals of change that point toward technological displacement. For example, lights-out manufacturing, in which factories are fully automated and only a few people are employed to tend to the machines, is on the rise. Transportation is on the verge of being automated: the ride sharing company Uber is trialing self-driving cars;[8] and Uber Freight is taking orders for autonomous trucks,[9] potentially displacing millions of workers. Artificial intelligence is replacing some insurance industry employees, including thirty-four people who were laid off from Japan's Fukoku Mutual Life Insurance,[10] and is writing some news stories.[11] Smart machines are also competing with people's ability to perform complex cognitive tasks in medicine and the arts: robotic surgeons such as the Smart Tissue Autonomous Robot have been shown to outperform human surgeons,[12] and an artificial intelligence recently completed a painting considered to be the equivalent of an original Rembrandt.[13]

With signals of change supporting both the potential for smart machines to create or reconfigure jobs and to cause widespread technological displacement, experts are making divergent projections. Supporting the possibility that new and reconfigured jobs will employ people faster than smart machines can displace us, economist James Bessen of Boston University points out that automation has historically created or redefined jobs instead of destroying them. He argues that technology is not eliminating jobs but is instead creating the demand for new skills. Bessen forecasts an increase in jobs, specifically those associated with computer use, due to technological change.[14] Similarly, the World Economic Forum projects modest job growth through 2020, with requisite skills changing rapidly.[15] A recent Pew survey of some 1,896 experts examining the potential effects of robotic advances on the economy in the year 2025 found that 52% of respondents thought that technology would create more jobs than it would displace.[16]

DEFINING DIFFERENT TYPES OF TASKS

Cognitive and manual routine tasks are tasks or jobs that are well-defined, routine or "rules-based." Examples include many accounting, transportation, construction, repair, monitoring, and production-based tasks and jobs.

Cognitive and manual non-routine tasks are tasks or jobs that are less well defined and that require situational adaptability, persuasion, problem solving and creativity. Examples include managerial, creative, medical, caring and science-based tasks and jobs.

Both routine and non-routine tasks will be affected by the rise of smart machines.

Supporting the potential for widespread technological displacement, a 2013 study by Carl Frey and Michael Osborne of the University of Oxford suggests that 47% of current US middle-class jobs are at risk due to automation over a twenty-year period.[17] A 2015 McKinsey Global Institute study brings the threat of technological displacement much nearer term, stating that 45% of the activities that workers do today could already be automated.[18] The OECD estimates that technology already accounts for a nearly 80% drop in labor share among its member countries indicating that, even in those countries experiencing GDP growth, much of that growth can be attributed to increased technological efficiency rather than human output. This drop provides strong evidence that displacement is already underway.[19]

While the full impact of smart machines in the workplace is not yet clear, we can anticipate that their rise will force us to reevaluate the role of people in the workplace, either almost entirely or in regard to the kinds of skills we need to thrive and the frequency at which we need to acquire new ones.

The Decline of the Full-Time Employee

Technology is also changing the structure of work, due in large part to the lower coordination costs afforded by the Internet and the access to an expanded labor pool resulting from globalization. The Internet is making it increasingly cost effective for firms to access people with specialized skills on the open market instead of employing people full-time. Globalization has opened up an international talent pipeline and continues to give firms access to cheaper labor markets and specialized talent. Such shifts are contributing to shortening employment tenure, the spread of contingent and project-based work, and the rise of taskification.

By 2040, we will likely see a significant decline in full-time employment, with more people piecing together career mosaics comprised of a variety of jobs and work experiences. Career mosaics could include radically different types of work, sometimes with different jobs and tasks spread over a period of time and sometimes with them taking place concurrently. For people employed full time by one organization, jobs and job descriptions are likely to become more and more fluid, flexible, and project based. Employees are likely to move through their workplaces horizontally rather than vertically, taking on a wide variety of tasks and projects as needs change.

Already, average job tenure is falling. Today, the average adult holds 11.7 jobs in his or her lifetime.[20] To put that statistic in perspective, if the average adult works for fifty years, that person will have a new job roughly every four years. The structure of work will change further in the coming decades as project, short-term workers and independent contractors take on more contingent, project-based work. McKinsey Global Institute estimates that 54 to 68 million people in the United States already work in the project-based economy.[21] Intuit forecasts rapid growth in this arena, with the independent workforce exceeding over 40% of the US workforce by 2020.[22]

Taskification is also on the rise. This term refers to the breaking down of formal jobs into discrete tasks, often at lower wages and with informal job structures. Current examples of taskification include Amazon Mechanical Turk,[23] an online, crowd-sourced marketplace where individuals and businesses coordinate on

"human intelligence tasks," or tasks that computers are currently unable to complete. Task Rabbit[24] is an online platform that matches freelance labor with people who need tasks, such as house cleaning, home repair, or running errands, completed. The ride sharing services Uber[25] and Lyft,[26] which have disrupted the taxi industry, use algorithms to match drivers with riders. These algorithms tell drivers where to go and then collect payment, while the drivers' task is simply to drive.

Generational attitudes may also affect the structure of work. Compared to older generations, the Millennial generation, born between 1982 and 1995,[27] has already shown less loyalty to traditional institutions, including employers. Its expectations for engagement have helped shift some workplace structures to be less hierarchical, and its "always on" habits have blurred the boundaries between work and home life. As generation Z, born from 1995 to 2010,[28] enters the workplace, they will view short-tenure employment, project-based work, and taskification not as emerging phenomena but the new normal for structuring work. This perspective will influence their ideas of what work should be and what it should look like and could further exacerbate the decline of the full-time employee.

As digital technologies continue to advance and people's expectations about what work looks like continue to change, it will become increasingly easy to break down many existing jobs into tasks and to manage them algorithmically. The risk of technological displacement due to automation could also increase. While we do know what balance of full-time employment, short-term contracts, project-based work, and taskification will emerge by the year 2040, we can anticipate that the structure of work will become increasingly granular, with fewer full-time employees than exist today. Depending on what societal structures and supports exist around work, the employment landscape could also become more competitive.

Accelerating Technology

While work has historically changed in response to available technologies and social and organizational structures, the rise of smart machines and the decline of full-time employment promise to have huge impact given the exponential rate at which digital technologies are advancing. This rate is already making the cycle of change much more rapid than in the past, and it will only continue to pick up speed. As the rise of smart machines and the decline of full-time employment continue to shape work between now and 2040, we can expect the employment landscape to change very rapidly. In face of this rapid rate of change, education stakeholders need to anticipate how work might evolve and need to redefine readiness for a new era.

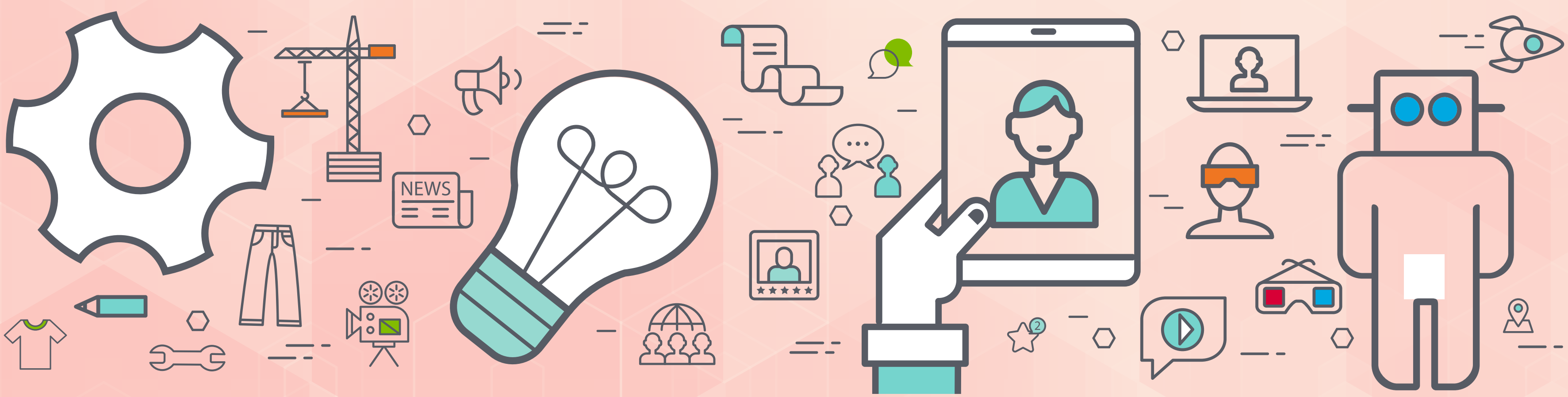
A HISTORICAL VIEW: FOUR INDUSTRIAL REVOLUTIONS

Technology's changing the means of production, and thus changing the ways we work, is not a new phenomenon. Looking back at the 18th and much of the 19th centuries, the **First Industrial Revolution** took place, causing predominantly rural and agrarian societies to become increasingly urban and industrialized due to the technological advances such as the steam engine and the emergence of textile and iron industries.[29]

The period between 1870 and 1914 brought on the **Second Industrial Revolution** due to such technological advances as the telephone, the light bulb, the internal combustion engine and due to the application of electricity to create mass production. During this period, many pre-existing industries experienced growth; and new industries, such as steel, electricity, and oil, emerged.[30]

The 1980s introduced the **Third Industrial Revolution**, also known as the Digital Revolution.[31] During this period, technology advanced from mechanical and analog electronic devices to digital ones. Developments during this period included many communications and information technologies, among them the personal computer, the Internet, cell phones, and smart phones. Again, these technologies affected many established industries, causing significant disintermediation; and enabled the creation of new ones such as the computer industry (both hardware and software development), web development, and mobile communications.[32]

The **Fourth Industrial Revolution**, which is unfolding around us and which we call the era of partners in code, builds upon the technological advancements that emerged during the third Industrial Revolution to represent new ways in which emerging technologies might become embedded in our organizations, societies, and bodies. This industrial revolution is characterized by technological advancements in robotics, artificial intelligence, nano- and biotechnologies, the Internet of Things, 3D printing, and autonomous vehicles.[33] These technologies will be increasingly wearable, embedded in the world around us, connected to other devices, and smart.



A New Foundation for Readiness

A series of in-depth interviews and site visits with employees working at cutting-edge organizations and as independent contractors helped us examine ways in which the changing nature of work is beginning to impact workers today.[34] Based on that ethnographic research and on additional secondary research, we forecast key characteristics shaping work in the year 2040 and a new framework for readiness that education stakeholders can begin integrating into practice, policy, and systems design today.

Future Work Characteristics

By 2040, most work will have the characteristics described below. These characteristics are emerging from cutting-edge work today and will become more pronounced by 2040.

Market-driven and user-centered: Technology and globalization are creating an expansion of middle classes and are opening new markets around the world. Massive data streams are revealing insights about market niches and opportunities to design targeted goods, services, and experiences. To gain market advantage, organizations will frequently need to reposition themselves and shift strategic goals. Market-driven work will be highly problem-driven, ambiguous, and volatile.

Data and metrics driven: Work at all levels will be increasingly quantified, with individual performance assessed and contributions to corporate goals measured. Frequent measurement and quick feedback will drive a practice of constant improvement and learning.

Modularized and recombined: Work will be increasingly broken down into discrete parts – whether projects, tasks, campaigns, or initiatives – each with its own team, culture, approach, and goals. Modularization will require thoughtful design of work flow and component pieces, along with extensive coordination and synthesis to meet high-level goals.

Grounded in Relating: Relationships will help determine success and will frame how work is conducted. Leading-edge work is already collaborative, team-driven, collegial, and inclusive. Cultivating productive relationships will continue to be an essential component of work in many contexts.

Interwoven with Learning: Both organizations and workers will need to adapt frequently, learning repeatedly in response to changing conditions. The act of working will become learning, as people adopt new skill sets to align with employment opportunities. Constant learning will blur the lines between our personal and professional lives and will drive some workers to take on passion-based projects to learn new skills.

Drawing upon these future work characteristics and considering the speed at which the rise of smart machines and the decline of the full-time employee are impacting work, we forecast that the skills and traits that define readiness for further learning, career, and life will shift away from a bias toward knowledge and cognition. In place of academic content, college readiness, and near-term job-specific skills, readiness will come to be defined by a new foundation that undergirds people's ability to develop the more ephemeral skills necessary to succeed in specific contexts.

This new foundation for readiness starts with core social-emotional skills and practices. Layered atop them are foundational cognitive and metacognitive practices that effectively address the new nature of work in 2040. This new foundation for readiness promises to prepare all learners to adapt and grow effectively to meet the opportunities presented by a new world of work.

Cognition is the process of acquiring knowledge and developing understanding through thought, experiences, and senses.[35] Cognition includes such processes as attention, evaluation, decision making, judgement, and memory.

Metacognition can be defined as "thinking about thinking." It involves higher-order thinking skills, such as analysis, synthesis, and critical thinking, as well as knowledge about when and how to use certain strategies for learning and problem solving.[36]

Helping People Grow: Core Social-Emotional Skills

The core of the new foundation for readiness lies in developing a strong inner self that is resilient, reflective, and able to develop positive connections and relationships. Our emotion system is an important mechanism for sensing, interpreting, and communicating information about the world and other people. It affects our executive function — our decision-making, focus, and attention – as well as our memory, our relationships, our physical and mental health, and our learning. If we cannot manage them, our emotions can sabotage our goals and relationships.

In the context of future readiness, social-emotional skills provide the basics for building effective work practices, learning strategies, and career development approaches that will lead to success in academic pursuits, work, and life. More specific social-emotional skills and their future importance are detailed below, with quotes from our research interviewees illustrating how current cutting-edge work demands them.

Self-Discovery: Deep Self-Knowledge

In order to create fulfilling and successful careers, workers will need to continue to discover their own personal and professional strengths, weaknesses, passions, and emotional patterns. Self-discovery will also help people develop visions for their lives and will fuel creativity.

"Confidence is important. Not just confidence in what you know, but confidence about what you don't know. Being able to say, 'I haven't done this before, I have no idea, but I am going to figure it out.'"

— Mobile engineering manager, cognitive game company, KnowledgeWorks interview

Individual Awareness: Emotional Regulation

Workers will need to be able to recognize their own emotions; understand the triggers that create them; and shift to more desired, productive emotional states.

"There are definitely certain moments where you have this big project, and you've been working on it for a really long time, and a deadline is coming up, and literally no aspect of your project is working. You just want to take your laptop and throw it off the top of the building...Those are the times when you have to just take a deep breath and think about what you need to do and just sit down and get it done."

— Software engineer, digital music company, KnowledgeWorks interview

Social Awareness: Empathy and Perspective-Taking

Success at work will increasingly come from building social relationships of all kinds to support learning, collaboration, and innovation. In order to understand their behaviors, workers will need to be able to recognize others' emotions and perspectives. Deep empathy will also be critical for building inclusive work environments that are truly collaborative, innovative, and adaptable.

"I'll go to my boss and say, 'I messed this thing up, I don't know how to fix it, I need your help.' And he says, 'Okay, cool, I see what's going on, here's what I think you can do; also, I take ownership in not supporting you in the way that you could've been supported to keep this from happening in the beginning.'"

— Logistics manager, outdoor education nonprofit, KnowledgeWorks interview

Helping People Navigate: Foundational Cognitive and Metacognitive Practices

The core social-emotional skills above enable a set of foundational cognitive and metacognitive practices that will help workers overcome the challenges of navigating, adapting, and growing in the emerging work environment. These foundational cognitive and metacognitive practices will help people move successfully from one situation to the next and adapt as the circumstances around them change. These practices and their significance are detailed below and on the next two pages, with quotes from our research interviewees illustrating their application in current cutting-edge work.

Thrive in Ambiguity and Uncertainty

Rapidly changing market positioning and new service niches can leave workers with fluid work goals and vague work tasks. The fast pace of work and volatility of priorities can be challenging for those without the skills to manage themselves and figure out solutions. To thrive in this context, people will need to:

- Create structures to organize, plan, and prioritize work;
- Develop adaptability and resourcefulness;
- Manage emotions;
- Balance confidence with humility; and
- Seek out help.

"I had no guidance other than 'Go figure it out.' What makes you a valuable employee is the ability to champion something that you aren't necessarily comfortable with and succeed outside your comfort zone."

— Senior software engineer, digital music company, KnowledgeWorks interview

Communicate and Create with Numbers

Accelerating technologies are creating a multitude of ways to capture data and mine it for strategic insight. Data and analytics describe the performance and impact of teams, individuals, and products. Drawing upon numerical literacy to create and communicate stories is essential for success. To thrive in this context, people will need to:

- Use metrics and data tools to guide and assess performance,
- Develop insight and meaningful narratives from data,
- Use math to generate ideas, and
- Use data to make informed decisions.

"I'm very data driven. If they want to see a 350% increase in revenue driven by my work from last quarter, I need to dive in and look at if it's even humanly possible."

— Director content marketing, crowdfunding company, KnowledgeWorks interview

Learn Anything, Anywhere

Building learning ecosystems of mentors, online supports, formal classes, and informal study will be necessary for future success. While different work opportunities will present different types of learning and educational opportunities, all workers can expect to be learners, mentors, and teachers in some capacity. To thrive in this context, people will need to:

- Create learning resource ecosystems to support their goals;
- Give and receive feedback;
- Cultivate mentors, both internally and externally and both formal and informal;
- Use side projects to grow skills and fuel passions; and
- Reflect on their learning processes, goals, strengths, and weaknesses.

"I observe people who've been here five or six years; they're always asking questions, and that's something I'm trying to mimic. It shows that they're constantly trying to learn more and more. No one's a master at what they do. Everyone's trying, everyone's learning, so that's refreshing."

— Mobile engineering manager, cognitive game company, KnowledgeWorks interview

Cultivate Inclusive Communities

Innovation, breakthroughs, and creative problem solving require diverse contributions and approaches. Leveraging the perspectives and experiences of diverse peers cannot happen without a practice of inclusion and emotional safety in which team members feel that they can collaborate openly and take risks without negative consequences. To thrive in this context, people will need to:

- Share responsibility;
- Focus on results, not personal agendas;
- Create trust and psychological safety; and
- Coach others and help them figure things out.

"We have an increasingly diverse workforce in terms of backgrounds, but also in the ways that people think. We have this whole interesting combination of people who have been at big companies, small companies, startups their entire [working] lives, companies that did things really well, companies that did things really poorly. You have this collision of ideas. Collaborative teams get things done here."

— Senior software engineer, digital music company, KnowledgeWorks interview

Make Friends with People and Machines

The future workplace will be characterized by intimate relationships with people and machines. Knowing how to augment and improve performance by partnering with both people and smart digital tools and software will be critical to successful work performance. To thrive in this context, people will need to:

- Communicate clearly across all levels;
- Practice active listening;
- Manage non-productive emotions and shift to more productive emotional states; and
- Use software tools, artificial intelligence, and digital assistants to grow their value and performance.

"Knowing what resources you have at your disposal and whether that's people or tools, your own experience, other people's experiences [is key to success]."

— Senior software engineer, digital music company, KnowledgeWorks interview

Take Initiative and Self-Advocate

Fast-paced work environments are focused on achieving growth targets and market success, not on planning individual workers' careers. To gain career mobility across work and employment settings, workers will need to seek out opportunities, communicate their value, and pitch themselves. The motto "Work for it, don't wait for it,'" will be a guiding principle. To thrive in this context, people will need to:

- Negotiate projects with managers or identify and champion new ones;
- Pitch themselves to others, demonstrating their value;
- Be proactive and autonomous; and
- Experiment with new jobs, tasks, and skills.

"The only reason I have this position today is because I've literally had to ask for it each step along the way. Every stage of my growth, it wasn't given to me, I had to ask someone, 'Can I do this? How can we make this happen?'"

— Content marketing team member, crowdfunding company, KnowledgeWorks interview

Think Differently

Novel ideas come from unconventional or unexpected ways of looking at a problem or idea. Using various cognitive frameworks and disciplinary models is important for creativity and innovation. Workers, either individually or collaboratively in groups, will need to learn how to diversify their thinking. To thrive in this context, people will need to:

- Use frameworks and models from diverse disciplines,
- Reflect on their thinking and problem-solving approaches,
- Branch ideas to expand them and build off others' ideas, and
- Synthesize ideas into deeper understanding.

"I'm happy about having had so many liberal arts [classes], because when you're learning so many different types of subjects, you don't study English the same way you study computer science. You don't ever view art history and geology in similar manners. I found that these different approaches to learning, these different ways of tackling problems, helped develop my creative thinking and my resourcefulness."

— Senior software engineer, digital music company, KnowledgeWorks interview

Solve Problems

The collective problem solving of a company is what drives it forward into new markets with innovative products, services, and experiences. Problem solving – or finding plausible and meaningful solutions to a challenge – will comprise future work. Approaching problems as learning opportunities will help grow organizational and human capital. To thrive in this context, people will need to:

- Think analytically and critically to break down problems,
- Use analogies and provocations to inspire approaches, and
- Practice empathy to discern human needs and value.

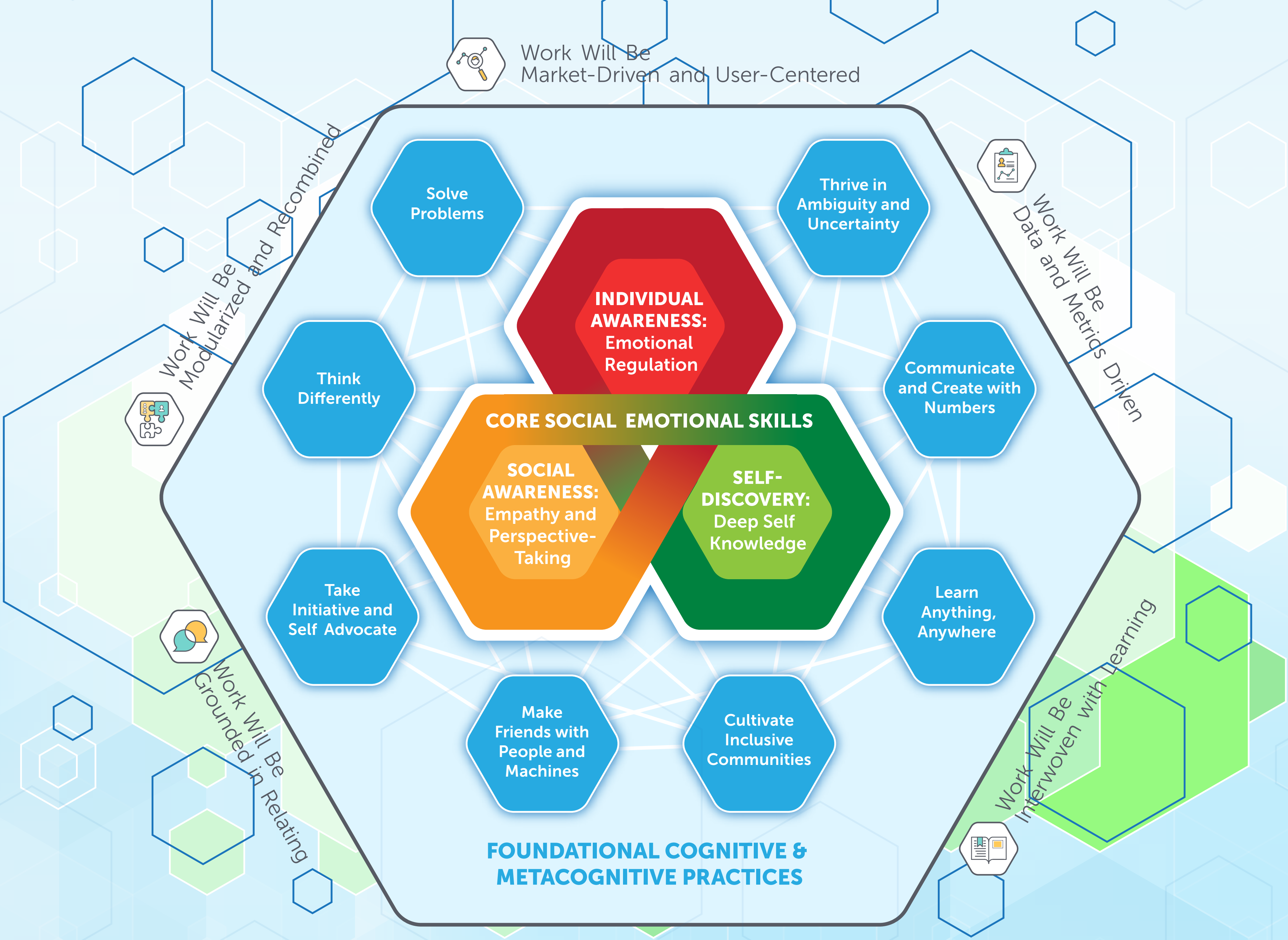
"There's still tons and tons and tons of stuff I don't know, but coming here, I approached it less of like, 'Oh, I don't know any of this,' and more of like, 'Okay, here's my challenge. What don't I know? What tools can I give myself in order to actually solve this problem?'"

— Senior software engineer, digital music company, KnowledgeWorks interview

Developing the Uniquely Human

This new foundation for readiness promises to equip young people to navigate the uncertain and rapidly changing future of work. It will provide a foundation for success regardless of exactly how the rise of smart machines and the decline of the full-time employee end up affecting work in 2040. As this framework demonstrates, redefining readiness at the K-12 and postsecondary levels will focus more on helping people develop uniquely human aptitudes and practice resilience than on training them for specific jobs or skills. Without a focus on the inner human core, rapid skill development will be very difficult. There will be a place for job-specific training, but how people will access it and how people will draw upon the foundation for readiness to achieve success could vary greatly depending on how two critical uncertainties related to the future of readiness play out.

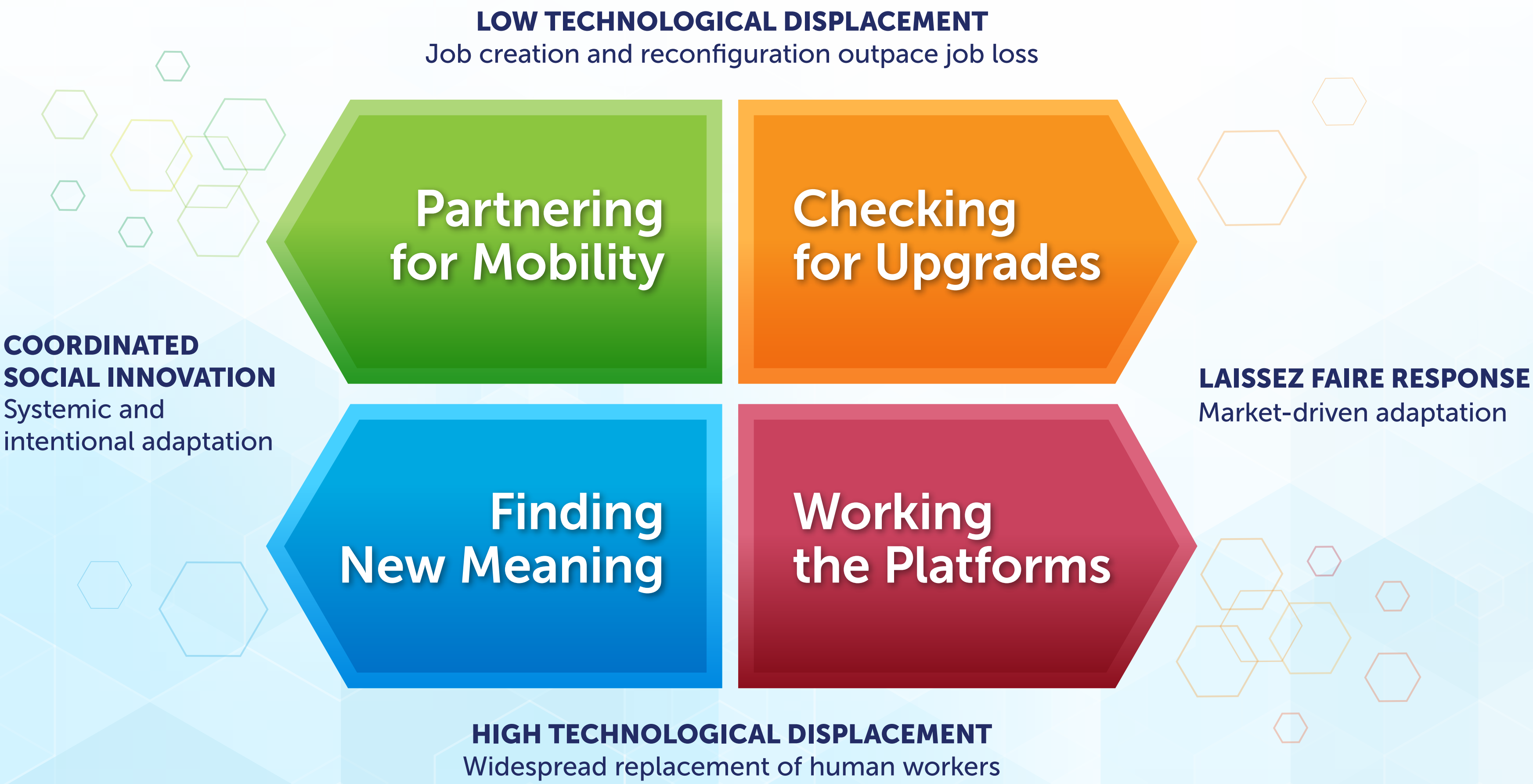
A New Foundation for Readiness



Four Scenarios for the Future of Readiness

Today we can identify the rise of smart machines and the decline of the full-time employee as key drivers of change reshaping work and can project future work characteristics based on current cutting-edge experience. However, we cannot yet know how those factors and people's responses to them will unfold to redefine readiness for 2040. As we consider possibilities, two critical uncertainties promise to shape the future of readiness and influence the contexts in which people might apply the new foundation for readiness to achieve success:

- Will there be high or low **technological displacement** of human workers?
- Will the **societal response** be systemic and intentional or market driven?



The first critical uncertainty explores the ways in which different levels of technological displacement might impact human workers. On one extreme is a high level of displacement, with the rate of displacement outpacing the rate of job creation. On the other extreme is low technological displacement, where many existing jobs are reconfigured and the creation of new jobs outpaces the rate at which other jobs are eliminated.

The second critical uncertainty focuses on the question of whether the societal response to the changing nature of work will be systemic and intentional or market driven. At one extreme, coordinated social innovation reflects intentional systemic adaptation, such as the New Deal programs created in response to extreme levels of unemployment during the Great Depression. On the other extreme, a laissez-faire approach reflects market-driven adaptation, as exemplified by private-sector employment training programs such as the Apple Store Leader program, which trains employees in the skills Apple sees as being vital to managing its stores.[37]

To explore how these critical uncertainties might shape what readiness looks like in the year 2040, this paper explores four scenarios at their intersection.

Each scenario explores what readiness could look like by 2040 when two extremes combine and how the new foundation for readiness might apply.

Each scenario includes the following:

- A short overview,
- Two profiles of fictional personas aged thirty-five and under that illustrate what it might take to develop readiness in the scenario,
- A list of defining features recaps distinctive elements of the scenario,
- Three signals of change highlighting current developments that support those defining features,
- A list of readiness factors in action illustrating which dimensions of a new foundation for readiness apply most directly to the scenario, and
- Strategic considerations for K-12 and postsecondary education.

In addition to exploring the intersection of the critical uncertainties, the scenarios include some details drawn from developments, such as automated performance management systems, that are nascent today but which could develop further by 2040. They also make some assumptions about how contextual factors, such as the role of unions, might support possible future developments.

Partnering for Mobility

Low Technological Displacement + Coordinated Social Innovation

While automation has eliminated some jobs and changed others, new occupations have emerged. Many people work full-time but for short stints, completing rapidly evolving project-based work that is coordinated by organizations. Partnerships across employers, communities, and state and federal agencies use predictive analytics to project workforce needs and to provide timely skill development through adaptive career pathways. This coordinated approach helps individuals develop mosaic careers and find their niche in a constantly changing labor market.

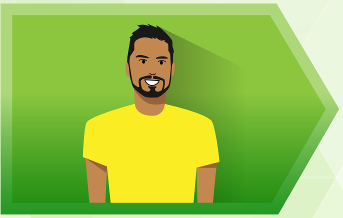
Overview

With many unsafe manual tasks and routine cognitive tasks having been eliminated by automation and with new human-machine partnerships, workers are supported in accessing occupations that provide high-value services and experiences. Jobs are designed to leverage artificial intelligence systems and robots so as to allow people to maximize their unique contributions. Career mobility depends on workers' ability to keep up with their machine partners and to continue to add distinctly human value.

Employers are still the major players organizing work. They hire, evaluate, and pay workers in relatively traditional ways, although they rely heavily on smart algorithms and data analytics to streamline work assignments and coordination. Most work assignments are project-based, lasting several months to a year, and most employees stay at an organization for one to three years. The combination of flexibly-staffed project teams and short employee tenure allows organizations to realign quickly to new market opportunities and bursts of demand.

Reskilling (developing new skills) and upskilling (building off or improving existing skills) are constant. Strategic partnerships between employers and regional lifelong learning offices use predictive modeling to anticipate workforce needs and to align training programs and credentials through adaptive career pathways. Workplace performance data and review mechanisms provide employees with a constant stream of feedback that helps them identify what skills they might need for career growth and recommends platforms for continued education. Because new skills are the currency for mobility in this employment landscape, employers that provide high-quality performance feedback and training are in demand. It is not uncommon for employees to negotiate richer education benefit packages while keeping salaries constant.

To support people in keeping pace with the need for constant reskilling and upskilling, public-private partnerships have invested in new learning and employment infrastructures, including free postsecondary education at many state colleges and universities and expanded micro-credentials and certificates that dynamically link learning pathways with careers. Success of such strategies depends on robust workforce data and nuanced analytics that help tailor flexible and adaptable learning pathways. To provide this information, the U.S. Bureau of Labor Statistics has rebooted to monitor and track workforce trends and emerging needs. In addition, most states have replaced their Departments of Economic Development with Departments of Lifelong Learning. These departments have become centers of education and social policy innovation. Innovations include assigning to every K-12 and postsecondary student a personal learning bot that leverages artificial intelligence and machine learning to provide smart support and feedback and managing education tax credit funds that support individuals in finding and rediscovering their niches in a constantly changing labor market.



FUTURE READINESS PROFILE

Darryl: 30, Senior Data Scientist

When he graduated from high school, Darryl enrolled in the career development program at his regional Lifelong Learning Center, which had facilitated a strong partnership among the state university campuses and regional employers, creating stackable micro-credentials to prepare workers for emerging high-demand fields. An analysis of his K-12 student record and after-school learning experiences and an in-person interview produced a set of employment scenarios and questions that helped Darryl filter job possibilities and explore training and development pathways. Having liked his STEM project work in high school, he focused on the data science career theme.

In focusing on that theme, Darryl pursued a university apprenticeship program that integrated study and work, allowing him to experience how data science jobs differed in various industries. He completed project work in transportation, warehousing, and order fulfillment, learning about industry-specific issues, experiencing diverse organizational cultures, and taking stock of opportunities for job mobility.

Now, Darryl is known for his strong management and inclusive team-building skills, something he learned from an outstanding mentor who remains a career confidante. These leadership skills have helped him land various project-lead positions at StreamMe, an innovative entertainment company, stretching his tenure to almost three years. Darryl currently oversees a team comprised of three data scientists and a group of data bots. He works across the sales, marketing, and product development departments deploying the bots to improve analytics and reveal new insights for strategic decision-making. Even though Darryl is working full-time, he checks in regularly with his counselor at the Lifelong Learning Center to review his work-life portfolio. They discuss what performance scores need improvement and how Darryl can best communicate his work experience to reflect his value.

FUTURE READINESS PROFILE

Sofia: 27, Social Resources Advocate

As the first in her family to graduate from high school and pursue higher education, Sofia wanted to put her skills to use helping disenfranchised communities. Having come from an immigrant family that worked mostly in domestic service, social justice was important to her. In her job at the County Social Resource Agency, Sofia responds to voice and video inquiries from low-income residents and helps direct them to specific social and emergency services, which may include medical care, mental health support, housing, legal advice, or education.

Most inquiries come from non-English speakers who are in crisis mode. As a social resources advocate, Sofia needs to listen actively to callers' stories and determine the best way to direct them to the services they need. Each call represents a unique human story. Voice and facial recognition software interprets and translates the calls, including callers' emotional state, and makes preliminary recommendations for services. Sofia adds value by detecting more nuances and by asking contextual questions that help her glean additional information about the callers' needs. Her job was almost fully automated by an artificial intelligence referral system, but controlled trials showed that a combination of social resource advocates plus artificial intelligence tools resulted in more successful service placements.

Sofia's lifelong learning account managed by the Department of Lifelong Learning supports her on-the-job technical training, building out her work-life portfolio and her qualifications for other service-related jobs in the county. Custom research bots provide her with policy and legal updates affecting her clients as well as with more immediate information such as reports of extreme weather that might increase requests for food and shelter. A deep-learning system maintained by the county allows her to create apps to improve services for client groups whom she regularly serves. Additionally, Sofia's work is tracked against performance metrics that she uses as feedback to help her maintain high-quality machine-assisted services. With these supports, she will be able to translate her demonstrated experience into other high-touch, care-based service roles.

PARTNERING FOR MOBILITY

DEFINING FEATURES

- **Partnerships** between people and machines outpace solo robot or solo human performance, creating a flourishing of smart assistants and machine-assisted occupations.
- Data-driven feedback for individual workers helps them choose skill-building opportunities as they develop portfolio-based **mosaic careers**.
- Detailed workforce analytics and modeling provide employers and credentialing institutions with a shared vision of workforce needs that supports the design of **adaptive career pathways**.
- Free higher education and an expanded system of **micro-credentials and certificates** drive skill acquisition and ongoing learning to improve job mobility.
- Public-private partnerships build a **lifelong learning and employment infrastructure**, supporting workers with skills and practices for mobility across projects and employers.

Signals of Change

- Companies such as Talent Analytics[38] are using predictive analytics to create job-pathway maps inside organizations based on employee talent and organizational needs and to create predictive job maps that support workforce planning.
- Partner4Work, the City of Pittsburgh's Workforce Development Board, has partnered with the Community College of Allegheny County to offer tuition-free, micro-credentialed vocational training,[39] with additional supports, for sixty students.
- Platforms such as MentorCloud[40] and MentorPitch[41] match top experts and mentors with mentees, helping mentees develop as professionals, gain valuable skills, and benefit from the guidance of people with more professional experience.

Readiness Factors in Action

In a world of new machine-assisted jobs and systemic social support, new opportunities emerge as workers leverage artificial intelligence and data streams to identify skill development opportunities and take advantage of both adaptive career pathways and a broad range of workforce-aligned credentials. Particularly relevant dimensions of the new foundation for readiness are listed below.

Social Awareness: Empathy and Perspective-Taking

Sofia's skills in social awareness allow her to identify and recognize her clients' emotions and ask them discerning questions that help her direct them to the services that they need, ultimately improving both her performance and her clients' experience.

Create and Communicate with Numbers

Darryl's job is rooted in making sense of data and communicating new insights via analytics. Sofia also is skilled at interpreting feedback data to improve her own performance.

Cultivate Inclusive Climates
Darryl's strong reputation depends in large part on his ability to build inclusive teams and help his collaborators shine, thus improving overall team performance.

Make Friends with People and Machines
Sofia's success reflects her ability to grow in collaboration with her smart machine partners. She uses her access to lifelong learning to find ways of making her automated partners help her do her job better, thus ensuring that she remains a valuable contributor.

Strategic Considerations

- Educators will need to model positive behaviors that help students learn how to develop positive, healthy relationships across diverse contexts.
- K-12 schools and postsecondary institutions will need to help students develop human-machine partnerships in ways that augment and leverage their uniquely human capabilities.

Checking for Upgrades

Low Technological Displacement
+
Laissez Faire Response

As they move from project to project, professional nomads seek constantly to improve their performance by upgrading their skills, digital tools, and social capital. With their digital assistants, they shoulder responsibility for building their own capacity, cultivating professional mentoring networks, and seeking out collaborative project teams. Individuals must chart their own paths through a highly fluid landscape of independent, contingent employment.

Overview

In this fluid employment landscape, contingent work is closely tied to the emerging needs of organizations that are reconfiguring work processes as they leverage artificial intelligence systems and smart devices. Professional nomads follow short-term project contracts and worker-friendly labor markets. Many workers juggle multiple contracts to hedge against having no work. Employers focus on doing more with less, creating highly effective human-machine partnerships that leverage smart systems and retain a small number of full-time employees. Extensive use of contingent project workers allows organizations to expand and contract as market needs vary. Full-time positions, for those who can find them, average one to three years and leverage specialized knowledge and expertise.

Most occupations are heavily integrated with artificial intelligence systems that combine specialized human expertise with insights from data mining and decision-making algorithms. Keeping current with digital tools and software applications is necessary to continue to be effective in these integrated environments. Individuals must constantly upgrade their technical and domain expertise to find the next project.

With little on-the-job training and no coordination among post-secondary institutions and employers or other systemic supports, individuals must find their own way. Professional and social lives overlap as workers are "always on." Every social interaction could be the source of a new gig, a new mentor, or a new insight into a key technology or market shift. Building trusted social capital, a solid reputation, and strong support networks is necessary to ensure consistent contracts and access to organizational decision-makers.

In addition, individual workers must seek out learning and reskilling opportunities, whether on the job or during off-peak employment periods. Successful workers consider learning a necessity for which they take responsibility. However, low-skill workers often scramble to access the resources, relationships, and ongoing learning necessary to keep up with the rapid pace of change. Many communities have demonstrated against the new human-machine workforce configuration, creating a backlash against automation, including boycotts of employers who do not hire mainly human.

Some socially conscious employers and wealthy benefactors seek to improve local and regional employment participation rates and worker mobility by partnering with innovative mayors and governors to create data-driven postsecondary education and reskilling programs. Other stakeholders cling to old paradigms or insist that the market will prevail. The U.S. Bureau of Labor Statistics attempts to regulate automation by advocating for tax abatements for organizations that hire mainly human. Divides exist among organizations looking for new efficiencies through automation, organizations that insist on hiring human to reflect their values or reach niche markets, and organizations that lack the resources to invest in the latest automation infrastructure.

FUTURE READINESS PROFILE

Damian: 25, Residential Health Aide

Damian completed his associate degree in physical therapy at a community college but soon realized that he needed more technical knowledge to be able to work in state-of-the-art health residences. He attended a work-and-learn program to supplement his degree with a credential as a machine-assisted health aide. There he learned how to partner with care-bots in different settings to health monitoring, therapy, and social engagement support.

Damian's current job is a six-month stint at Loyola House, a senior citizen residence. Loyola House is a smart-health residence embedded with sensors, health monitors, and other input devices that capture data about its residents. Damian partners with Gini, his mobile care-bot, to mine various data streams, such as diet, sleep, mobility and social interaction, for a daily snapshot of his patients. Each day, Gini helps Damian stay on top of each resident's activities, medications, and issues. Gini is also able to perform support functions such as bringing medications to Damian, checking to make sure that residents who have not left their rooms for some time are doing well, and capturing video to show Damian how residents are interacting so that he can quickly take stock of social groups and dynamics. Gini enables Damian to perform as much work as two or three health aides used to do. Plus, the data-rich reports that Gini provides supports Damian in having rich discussions about the residents with the residence's lead nurses and medical director.

Despite being a great fit at Loyola House, Damian will leave after a group of residents moves to a more intensive medical health facility. Because he knows he always has to be looking for the next gig, Damian keeps in touch with his social network from his work-and-learn program and regularly visits with two of his favorite instructors about new ways to apply his skills. He carefully curates his career portfolio, including links to his community college coursework and work-study credential, along with video clips from professors and work supervisors discussing his strengths – one of which is that he is "highly adaptable."

FUTURE READINESS PROFILE

Roxanne: 31, Cybersecurity Project Manager

Roxanne spent four years in the military as a network specialist stationed abroad before she returned home and continued her education through her veteran's benefits. Now, companies hire her on a project basis to break down their firewalls and then redesign them for better security. Roxanne likes the independence of being able to move from project to project, getting to know different industries and organizational concerns and sometimes new cities.

Through her string of projects, she has collected a rich set of references and professional colleagues, both internal IT professionals and the non-techies whom she considers friends. They often refer to her as the go-to expert for shoring up corporate networks. In turn, Roxanne often reconnects with some of her military buddies and subcontracts with them to prevent attacks on her systems so that she can keep her skills current and learn how to build more secure systems. Her reputation is one of a positive, no-nonsense professional who is disciplined, thorough, and up-to-date with current attacks and fixes.

Even though Roxanne's portfolio is full of praise, successful results, and diverse experiences in the civilian and military fields, she keeps seeking out ways to expand her knowledge. She thinks of herself as a craftswoman because each project that she takes on has a unique solution and strategy. As such, new approaches require not only cutting-edge technical knowledge but also a broad, creative approach to problem solving that may draw upon history, philosophy, or even music. During downtime, Roxanne enrolls regularly in intensive online courses, earning supplemental certificates and targeted credentials in areas that she hopes will open new opportunities. She also pursues self-study projects with her peers. Roxanne points to her military training as the foundation for such discipline, resourcefulness, and focus on outcomes.

CHECKING FOR UPDATES
DEFINING FEATURES

- Extensive human-machine partnerships help employers do more with less, expanding the impact of fewer full-time employees and pushing many people into **independent, contingent work**.
- **Individuals must take responsibility** for staying relevant to organizations' needs and for maintaining their ability to partner with rapidly changing smart devices and artificial intelligence assistants.
- **"Always-on" workers** blur the lines between work, play, and social life as every moment has the potential to contribute to building necessary professional social capital and experiences.
- **Response to the new automation infrastructure varies**, as some people protest to keep jobs human and others partner to create local innovations in support of worker mobility.

Signals of Change

- Organizations such as Skillshare[42] and programs such as Udacity's nanodegrees[43] offer highly specialized classes designed to help people upskill or reskill rapidly and at minimal cost.
- BMW's apprenticeship program,[44] a partnership between the automaker and Greenville technical college, is designed to produce highly skilled workers who meet BMW's needs. The program was created because of the difficulty that BMW had in finding qualified candidates for its South Carolina plant.
- Though farmers have long been partnering with technology, recently some have been utilizing drones[45] to map fields and robots[46] to help weed crops. Partnering with these machines has made these farmers' work more efficient and has increased the impact of human labor while reducing the number of people involved.

Readiness Factors in Action

In a world of contingent work and little social support, building skills for career mobility is a key goal. Contingent work is closely tied to the emerging needs of organizations that are reconfiguring work processes as they leverage artificial intelligence systems and smart devices. Successful workers keep current with how these rapidly changing human-machine partnerships affect project-based work. Particularly relevant dimensions of the new foundation for readiness are listed below.

Individual Awareness: Emotion Regulation, Take Initiative and Self-Advocate

Both Damian and Roxanne must promote themselves and advocate for each job, proving their value and skills. Despite being a good fit at Loyola House, Damian acknowledges the reality of having only a six-month contract and focuses on taking positive steps toward getting the next one. He does not let his emotions sabotage his career mobility.

Thrive in Ambiguity and Uncertainty, Think Differently, and Solve Problems

Roxanne's projects can be ill-defined and vague, yet they are high stakes for the client. Her clients expect her to "figure it out" and "make it work" with little direction. She relies on her creative approaches to problems, analogous thinking, and her diverse disciplinary background.

Learn Anything, Anywhere

Both Damian and Roxanne direct their own learning and career development. They create ecosystems of support, resources, learning experiences, and relevant credentials so that they can continue to attract and secure project work.

Strategic Considerations

- Schools will need to foster mastery in flexible contexts that help prepare students for an employment landscape that requires ongoing learning in uncertain environments.
- Educators will need to learn about artificial intelligence and intelligence augmentation and will need to develop and model new teaching and learning mindsets that work with smart machine partners.

Finding New Meaning

High Technological Displacement + Coordinated Social Innovation

Artificial intelligence and automation have streamlined global production to such an extent that dividends from extreme efficiencies now fund a new social infrastructure. Paid work has become just one of several options for earning a living and contributing to society. Social policy and political will enable new social support structures and platforms for exchange that leverage human potential and ingenuity and fuel a human-centered economy.

Overview

Though many jobs have been eliminated, social systems and supports have helped create a new human-centered economy that derives value from human emotions, affective qualities, and creative capabilities. Universal basic income programs, automation efficiency taxes, and other mechanisms for funding social supports and redistributing resources differ by state yet share the goals of buffering people against changing family and economic conditions, liberating human potential, and creating productive opportunities to carry out meaningful work with social purpose.

In this new climate, highly compensated work has shifted to fields that leverage human emotions and uniquely human capacities and practices such as relationship cultivation, decision-making, artistic thinking, creative production, and novelty generation. Touch- and relationship-intensive caring roles such as nurses, educators, child- and elder-care providers, and companions have expanded and diversified, combining artificial intelligent expert systems with human expertise.

As cheap, mass-produced products have flooded the market, artisanal one-of-a-kind production has also grown in value. Artisans and craft producers add value by developing close relationships with their customers.

Furthermore, the arts have been reinvigorated as key sources of innovation and strategic thinking. People see art productions as important shared community experiences and see artistic thinking as unlocking shared understanding in the business world by helping stakeholders reframe problems creatively, find relationships among unrelated events and ideas, develop different perspectives on issues, and use imagination to spark insights and generate novel ideas.

In addition, new civic funds stimulate a range of community infrastructure projects, local social enterprise ventures, and care-based or cultural production collectives. Most people participate regularly in such ventures, either as a way of gaining new perspective on future opportunities between work engagements or as a way of adding value on top of their basic income. Participation in these efforts is compensated with various forms of credits and vouchers for goods and services. The U.S. Bureau of Labor Statistics has transformed its focus to coordinate and track these efforts, measuring both participation and social impact contribution.

As preparation for traditional careers has become less important, education has been forced to reevaluate its purpose. A focus on personal growth has led to credentials that certify proficiency in social-emotional and metacognitive skills, as well as higher-order cognitive practices. Some people have found it difficult to transition to an economic model based on personal goal-setting and intrinsic definitions of success. A cultural divide exists between traditionalists who believe that paid work is the only valid form of compensation and contribution to the economy and those who measure value and impact in broader terms.

FUTURE READINESS PROFILE

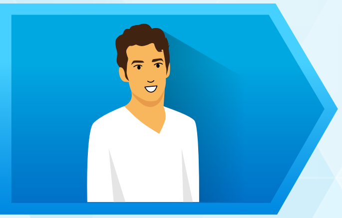
Amanda: 29, Smart-Clothing Entrepreneur

Amanda initially started WellWear as a side project in high school. WellWear's mission is simple: to make clothing that helps people be well. Amanda developed her first WellWear piece while she was interning at the Northside DIY Make Lab. It was a long-sleeve T-shirt in various colors that provided tiny pulses to remind people to breathe when their heart rates escalated. At the Make Lab, Amanda got to try out various ways to experiment with sensors and learn how to make clothes that help people feel better. After rave reviews and consistent sellouts at community craft markets and on her online store, she decided that designing sensor-enabled clothing was her calling.

Amanda used money from her monthly universal basic income dividend to enroll in a series of hybrid courses in entrepreneurship and business management. In addition to offering lectures, online discussions, and homework, the courses provided weekly in-person support for developing individual projects. A successful crowdfunding campaign helped Amanda purchase some basic cutting and sewing equipment, and soon she had her own small craft shop.

In keeping with her company's mission, Amanda checks in regularly on SoGood, the social impact project hub that matches volunteers with projects. Participating in several collaborative projects funded by the civic participation fund introduced her to other compassionate creatives in her area. For low-income children, she helped make coats that converted into sleep sacks for napping in comfort; for elderly people, she contributed to the design of sweaters whose weave tightens or loosens depending on body and external temperature. Amanda loves these projects, as she feels that they let her make a meaningful contribution to her community and she gets to meet and co-create with wonderful people.

Amanda doesn't have a degree, but she has a long list of completed credits, certifications, and work experiences that she has accumulated over the years. She sees her life, work, and education as one exploration and application of her purpose.



FUTURE READINESS PROFILE

Humberto: 34, Corporate Artist in Residence

Humberto had been a strong math student at his STEM early college high school, but when he enrolled in college he decided to major in art, his true passion. Part of what compelled Humberto in math was its beauty and elegance. He kept a minor in data science to exercise that form of thinking but went on to get a Masters in Fine Arts. Upon graduating, he participated in a series of community art installations sponsored by the Civic Arts Initiative, an automation dividend program in his city. Because the installations were intended to help communicate several environmental-, health-, and energy-related public policy issues at the community level, Humberto was part of a diverse team of public health, climate, energy, and transportation professionals and artists.

While focusing on art, Humberto continued to keep up with data science through various learning opportunities. Some were in-person seminars hosted by local tech companies and universities, and others were virtual courses that lasted several weeks to a year. Some of these learning opportunities contributed to additional certifications in specific subject matter and skills; others were purely for personal growth. All of them became a part of Humberto's interactive portfolio showing his development as an artist-scientist and eclectic thinker.

At his current position as Corporate Artist in Residence, Humberto works on special projects that involve diverse team members with creative problem solving skills and flexible thinking frameworks. His team contributes at critical moments in projects, aiming to visualize possibilities and provoke new thinking to reveal alternative strategies, novel design concepts, or new insights into problems. One of Humberto's side projects is a game that helps kids identify their passions and cultivate provocative thinking and problem solving in daily life.

FINDING NEW MEANING
DEFINING FEATURES

- Robust social infrastructure and policies support a new **human-centered economy**, driving growth in the caring professions, the arts, and civic projects.
- Many jobs and other productive occupations leverage artificial intelligence to support **uniquely human capacities** such as intuition, emotion, artistic thinking, and persuasion.
- While the specific mechanisms for **funding social supports and redistributing resources** vary by state, there is shared understanding that people need a steady foundation on which to build meaningful contributions.
- Career planning has become **life planning**, with education shifting its focus toward **personal growth** over access to the labor market.

Signals of Change

- In an effort to help address the social cost and inequalities created by technological displacement, Bill Gates, co-founder of Microsoft, recently proposed a tax on the robots[52] that are replacing human workers.
- Experiments in universal basic income[53] are taking place all over the globe. For example, Y Combinator plans to pay 100 families in Oakland, California, $1,000-$2,000 per month; and Utrecht, the Netherlands, plans to give 250 Dutch citizens the equivalent of $1,100 per month.
- Stanford University's wildly popular course, Designing Your Life,[54] employs design thinking to help students think beyond career preparation to navigating broader decisions about life after graduation.

Readiness Factors in Action

A world with widespread automation and coordinated social innovation requires individuals to develop deep self-awareness and to engage in ongoing self-development so that they can effectively steer their own passion-based careers. Employment opportunities emerge from continuous discovery and refinement of individual passion and purpose and from developing the skills to link that passion and purpose to a job, project, venture, or creative pursuit. Particularly relevant dimensions of the new foundation for readiness are listed below.

Self-Discovery: Deep Self-Knowledge

Amanda and Humberto follow their own passions to find work that is both meaningful to them and productive for society. The mission of Amanda's clothing company reflects her personal values and purpose, making her social-impact clothing projects as important as her commercial sales.

Solve Problems, Cultivate Inclusive Communities

Amanda's side projects through the civic participation fund require solving problems and using collaboration and imagination as she weaves her expertise into the group. Humberto's work also requires working effectively with diverse teams to illuminate new perspectives on projects.

Think Differently

Amanda's and Humberto's work lives reflect their ability to think differently and to take risks in exploring new ideas and concepts. Since Humberto is paid for his ability to develop and apply creative thinking frameworks to problems, thinking differently is his most marketable skill.

Strategic Considerations

- Educational pathways will need to help learners develop self-awareness that can serve as a compass for lifelong learning journeys.
- K-12 schools and postsecondary institutions will need to prepare learners for a world where paid work may no longer be the primary organizing principle.

Working the Platforms

High Technological Displacement + Laissez Faire Response

In this highly competitive and heavily automated scenario, most workers carry out extremely fragmented tasks managed through dispatching platforms instead of through traditional employers. Reputation management is key to finding successful matches. Quantified workers develop emotional resilience by devising their own strategies for maintaining a positive outlook. They also develop competitive strategies for navigating employment platforms and persisting to piece together enough work.

Overview

With a focus on economic productivity through intensive automation, extreme taskification is the norm for all but the most highly-skilled people. Most workers interface directly with dispatching platforms, rather than with employers, to find discrete pieces of short-term work. Most employment is precarious and transactional. Low-skilled workers compete locally for personal service, physical labor, and administrative tasks, while middle-skilled workers compete globally for professional and knowledge work. High-skilled workers often play roles such as decision makers and strategists, using artificial intelligence, augmentation technologies, and creativity to help direct organizations and platforms and to secure scarce full-time employment.

With a proliferation of sensor networks and advances in data collection and processing, quantified workers' performance is highly monitored, aggregated, and assessed. People are as good as their most recent performance and reputation scores. Even full-time employees within a single organization tend to move from task to task as algorithmic management tools assign work and coordinate output.

Some dispatching platforms serve as reliable hubs of professional development and support, while others effectively function as digital piece-work factories. A few unions have developed platforms to protect workers from abuse. They offer members opportunities to improve skills, build reputations, and move toward relatively satisfying work. People with effective entrepreneurial skills and network-building social capital can use platforms and smart devices to create small businesses or to provide skilled production and experiential services, particularly in the trades, artisanal specialties, and the care economy.

In this very granular and competitive landscape, post-secondary degrees are typically seen as luxuries that are slow to translate into high performance scores that drive income. In place of traditional degrees and certificates, most people assemble dynamic work life-logs that capture evidence of competency through easily comparable quantifiable performance metrics. Those with resources to earn post-secondary degrees often thrive when they can leverage those degrees to work in decision-making and strategic positions or in highly specialized fields, but sometimes even they have to work the platforms long enough to build the reputation needed to transition into organizationally-based work. In contrast, workers who lack marketable skills usually find it hard to move beyond the grind and low wages of transactional piece work, especially given the lack of social safety nets and readily accessible training.

In the absence of a coordinated response to intensive automation, communities have become polarized economically. Chronic unemployment and under-employment are common. A shrinking tax base has strained public infrastructure and services in many places. Some communities have adapted as alternate economies, such as the maker, sharing, collaborative, and open source economies, have emerged or as local benefactors have supported pockets of innovation. Despite the challenges of working in a highly platform-based landscape, some people value the flexibility and self-determination that now characterizes most work.

FUTURE READINESS PROFILE

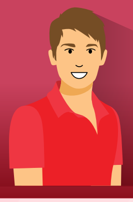
Marika: 29, Super-Tasking Virtual Reality Designer

Marika is a Super Tasker, managing her own virtual reality design practice on UpWork and other reputable matching platforms. Her work includes both international clients with whom she interacts digitally and local clients with whom she can meet to discuss task specifications. Mostly, Marika simply does her bit and passes on the work for integration into a larger project. For now, she likes it that way. Working the platforms allows her to go on work binges and then take time off when she feels the need for a break. Not that she has much choice – not many designers can snag full-time work these days, even with extensive portfolios.

During Marika's first year or two working the platforms, she lost several bids to others with more experience or with distinguishing features to their work portfolios. Then she met some members of the local Digital Arts Guild at a social networking event and got some crucial tips that helped her excel at platform-based work. By learning to use software-coding bots to code basic features in a 3D scape, she developed a specialty in designing the emotionally engaging interactions and nuanced experiences that hook users. The emotional intensity, flow, and aesthetic of her work make her a highly valued, in-demand virtual reality designer.

Marika also improved her management of platform-based work by registering at an open virtual academy to learn basic business skills, including account management, financial planning, client relations and negotiations, and project management. In addition to keeping her organized, these skills helped her develop the confidence not to underbid in a competitive market. She learned to manage her personal brand by completing an online tutorial in data analytic tools that determine her hit rate for various types of portfolio content and her success rate in winning bids. Included in the analytics are her client feedback scores, which rate her high in the affective skills that help her stay calm under pressure, meet deadlines, and focus through ambiguity.

Now that Marika's scores have increased and her brand has become more widely known, she is often asked to share her skills by teaching small classes and seminars for those looking to cultivate similar skill sets. To compensate for having little social interaction at work, she also mentors at a virtual reality community lab and teaches virtual reality at a summer camp for kids.



FUTURE READINESS PROFILE

Dennie: 29, Smart Building Repair Person

Dennie remembers seeing the dispatch request notifications appear whenever he would sneak a few moments to turn his smart lenses on while sitting in class during high school. He was always looking for opportunities to make extra money via platforms such as Task Rabbit and Thumbtack: errands, yard work, delivery, cleaning out attics, house painting. He knew that such work was a dead end, but it provided him with the extra money he needed to contribute to his family's finances.

Also during high school, Dennie started helping his uncle, who was a plumber. Dennie learned the basics of the craft and admired how his uncle systematically approached problems. While many of his peers took on internships and unpaid tasks to build their reputations, Dennie found the work he did with his uncle fascinating enough to enroll in the community college's smart building technology certification program, a move that many thought was a gamble given how long the program took and the speed at which the employment market moved. Students learned about the automated processes that control and operate the maintenance systems in intelligent buildings, including heating, ventilation, air conditioning, lighting, security, and other systems. Increasingly, these automated systems became sensor-based and integrated with artificial intelligence and dispatch functions. However, despite advances in smart-building technology, students still had room to solve problems when the software failed or sensors only showed a part of the problem.

Dennie liked the mix of old-fashioned trade and cutting-edge technology, using artificial intelligence as a partner. He joined the smart building services union and gained access to a dispatching platform that managed residential buildings in the heart of the city. After his apprenticeship with the union, he became active on the platform, going out on his own repair gigs. As a newbie on the platform, his performance rating was low, but his uncle and some of his plumber friends added references that bumped his score into the competitive "reliable service" range. One gig followed another, and soon Dennie was regularly busy, responding to repair calls, logging into the platform to record his completed tasks, and monitoring his client satisfaction ratings.

As required by the union, Dennie must update and renew his certificate regularly to stay current in building systems technologies. Luckily, the union offers courses through the community college. On his own dime, Dennie also enrolled in business management and financial planning classes to help him manage his money. Dennie's dream is to leverage the dispatching platforms to develop his own small business with a team of professionals to tackle bigger jobs with more continuity.

WORKING THE PLATFORMS

DEFINING FEATURES

- **Extreme taskification**, or the disaggregation of full-time jobs into discrete tasks, characterizes work for most people, with a small group of super-skilled, specialized workers retaining full-time, consistent employment in hard-to-code positions.
- Most people are **dispatched** through matching platforms that seek to connect the right person with the right task efficiently and at low cost.
- **Quantified workers** are heavily monitored and evaluated through data capture and analytics, driving reliance on scoring mechanisms to inform automated matching.
- Traditional certificates and degrees have been replaced by **work-life logs** that record quantifiable performance metrics showing proof of work and experience.

Signals of Change

- BetterWorks,[47] a Silicon Valley startup, has created a platform for "quantified work" that gives employees the ability to see what others are doing through real-time performance measurements and collaborative goal setting.
- Dynamo[48] gives a glimpse of what a union might look like in a gig or taskified economy. Designed for workers employed through Amazon's Mechanical Turk[49] platform, the site allows workers to discuss workplace issues, write petitions, and advocate for change.
- Sony's Lifelog App[50] helps people collect massive amounts of data, from their sleep patterns to how many calories were in a piece of pizza[51] they ate last year. The app is intended to help users remember everything, instantly, by logging all the data they possibly can.

Readiness Factors in Action

A heavily quantified, platform-based employment landscape with little social support places significant responsibility on individuals to demonstrate value and manage effective contribution across multiple platforms over time. This landscape is tough on the psyche, demanding emotional resilience and high levels of initiative to conquer the platform. Particularly relevant dimensions of the new foundation for readiness are listed below.

Individual Awareness: Emotional Regulation, Thrive in Ambiguity and Uncertainty

Platform work is highly uncertain, with algorithms, not people, matching job seekers to tasks. Marika and Dennie learn to redirect negative emotions that may arise and to focus on positive emotions that help them be productive and perform well.

Communicate and Create with Numbers

Both Marika and Dennie find ways to translate their performance and experience into data that can be processed by matching and dispatching algorithms. Without the opportunity to interact directly with recruiters, they need to understand platform algorithms and analytics so that their profiles attract matches.

Take Initiative and Self-Advocate

Both Marika and Dennie understand that they need to be the drivers of their own careers. They self-advocate, seeking out new learning opportunities that will help them succeed in platform-based work.

Strategic Considerations

- Education institutions will need to align traditional diplomas and degrees with the nonlinear and fluid nature of platform-based work.
- Learning communities will need to play an active role in helping students cultivate their personal brands, looking beyond traditional academic attainment and extracurricular involvement to reputation management.

Looking across the Readiness Scenarios

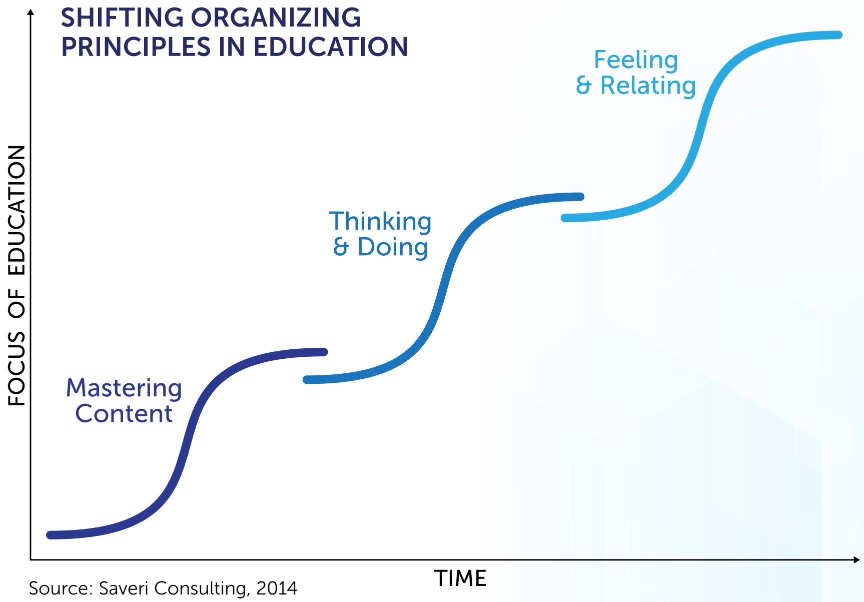
The four scenarios for the future of readiness explore critical uncertainties about the extent to which smart machines will reconfigure or replace human work and the degree to which the societal response will be systemic and intentional or market driven. In depicting future possibilities, these scenarios can guide consideration of how the new foundation for readiness might apply in different employment landscapes and in preparing for change today. Readiness in 2040 will likely reflect elements of all four scenarios, along with other developments that we have not explored, foreseen, or imagined.

While each scenario highlights some of the future readiness factors more than others, we see the new foundation for readiness as being relevant to all of them. Indeed, choosing different details for the profiles could have brought different factors to the foreground. For example, “think differently” and “solve problems” are highlighted in the Finding New Meaning scenario but could also be a way out of super-tasking in Working the Platform.

In order to help students prepare for the employment landscape that they will be navigating in 2040, education stakeholders need to consider how the new foundation for readiness, and the specific ways in which it could affect success in different readiness scenarios, might affect K-12 and postsecondary education. Education stakeholders should also consider how they might activate the new foundation for readiness no matter how the future of readiness plays out.

Redefining Readiness: Opportunities for Education

As highlighted in the introduction to this paper, education systems have historically followed economic eras. To prepare for a future in which smart machines will be able to perform increasingly complex, non-routine work and full-time employment will be decreasingly common, today's education systems must change their central operating principles. They must continue to shift from a limiting focus on mastering content and must also move beyond the more recent focus on thinking and doing to establish a new focus on feeling and relating.



Source: Saveri Consulting, 2014

Leveraging the emotion system to interface with the world and to connect deeply with other people represents the uniquely human capacity that people bring to work. This capacity will ensure that we will continue to add distinctive value alongside smart machine partners. Establishing a new focus on feeling and relating will help education institutions and systems align with a future of readiness in which the core social-emotional skills and foundational cognitive and metacognitive practices that we have described in this paper will be more important and enduring than specific content or job- and task-related skills. While there will still be a place for both mastering content and thinking and doing, making feeling and relating central to learning will enable students to develop the skills and practices necessary to meet the emerging realities of work with adaptability and resilience.

This is the lens through which education stakeholders must imagine ways of incorporating the new foundation for readiness into schools and other learning communities. More specific opportunities for K-12 and postsecondary education are highlighted on the following page.

Opportunities for K-12 Education

Because they help shape the foundational behaviors and practices affecting how young people approach learning and their lives, K-12 educators have the opportunity to cultivate a new approach to readiness in deep and far-reaching ways. Some guiding principles for responding to this opportunity and incorporating the new foundation for readiness appear below.

Teach and integrate skills-based social-emotional curricula. The foundational cognitive and metacognitive practices that will enable success in the emerging workplace leverage core social-emotional intelligence skills: deep self-knowledge, emotional regulation, and empathy and perspective-taking. These skills are the building blocks for developing successful relationships with peers, collaborators, mentors, and clients. They also provide the foundation for practices that will help workers thrive in ambiguous and uncertain settings, develop adaptive behaviors for self-advocacy and problem solving, navigate challenging circumstances, and engage in personal reflection.

Just as educators scaffold numeracy and literacy across grades, they can guide the development of emotion-based skills and practices over time. Both individual development and the emotional climates in classrooms and schools can be assessed to track progress and to inform teaching strategies, as well as school programs and policies. Teachers and administrators can foster students' readiness for further learning, career, and life by treating social-emotional intelligence as a foundational curriculum that is developed in scope and sequence across the K-12 experience.[55] In addition, more states can incorporate social-emotional intelligence into educational standards.

Nurture aspirational visions. The K-12 years should strongly support self-discovery and experiences that inspire learning. Students should have the freedom to follow the natural ebb and flow of encountering their passions, exploring them deeply and then moving on to other interests that may spark new motivations and inspiration. Overscheduling squelches the organic process of self-discovery that propels a learner forward.

In contrast, exposure to big ideas, awe-inspiring questions, and new experiences has the power to draw in students and to help them find purpose, engage in collaboration, and make connections to the broader world around them. Indeed, research from the Greater Good Science Center suggests that experiencing awe helps bind people to the social collective and drives curiosity and wonder.[56]

Developing aspirational visions — future images of themselves in the broader world — can provide students with a useful filter to guide their learning journeys, giving meaning to academic content and skill development and providing intrinsic motivation to persist in the face of setbacks and failures. Asking students what issues they would like to address instead of what career they want to pursue can be one way of helping students set enduring long-term aspirations. Whatever the approach, continual development of both aspirational goals and visions of possible future selves will help students engage in self-directed learning during the K-12 years and beyond.

Bring ambiguity and uncertainty into the classroom. Future work environments will not have a syllabus and worksheets with example problems showing people what to do. Work tasks will likely be vague, emergent, and approachable through multiple solution pathways. To prepare for such conditions, students need to experience uncertainty, ambiguity, risk, and failure in ways that strengthen their ability to ask questions, make reasoned approaches, and seek help. Students also need to balance self-confidence and humility and become skilled at emotion regulation so that they can navigate the ups and downs of an uncertain work environment.

The more prescriptive learning activities are, the less likely they will contribute to students' ability to navigate ambiguity and uncertainty at work, in further learning, and in their lives. In contrast, looking for ways to bring passion-driven, open-ended projects; peer-based collaboration; and play-centered experimentation and creation into learning environments will help foster productive approaches to ambiguity and uncertainty.[57]

Encourage and support cognitive diversity and flexible thinking. Most future work will include significant amounts of informed decision-making and creative problem-solving using data and inputs generated by machine partners along with insights from human co-workers. Developing such skills requires safe, open, and comfortable learning environments where students can dig deep into their own experiences, learning, and perspectives to share ideas freely. This kind of sharing is a hallmark of creativity and innovation. In addition, recognizing and appreciating diverse disciplinary and cognitive perspectives, including the arts and creative practices, will be a core aspect of successful collaboration at work. Developing students' metacognitive abilities to reflect on thinking and to acknowledge diverse frameworks and their outcomes will also contribute to success. To encourage creative thought and personal growth, learning environments need to be psychologically and socially safe, stress-free, and physically supportive. In addition, students need to develop comfort in using thinking frameworks from diverse disciplines to stimulate ideas and identify novel approaches to problems.[58] Allowing all students down time and flexible schedules to "mess around," daydream, and explore ideas is critical for helping them develop cognitive flexibility.[59]

Use technology to augment human capabilities. Creating new knowledge and developing novel insights will be important human contributions to future workplaces. People will also be working alongside a variety of digital tools and machine partners that will augment our contributions in ways that can be hard to imagine today. To help prepare learners for future human-machine partnerships, educational technology needs to be designed, integrated, and applied in classroom activities in ways that support and augment human strengths. Students need to develop positive machine relationships that show an understanding of collaboration and the ability to make technology tools their partners.

When designing curricula and learning activities, educators can use technology to stretch the boundaries of thinking and to push higher-order analysis, synthesis, and creative and generative thinking. They can use technology to help students ask deeper questions; identify analogies for idea generation; and engage in lateral thinking and idea generation to imagine new concepts, ideas, and narratives. Technology should serve not as an endpoint but as means to facilitating deeper thinking.

Renegotiate definitions and markers of success. Traditional notions of school success are rooted in an achievement model that includes demonstrations of mastery of discrete bundles of skills and knowledge. Achieving an externally predetermined level of performance is the goal. In the future workplace, mastery will be elusive. As technologies continue to evolve to do more and different kinds of cognitive work, human jobs will require new kinds of context-dependent skills and knowledge. People will need to adapt quickly and to advocate for themselves in the pursuit of skill development. Future definitions of educational success and understandings of career possibilities will need to correspond with this new employment climate.

To help renegotiate definitions and markers of success, educators can consider shifting achievement metrics and assessments from a learning model that focuses on acquiring a defined set of knowledge and skills toward a learning model that addresses dynamic, emergent, and continuous learning along with social-emotional development. They can develop more comprehensive, yet individually supportive, ways for students and teachers to understand progress in these areas. They can also identify more complete ways for schools and school districts to describe their performance. In addition, students and educators would benefit from shifting their expectations around career outcomes to reflect the need for continual reskilling and to consider the possibility that some knowledge-based jobs may be more susceptible to automation than some jobs involving more manual tasks.

Prioritize the development of a reflective learning practice. People will excel in the future workplace when they can apply human creativity, aesthetics, and emotion in novel ways, often leveraging digital tools. Social and economic mobility will come from applying new digital tools and software to create opportunities for career and life pathways. Constant reflection on passion, purpose, aspirations, and goals will help people direct their learning and self-development. In this context, it is important for K-12 students to see reflective learning modeled by educators and other adults in their lives. Likewise, exposure to educators and other adults who employ and model growth-mindset strategies will be critical for illustrating patterns of reflection, self-assessment, emotion regulation, persistence, and work-around strategies in face of obstacles.

To help K-12 students develop a reflective learning practice, educators can find ways to get students actively engaged in their learning journeys, including both successes and failures. For example, educators can support students in setting and monitoring progress toward age- and context-appropriate goals. They can also facilitate access to real-world learning experiences and simulations that enable students to practice skills and reflect on outcomes. In addition, educators can embed reflection into curricula and redesign assessments to place more emphasis on reflection. Teachers can also ask students about their reasoning, acknowledge it, and help them channel it. Lastly, teachers can share their own meta-cognitive processes.

Rethink teacher preparation with social-emotional intelligence at its center. The changes needed to support students in preparing for the emerging world of work will require teachers who are themselves emotionally intelligent and who can model the skills and practices described in the new foundation for readiness. A growing base of psychological research shows that social-emotional skills are more predictive of success and adaptation than are intellectual skills; specifically, the emotional quality of our earliest attachments is perhaps the single most important influence on human development. It makes sense, then, that teachers, who spend hundreds of hours interacting with children, be educated in emotion science and trained in social-emotional intelligence.[60]

To help achieve that, teacher education needs to be redesigned with emotional intelligence at its core. For example, teachers need more concerted training in asking meaningful, respectful questions that help students' curiosity unfold and confidence grow. Teachers and other student-facing adults also need more training in creating emotional climates that support diverse learning experiences and productive social interactions. Above all, teachers need to understand how to be in relationships with students in ways that foster openness, trust, safety, and self-discovery.

Seek to cultivate deep partnerships with afterschool, summer, and out-of-school-time learning providers. Afterschool, summer, and out-of-school-time programs offer vital support for many learners, helping them develop and practice skills, complete homework, try out new activities, and explore their interests in safe settings. These programs often engage learners in more experiential and project-based learning than their schools provide and have been shown to have a positive impact on both academic achievement and school attendance. Afterschool, summer, and out-of-school-time programs have long played a vital role in fostering social and emotional skills, with many programs encouraging positive behavior, sparking engagement, and supporting the development of aspirational visions through career exploration.[61]

K-12 education would benefit from cultivating deep partnerships with afterschool, summer, and out-of-school time programs, encouraging exchanges of information, expertise, and best practices among staff and working to incorporate extended learning opportunities into students' personalized learning journeys. By changing approaches to factors such as time, structures, and graduation requirements and addressing logistical issues such as liability insurance and transportation, K-12 education can extend the range of experiences available to help students prepare for further learning, career, and life. K-12 education can also collaborate with afterschool, summer, and out-of-school-time programs to credential a broader range of learning experiences and may even consider shifting its role to focus less on providing learning and more on certifying mastery.

In many K-12 environments, responding to these opportunities will mean rethinking how learning is structured and organized; how resources, such as time, technology, and people are allocated to create meaningful learning opportunities; how learning is assessed and progress tracked; how space is used; and how educators are supported in modeling reflective learning and aspirational personal development. Redefining readiness requires taking a long view. Education stakeholders need to find ways of responding to these opportunities with the future in mind while also attending to immediate needs such as addressing equity.

WHAT MIGHT REDEFINING READINESS LOOK LIKE FOR K-12 EDUCATION?

Responding to these opportunities to incorporate the new foundation for readiness into K-12 learning environments could mean that:

- Students are grouped in new ways to follow flexible learning pathways.
- Classrooms become more fluid and open, enabling new ways of structuring learning.
- School schedules[62] are transformed to allow for more interdisciplinary collaboration, deep reflection, and personalized learning.
- Curriculum is inverted, with core social-emotional competencies shaping how inquiry projects are designed and what school and classroom rituals anchor the learning climate and culture.
- Educators redefine their roles to focus less on content or grade specialization and more on foundational skills and practices.
- Community partners become key assets for introducing new kinds of learning experiences that stretch students' comfort zones and expand their aspirations.[63]

Opportunities for Postsecondary Education

The changing nature of work is shortening the shelf-life of job-specific skills, transforming the nature of human contribution relative to that of smart machines, and coordinating work and productive processes in new ways that shift the focus of training and preparation for work. Although in the near-term postsecondary education institutions will continue to bear at least partial responsibility for helping students to get ready for their first careers, postsecondary education can no longer be viewed as an endpoint or as a final stage in the transition to work. Instead, it must be seen as one part of a lifelong pursuit of learning for personal and professional development. To that end, postsecondary institutions need to strike a balance between immediate and future workforce needs, helping learners enter the current job market while at the same time helping them lay the foundation for future readiness. Some guiding principles for responding to this shift and incorporating the new foundation for readiness appear below.

Integrate support for deep personal development. The new foundation for readiness represents practices that people will hone over their lifetimes. To help people prepare for the future work environment in which such skills will constantly be transformed, postsecondary institutions need to help people develop their human core. Deep personal development will prepare students to become more resilient and adaptable; will enable them to push through discomfort, navigate change, and identify aspirational goals; and will enable them to use new technology tools, including artificial intelligence, in service of their goals.

Postsecondary institutions can integrate support for deep personal development by creating robust programs that integrate the liberal arts across disciplines, especially in STEM fields. In so doing, institutions can look for ways to combine departments or to merge offerings in ways that allow students to create multifaceted learning without facing administrative hurdles. In addition, institutions would benefit from making social-emotional curriculum a core requirement of any program. They can begin incorporating that curriculum by finding ways to engage students in small-group reflective practices that allow them to flex their social-emotional skills and develop their inner selves. Institutions can also simulate prospective industry and occupational work situations to help students explore the kinds of challenges they might face and the ways in which strong social-emotional practices can help them thrive. In addition, institutions could offer lifelong learning experiences focused specifically on deep personal development.

Help students design their lives. Students' lifelong success will stem from the ability to identify and generate opportunities for diverse trajectories in work, civic, and social life. As key contributors to lifelong learning, postsecondary education institutions can play an important role in preparing students to develop a playbook of career and life strategies to guide their choices in a rapidly changing world of work. Individuals need support in strategizing for career and life options and choices rather than for linear career paths that may not endure.

Postsecondary institutions can provide such support by helping students look beyond their first jobs to imagine the possible arcs of their lives. Career planning could be recast as life planning, with counselors helping students explore what kinds of choices certain educational pathways provide and how those pathways might advance their personal visions and help them make an impact. Institutions could even help students and clients explore what success and fulfillment might look like in a future employment landscape in which paid work may no longer be a core element of identity.

Develop flexible and diverse pathways and programs. Given the shortening shelf-life of many skills, postsecondary institutions need to consider how credentialing and degree pathways and job training programs can help students develop timely skills while at the same time helping them develop the persistent readiness attributes that will serve them even if the skills associated with a specific pathway or program become obsolete. Developing competency-based pathways and programs, micro-credentials, stackable degrees, and certifications can help institutions support learners in developing both dimensions.

In developing flexible and diverse pathways and programs, institutions can articulate how their offerings help students develop foundational skills as well as context- and discipline-specific ones. Postsecondary institutions can also cultivate deep partnerships with local and regional industries and employers to project emerging workforce needs and provide insights into future in-demand competencies. In order to reach all students, institutions might also explore diverse formats and modes of learning, including face-to-face experiences, virtual and blended environments, and online social learning experiences. They can also consider ways of certifying attainment of competency regardless of where or how learning took place. Lastly, forming strategic partnerships and providing learning opportunities in and through creative venues may contribute to accessibility, convenience, and relevance for busy learners.

Support entrepreneurial career planning. As Ben Casnocha[64] advocates, having a start-up approach is key to successfully transforming a career in our rapidly changing world. Entrepreneurial career planning requires being flexibly persistent and being able to adapt to breakout opportunities. Postsecondary institutions need to help students determine passions and aspirations by creating opportunities for students to test assumptions about industries and professions.

Offering internships, project work, apprentice-ships, and network-building opportunities, will enable students to develop their initial competitive career advantage. Reaching further, postsecondary institutions can also create fluid programming that allows students to enter and exit formal learning processes at the right moments and for strategic purposes that advance their career and life aspirations rather than when institutional timelines demand. This fluid programming may include flexible learning pathways, modular or stackable credentials, and other mechanisms that help lifelong learners with frequent skill acquisition and personal growth and help institutions develop new business models for a new era.

Support students in creating their own learning ecosystems. To thrive as lifelong learners and navigate the rapidly changing employment landscape, students need to learn how to identify their own learning needs, strengths, and weaknesses; how to identify learning goals and pathways for career mobility; and how to navigate educational resources, including assessments and credentialing opportunities. Postsecondary institutions can support students' ongoing success by helping them create learning ecosystems that can evolve and support them over their lifetimes. These learning ecosystems, which might include faculty, other experts, digital tools, social networks, content, and learning experiences, will be key for students' lifelong personal and professional growth.

To support students in creating their own learning ecosystems, postsecondary institutions can provide courses, support structures, and other opportunities that help students develop reflective practices. Institutions can also use supportive structures and coaching to help students develop and maintain strong relationships with faculty, mentors, and peers. In addition, postsecondary institutions can help students identify and assess digital tools, including artificial intelligence, that can help them build useful social networks and access resources and experiences that will contribute to their learning. Institutions can also consider how they might foster interconnected learning ecosystems that help learners move easily among different kinds of learning experiences, resources, and supports, not all of which they offer directly.

Support adult learners through the reskilling and upskilling process. Reskilling and upskilling will be frequent in the emerging world of work. However, for many adults, the established narrative of choosing a field and sticking with it might make the need to reskill and upskill challenging. Postsecondary institutions can help learners foster future-ready expectations about the evolution of job skills; help them see how to build off their prior experiences; and help them realize that the new foundations of readiness can be cultivated by anyone, regardless of age.

To support adult learners through the reskilling and upskilling process, postsecondary institutions can help adult learners make realistic assessments of what skills will help them stay relevant in relation to current and emerging employment opportunities and can then ensure that programs help learners develop those skills in a timely manner. Cultivating deep partnerships with local and regional industries and employers can help postsecondary institutions provide appropriate guidance and offerings. In addition, postsecondary institutions can cultivate personalized learning pathways – including new kinds of structures reflective of lifelong learning needs – that are informed by the evolving nature of job-specific skills and are oriented around learners' needs and previous experiences. Postsecondary institutions can also foster peer networks that help adult learners develop foundational readiness practices in supportive settings. Lastly, finding ways to lower barriers to access promises to help adults meet lifelong learning needs; such approaches could involve advocacy along with adjustments to institutional policy and financial structures.

Looking across these opportunities, postsecondary institutions would benefit from placing greater programmatic focus on helping learners deepen core social-emotional skills and effectively apply the foundational cognitive and metacognitive practices in service of continual self-renewal and reinvention. Additionally, institutions would benefit from re-examining their organizational, program, and delivery structures so that they can be more modular, flexible, and nimble to address workers' changing lifelong needs.

WHAT MIGHT REDEFINING READINESS LOOK LIKE FOR POSTSECONDARY EDUCATION?

Responding to these opportunities to incorporate the new foundation for readiness into postsecondary learning environments could mean that:

- Postsecondary programs focus more on supporting deep personal development as well as context- and discipline-specific skills and knowledge.
- Postsecondary offerings and business models diversify, with a multitude of formats and structures engaging learners and increasing access.
- Postsecondary institutions contribute to student-driven and student-designed ecosystems of supports that evolve over time and reflect students' strengths, weaknesses, and needs.
- Institutions help students plan for both their careers and their lives and respond to changing conditions.
- More learners weave in and out of postsecondary learning experiences as their career development needs dictate.
- Postsecondary institutions collaborate more extensively with workplace partners.
- Faculty professional development shifts to reflect both a greater focus on supporting the development of foundational cognitive and metacognitive practices and ongoing learning related to relevant workplace skills.

Imagining New Education Systems

The opportunities on the previous pages highlight some ways of responding to the new framework for readiness to ensure that learners will be prepared to navigate whatever combination of technological displacement and societal response come to pass by 2040. You will no doubt question some of the opportunities and identify others not listed here. Because a new economic paradigm is emerging, it will take many perspectives and many practices to transform today's education systems to respond effectively and fully to the changing nature of readiness. It will also take patience, perseverance, and iteration.

We owe it to current and future students to reframe our approaches to readiness. This is the most urgent issue on the horizon for learning.

CURRENT EFFORTS TO REDEFINE READINESS

While this paper explores what readiness might look like in 2040, there are many organizations working diligently to redefine readiness now. A partial list of such organizations appears below.

Ashoka Changemakers

Pioneers in the field of social entrepreneurship, Ashoka Changemakers seeks to create positive change. Started in 2012, its Start Empathy initiative partners with elementary, middle, and high schools to prioritize empathy, teamwork, leadership, and changemaking in students.[65]

CASEL

The Collaborative for Academic, Social, and Emotional Learning (CASEL) works to make evidence-based social and emotional learning an integral part of education for students in the preK-12 education system.[66]

Center for Curriculum Redesign

The Center for Curriculum Redesign brings together academic institutions, international organizations, non-profits, and corporations to design academic curricula that address what students should learn in the 21st century.[67]

Connecting Credentials

This national campaign established by Lumina Foundation and Corporation for a Skilled Workforce seeks to create a credentialing ecosystem that reflects the needs of 21st century learners, employers, and the economy.[68]

Deeper Learning

This competency framework seeks to create dynamic learning environments that help students foster deep understanding of core content so that they can use that knowledge to solve problems, think critically, communicate effectively, and be self-reflective about their learning.[69]

Partnership for 21st Century Skills

The partnership's framework for 21st century learning includes student outcomes representing skills, knowledge, and expertise that students need to succeed in work, life, and citizenship, along with necessary support systems.[70]

The Readiness Project

By identifying readiness abilities and practices and surfacing deep and persistent readiness gaps, along with common traps in systems and settings, this campaign by the Forum for Youth Investment aims to build a national movement making readiness a right and within reach for all youth.[71]

Redefining Ready!

Launched by AASA, The School Superintendents Association, Redefining Ready! is a national initiative to introduce new research-based metrics for assessing whether students are college, career, and life ready.[72]

Yale Center for Emotional Intelligence

Through conducting research on the power of emotions and partnering with schools, the center creates educational approaches that teach emotional intelligence to children and adults, helping them develop the skills they need to succeed in school, work, and life.[73]

Making Sense of Readiness Redefined in Your Context

By exploring future possibilities and opportunities to respond, education stakeholders can help ensure that the plans you make today will support students in being ready for whatever further learning, career, and life look like in 2040. The discussion and activity prompts below will help you apply the ideas in this paper to your context.

1. Readiness Framework Responses

Gather a group to discuss your responses to the new foundation for readiness using some or all of the prompts below.

A **Divide into pairs or groups and assign each group one or two profiles from the scenarios, making sure to reflect all the scenarios across the groups. Ask participants to discuss the following:**

How do the core social-emotional skills and foundational cognitive and meta-cognitive practices from the new foundation for readiness help the characters in the profiles navigate the scenarios?

What other kinds of issues and tasks might the characters encounter in their scenarios, and what specific skills and practices might help the characters respond productively?

How might you help students or staff develop the skills and practices that came to the fore of your discussion?

B **Discuss the implications of the new foundations for readiness for both classroom teachers or faculty and education administrators. Then consider:**

How might your organization provide educators with training in social-emotional intelligence?

What resources are available to support educators' development in this area?

What educational programs, expert practitioners, or providers in your area address social-emotional skills, and how might you partner with them?

Conclude by making a list of resources and programs that you can contact to explore how you might develop social-emotional intelligence in your organization. Also, list other action steps that you can take to follow up on your conversation.

C **Divide into teams by grade level (and by subject if there are enough people). Create a list of core curriculum activities by grade level. For each activity, examine how the activity can be revised, enhanced, or modified in ways that address the foundational cognitive and meta-cognitive practices in the readiness framework. What new resources, tools, partners, or colleagues would help make these redesigns successful? Share the redesigns with another team and get feedback to inform further revisions.**

2. Scenario Responses

Looking back at the readiness scenarios, explore your responses to them, either on your own or with a group, by exploring the questions below.

A **Using a blank scenario grid with the axes labeled, list how each scenario might support or create challenges for organization's vision, mission and values. Consider:**

In which scenarios do you see alignment with your vision, mission, and values?

Which scenarios might create challenges for your vision mission, and values?

If you are working in a group, discuss and then vote on the most important insights from this discussion.

B **Next, explore how your organization's vision, mission, values might be revised to reflect the emerging world of work and the new framework for readiness. Consider:**

What new elements might need to be incorporated into your vision, mission, and values?

What might you need to remove or rephrase?

C **Either on your own or with a group, consider what your responses to these questions might suggest for your organizational strengths and weakness in responding to the changing nature of work and readiness.** As you explore, write down the areas of opportunity that you see for your organization. These could be areas where your organization is strong, points of weakness where it could improve, or even blind spots. You might also discuss one or more of the strategic considerations embedded in the scenarios.

3. Education Opportunities

Looking back at the "Redefining Readiness: Opportunities for Education" section of this paper, pick one of the opportunities that seems relevant to your organization and prototype how your organization might respond to it. Alternatively, you can prototype a response to one of the opportunities that you identified when exploring the readiness framework or the readiness scenarios. To create your prototype:

A **Generate ideas for new products, services, programs, tools, or partnerships that would respond to the opportunity that you selected.**

B **Select one solution to develop further.**

C **Develop your solution either by drawing or by building a model using available materials. As you do so, consider:**

- What is your solution called?
- What does it do?
- How does it work?
- Who is involved?
- What benefits does it create? For whom?
- How does your solution respond to the opportunity that you selected?

D **After developing your prototype, discuss what it might suggest for your organization's practice and consider how you might move forward.**

Further Reading

The resources listed below provide additional perspectives on the future of readiness, learning and work.

Future of Readiness

- *Four-Dimensional Education: The Competencies Learners Need to Succeed* by Charles Fadel, Maya Bialik, and Bernie Trilling[78]
- "The New Learning Economy and the Rise of the Working Learner" by Parminder Jassal and Hope Clark[79]
- "Preparing Students for a Project-Based World" by Bonnie Lathram, Bob Lenz, and Tom Vander Ark[80]
- "Ready by Design: The Science (and Art) of Readiness" by Stephanie Krauss, Karen J. Pittman, and Caitlin Johnson[81]
- *Rethinking Readiness: Deeper Learning for College, Work, and Life* edited by Rafael Heller, Rebecca E. Wolfe, and Adria Steinberg[82]
- *Foundations for Young Adult Success: A Developmental Framework* by Jenny Nagaoka, Camille A. Farrington, Stacy B. Ehrlich, and Ryan D. Heath with David W. Johnson, Sarah Dickson, Ashley Cureton Turner, Ashley Mayo, and Kathleen Hayes[83]

Future of Learning

- "Certifying Skills and Knowledge: Four Scenarios on the Future of Credentials" by Jason Swanson[84]
- *The Future of Learning: Education in the Era of Partners in Code* by Katherine Prince, Andrea Saveri, and Jason Swanson[85]

Future of Work

- *The Fourth Industrial Revolution* by Klaus Schwab[74]
- "The Futures of Work" by the Foresight Alliance[75]
- *Machines of Loving Grace* by John Markoff[76]
- *The Second Machine Age* by Eric Brynjolfsson and Andrew McAfee[77]

Appendix

About the Authors

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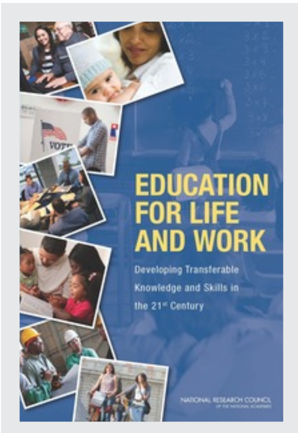

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EDUCATION FOR LIFE AND WORK

Developing Transferable Knowledge and Skills in the 21st Century

Committee on Defining Deeper Learning and 21st Century Skills

James W. Pellegrino and Margaret L. Hilton, *Editors*

Board on Testing and Assessment
and
Board on Science Education

Division of Behavioral and Social Sciences and Education

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This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the NRC's Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for objectivity, evidence, and responsiveness to the study charge. The review comments and draft manuscript remain confidential to protect the integrity of the deliberative process. We thank the following individuals for their review of this report: Diane F. Halpern, Department of Psychology, Claremont McKenna College; Karen R. Harris, Department of Special Education and Literacy, Peabody College, Vanderbilt University; Kevin Lang, Department of Economics, Boston University; Richard Lehrer, Department of Teaching and Learning, Peabody College of Vanderbilt University; Frank Levy, Department of Urban Economics, Massachusetts Institute of Technology; Lorrie A. Shepard, School of Education, University of Colorado at Boulder; and Nancy T. Tippins, Sr. Vice President and Managing Principal, Valtera Corporation, Greenville, SC.

Although the reviewers listed above provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft of the report before its release. Deborah Stipek of the Stanford University School of Education and Elisabeth M. Drake, retired associate director for new energy technology, Energy Laboratory, Massachusetts Institute of Technology, oversaw the review of this report. Appointed by the NRC, they were responsible for making certain that an independent examination of this report was carried out in accordance with institutional procedures and that all review comments were carefully considered. Responsibility for the final content of this report rests entirely with the author and the institution.

Finally, we thank our colleagues on the committee for their enthusiasm, hard work, and collaborative spirit in thinking through the conceptual issues and challenges associated with addressing the charge to the study committee and in writing this report.

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Committee on Defining Deeper Learning and 21st Century Skills

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Summary

Americans have long recognized that investments in public education contribute to the common good, enhancing national prosperity and supporting stable families, neighborhoods, and communities. Education is even more critical today, in the face of economic, environmental, and social challenges. Today's children can meet future challenges if their schooling and informal learning activities prepare them for adult roles as citizens, employees, managers, parents, volunteers, and entrepreneurs. To achieve their full potential as adults, young people need to develop a range of skills and knowledge that facilitate mastery and application of English, mathematics, and other school subjects. At the same time, business and political leaders are increasingly asking schools to develop skills such as problem solving, critical thinking, communication, collaboration, and self-management—often referred to as "21st century skills."

Private foundations, policy makers, and education organizations use a variety of names for the lists of broad skills seen as valuable. To help the public understand the research related to the teaching and learning of such skills, several foundations charged the National Research Council (NRC) to:

- Define the set of key skills that are referenced by the labels "deeper learning," "21st century skills," "college and career readiness," "student centered learning," "next generation learning," "new basic skills," and "higher order thinking." These labels are typically used to include both cognitive and noncognitive skills—such as critical thinking, problem solving, collaboration, effective communication, motivation, persistence, and learning to learn that can be demonstrated within core academic content areas and that are important to success in education, work, and other areas of adult responsibility. The labels are also sometimes used to include other important capacities—such as creativity, innovation, and ethics—that are important to later success and may also be developed in formal or informal learning environments.

- Describe how these skills relate to each other and to more traditional academic skills and content in the key disciplines of reading, mathematics, and science. In particular, consider these skills in the context of the work of the National Governors Association and the Council of Chief State School Officers in specifying Common Core State Standards for English language arts and mathematics, and the work of the NRC in specifying *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (hereafter referred to as the NRC science framework).
- Summarize the findings of the research that investigates the importance of such skills to success in education, work, and other areas of adult responsibility and that demonstrates the importance of developing these skills in K-16 education.
- Summarize what is known—and what research is needed—about how these skills can be learned, taught, and assessed. This summary should include both the cognitive foundations of these skills in learning theory and research about effective approaches to teaching and learning these skills, including approaches using digital media.
- Identify features of educational interventions that research suggests could be used as indicators that an intervention is likely to develop the key skills in a substantial and meaningful way. In particular, for learning in formal school-based environments, identify features related to learning these skills in educational interventions in (a) teacher professional development, (b) curriculum, and (c) assessment. For learning in informal environments, identify features related to learning these skills in educational interventions in (d) after-school and out-of-school programs and (e) exhibits, museums, and other informal learning centers. For learning in both formal and informal environments, identify features related to learning these skills in education interventions in (f) digital media.

In approaching this charge, the committee drew on a large research base in cognitive, developmental, educational, organizational, and social psychology and economics for purposes of clarifying and organizing concepts and terms. However, we do not claim to provide precise, scientifically credible definitions of all the various terms that have come to populate this arena of concern and debate. This is due partly to the time constraints of the project and partly to the lack of definitive research on the range of skills and behaviors that have come to fall under the headings of "deeper learning" and "21st century skills." That said, the committee took initial steps toward clarifying the meaning of the term "deeper learning" and its relationship to competency clusters that capture various terms associated with the overarching label 21st century skills. In contrast to a view of 21st century skills as general skills that can be applied to a range of different tasks in various academic, civic, workplace, or family contexts, the committee views 21st century skills as dimensions of expertise that are specific to—and intertwined with—knowledge within a particular domain of content and performance. To reflect our view that skills and knowledge are intertwined, we use the term "competencies" rather than "skills."

CLARIFYING AND ORGANIZING CONCEPTS AND TERMS

The committee views the various sets of terms associated with the 21st century skills label as reflecting important dimensions of human competence that have been valuable for many centuries, rather than skills that are suddenly new, unique, and valuable today. The important difference across time may lie in society's desire that all students attain levels of mastery—across multiple areas of skill and knowledge—that were previously unnecessary for individual success in education and the workplace. At the same time, the pervasive spread of digital technologies has increased the pace at which individuals communicate and exchange information, requiring competence in processing multiple forms of information to accomplish tasks that may be distributed across contexts that include home, school, the workplace, and social networks.

As a way to organize the various terms for 21st century skills and provide a starting point for further research as to their meaning and value, the committee identified three broad domains of competence—cognitive, intrapersonal, and interpersonal. The cognitive domain involves reasoning and memory; the intrapersonal domain involves the capacity to manage one's behavior and emotions to achieve one's goals (including learning goals); and the interpersonal domain involves expressing ideas, and interpreting and responding to messages from others. We then conducted a content analysis, aligning several lists of 21st century skills proposed by various groups and individuals with the skills included in existing research-based taxonomies of cognitive, intrapersonal, and interpersonal skills and abilities.[1] Through this process, we assigned the various 21st century skills to clusters of competencies within each domain. Recognizing that there are areas of overlap between and among the individual 21st century skills

[1]The committee views the abilities included in these taxonomies as malleable dimensions of human behavior that can change in response to educational interventions and life experiences, in contrast to the common view of them as fixed traits.

and the larger competency clusters, the committee developed the following initial classification scheme (see Chapter 2):

- The Cognitive Domain includes three clusters of competencies: cognitive processes and strategies, knowledge, and creativity. These clusters include competencies, such as critical thinking, information literacy, reasoning and argumentation, and innovation.
- The Intrapersonal Domain includes three clusters of competencies: intellectual openness, work ethic and conscientiousness, and positive core self-evaluation. These clusters include competencies, such as flexibility, initiative, appreciation for diversity, and metacognition (the ability to reflect on one's own learning and make adjustments accordingly).
- The Interpersonal Domain includes two clusters of competencies: teamwork and collaboration and leadership. These clusters include competencies, such as communication, collaboration, responsibility, and conflict resolution.

IMPORTANCE OF 21ST CENTURY COMPETENCIES

The committee examined evidence of the importance of various types of competencies for success in education, work, health, and other life contexts (see Chapter 3) and concluded:

- **Conclusion: The available research evidence is limited and primarily correlational in nature; to date, only a few studies have demonstrated a causal relationship between one or more 21st century competencies and adult outcomes. The research has examined a wide range of different competencies that are not always clearly defined or distinguished from related competencies.**

Despite the limitations of the research evidence, the committee was able to reach three conclusions about the importance of various competencies:

- **Conclusion: Cognitive competencies have been more extensively studied than have intrapersonal and interpersonal competencies, showing consistent, positive correlations (of modest size) with desirable educational, career, and health outcomes. Early academic competencies are also positively correlated with these outcomes.**

- **Conclusion: Among intrapersonal and interpersonal competencies, conscientiousness (staying organized, responsible, and hardworking) is most highly correlated with desirable educational, career,**

and health outcomes. Antisocial behavior, which has both intrapersonal and interpersonal dimensions, is negatively correlated with these outcomes.

- **Conclusion: Educational attainment—the number of years a person spends in school—strongly predicts adult earnings and also predicts health and civic engagement. Moreover, individuals with higher levels of education appear to gain more knowledge and skills on the job than do those with lower levels of education, and to be able, to some extent, to transfer what they learn across occupations. Since it is not known what mixture of cognitive, intrapersonal, and interpersonal competencies accounts for the labor market benefits of additional schooling, promoting educational attainment itself may constitute a useful complementary strategy for developing 21st century competencies.**

At a time when educational and business leaders are increasingly interested in promoting deeper learning and development of 21st century skills, and in light of limitations of the available empirical evidence linking such competencies with desirable adult outcomes, we recommend further research:

- **Recommendation 1: Foundations and federal agencies should support further research designed to increase our understanding of the relationships between 21st century competencies and successful adult outcomes. To provide stronger causal evidence about such relationships, the programs of research should move beyond simple correlational studies to include more longitudinal studies with controls for differences in individuals' family backgrounds and more studies using statistical methods that are designed to approximate experiments. Such research would benefit from efforts to achieve common definitions of 21st century competencies and an associated set of activities designed to produce valid and reliable assessments of the various individual competencies.**

PERSPECTIVES ON DEEPER LEARNING

We define "deeper learning" as the process through which an individual becomes capable of taking what was learned in one situation and applying it to new situations (i.e., transfer). Through deeper learning (which often involves shared learning and interactions with others in a community), the individual develops expertise in a particular domain of knowledge and/or performance (see Chapters 4 and 5). The product of deeper learning is transferable knowledge, including content knowledge in a domain and knowledge of how, why, and when to apply this knowledge to answer questions and solve problems. We refer to this blend of both knowledge and skills as "21st century competencies." The competencies are structured around fundamental principles of the content area and their relationships rather than disparate, superficial facts or procedures. It is the way in which the individual and community structures and organizes the intertwined knowledge and skills—rather than the separate facts or procedures per se—that supports transfer. While other types of learning may allow an individual to recall facts, concepts, or procedures, deeper learning allows the individual to transfer what was learned to solve new problems.

The new Common Core State Standards in English language arts and mathematics and the NRC science framework are likely to strongly influence educational policy and practice in the coming decades. The committee reviewed these documents and compared them with our definition of deeper learning and with recent lists of 21st century skills, revealing important areas of overlap. The goals included in the new standards and the NRC science framework reflect each discipline's desire to promote deeper learning and develop transferable knowledge and skills within that discipline. For example, both the mathematics standards and the science framework include a "practices" dimension, calling for students to actively use and apply—i.e., to transfer—knowledge, and the English language arts standards call on students to synthesize and apply evidence to create and effectively communicate an argument. Our review leads to three conclusions (see Chapter 5):

- **Conclusion: Goals for deeper learning and some 21st century competencies are found in standards documents, indicating that disciplinary goals have expanded beyond their traditional focus on basic academic content. A cluster of cognitive competencies—including critical thinking, nonroutine problem solving, and constructing and evaluating evidence-based arguments—is strongly supported across all three disciplines.**

- **Conclusion: Coverage of other competencies—particularly those in the intrapersonal and interpersonal domains—is uneven. For example, standards documents across all three disciplines include discourse and argumentation (which includes both cognitive and interpersonal facets), but the disciplines differ in their view of what counts as evidence and the rules of argumentation. This uneven coverage could potentially lead to learning environments for different subjects that vary in their support for development of 21st century competencies.**

- **Conclusion: Development of the full range of 21st century competencies within the disciplines will require systematic instruction and sustained practice. It will be necessary to devote additional instructional time and resources to advance these sophisticated disciplinary learning goals over what is common in current practice.**

The standards and framework documents demonstrate each discipline's desire to develop skills and knowledge that will transfer beyond the classroom. However, the goals for transfer are specific to each discipline. For example, the NRC science framework aims to prepare high school graduates to engage in public discussions on science-related issues and to be critical consumers of scientific information. Research is lacking on how to help learners transfer competencies learned in one discipline or topic area outside the discipline or topic area:

- **Conclusion: Teaching for transfer within each discipline aims to increase transfer within that discipline. Research to date provides little guidance about how to help learners aggregate transferable competencies across disciplines. This may be a shortcoming in the research or a reflection of the domain-specific nature of transfer.**

To fill this gap, we recommend further research:

- **Recommendation 2: Foundations and federal agencies should support programs of research designed to illuminate whether, and to what extent, teaching for transfer within an academic discipline can facilitate transfer across disciplines.**

Deeper learning can be supported through teaching practices that create a positive learning community in which students gain content knowledge and also develop intrapersonal and interpersonal competencies. For example, an integrated science-literacy curriculum was tested in 94 fourth-grade classrooms in one southern state. The curriculum combined collaborative, hands-on science inquiry activities with reading text, writing notes and reports, and small group discussions. When teachers were randomly assigned to either implement the integrated curriculum or to teach science and literacy separately (using their regular materials), students exposed to the integrated curriculum demonstrated significantly greater gains on measures of science understanding, science vocabulary, and science writing. At the same time, the students developed the intrapersonal competencies of oral communication and discourse, as well as the interpersonal competencies of metacognition and positive dispositions toward learning (see Chapter 5). Other research also illuminates how intrapersonal and interpersonal competencies support deeper learning of school subjects. For example, the process of deeper learning to develop expertise in a domain of knowledge and performance requires months, or even years, of sustained, deliberate practice; such sustained effort is supported by the intrapersonal competency of conscientiousness. Development of expertise also requires feedback to guide and optimize practice activities and an individual with strong interpersonal skills will best understand and apply such feedback. Metacognition—the ability to reflect on one's own learning and make adjustments accordingly—also enhances deeper learning. We conclude (see Chapter 4):

- **Conclusion: The process of deeper learning is essential for the development of transferable 21st century competencies (including both knowledge and skills), and the application of 21st century competencies in turn supports the process of deeper learning, in a recursive, mutually reinforcing cycle.**

INSTRUCTIONAL FEATURES FOR DEEPER LEARNING

The committee's review of the evidence on teaching and learning of cognitive, intrapersonal, and interpersonal competencies supported the following conclusion (see Chapter 6):

- **Conclusion: Although the absence of common definitions and quality measures poses a challenge to research, emerging evidence indicates that cognitive, intrapersonal, and interpersonal competencies can be taught and learned in ways that promote transfer.**

The most extensive and rigorous research related to deeper learning comes from the learning sciences. Although this research has focused on acquisition of cognitive knowledge and skills, it indicates that deeper learning and complex problem solving involves the interplay of cognitive, intrapersonal, and interpersonal competencies. Over a century of research on transfer has yielded little evidence that teaching can develop general cognitive competencies that are transferable to any new discipline, problem, or context, in or out of school. Nevertheless, it has identified features of instruction that are likely to substantially support deeper learning and development of 21st century competencies within a topic area or discipline. For example, we now know that transfer is supported when learners understand the general principles underlying their original learning and the transfer situation or problem involves the same general principles—a finding reflected in the new Common Core State Standards and the NRC science framework, which highlight learning of general principles. Similarly, in solving problems, transfer is facilitated by instruction that helps learners develop deep understanding of the structure of a problem domain and applicable solution methods, but is not supported by rote learning of solutions to specific problems or problem-solving procedures. This kind of deep, well-integrated learning develops gradually and takes time, but it can be started early: recent evidence indicates that even preschool and early elementary students can make meaningful progress in conceptual organization, reasoning, problem solving, representation, and communication in well-chosen topic areas in science, mathematics, and language arts. In addition, teaching that emphasizes the conditions for applying a body of factual or procedural knowledge also facilitates transfer.

For instruction focused on development of cognitive competencies, whether delivered within or outside of school, and irrespective of support by digital media, the committee recommends (see Chapter 6):

- **Recommendation 3: Designers and developers of instruction targeted at deeper learning and development of transferable 21st century competencies should begin with clearly delineated learning goals and a model of how learning is expected to develop, along with assessments to measure student progress toward and attainment of the goals. Such instruction can and should begin with the earliest grades and be sustained throughout students' K-12 careers.**

- **Recommendation 4: Funding agencies should support the development of curriculum and instructional programs that include research-based teaching methods, such as:**

    - **Using multiple and varied representations of concepts and tasks,** such as diagrams, numerical and mathematical representations, and simulations, combined with activities and guidance that support mapping across the varied representations.
    - **Encouraging elaboration, questioning, and explanation—**for example, prompting students who are reading a history text to think about the author's intent and/or to explain specific information and arguments as they read—either silently to themselves or to others.
    - **Engaging learners in challenging tasks,** while also supporting them with guidance, feedback, and encouragement to reflect on their own learning processes and the status of their understanding.
    - **Teaching with examples and cases,** such as modeling step-by-step how students can carry out a procedure to solve a problem and using sets of worked examples.

- o **Priming student motivation** by connecting topics to students' personal lives and interests, engaging students in collaborative problem solving, and drawing attention to the knowledge and skills students are developing, rather than grades or scores.
- o **Using formative assessment** to: (a) make learning goals clear to students; (b) continuously monitor, provide feedback, and respond to students' learning progress; and (c) involve students in self- and peer assessment.

For instruction focused on development of problem-solving and metacognitive competencies, the committee recommends (see Chapter 6):

- **Recommendation 5: Designers and developers of curriculum, instruction, and assessment in problem solving and metacognition should use modeling and feedback techniques that highlight the processes of thinking rather than focusing exclusively on the products of thinking. Problem-solving and metacognitive competencies should be taught and assessed within a specific discipline or topic area rather than as a stand-alone course. Teaching and learning of problem-solving and metacognitive competencies need not wait until all of the related component competencies have achieved fluency. Finally, sustained instruction and effort are necessary to develop expertise in problem solving and metacognition; there is no simple way to achieve competence without time, effort, motivation, and informative feedback.**

Research on teaching and learning of competencies in the intrapersonal and interpersonal domains is less extensive and less rigorous than the research on deeper learning of cognitive knowledge and skills. Our review of the emerging research on these domains, as well as the more extensive cognitive research, suggests that the instructional features supporting development of transferable competencies in the cognitive domain may also support transfer in these domains (see Chapter 6):

- **Conclusion: The instructional features listed above, shown by research to support the acquisition of cognitive competencies that transfer, could plausibly be applied to the design and implementation of instruction that would support the acquisition of transferable intrapersonal and interpersonal competencies.**

To test this hypothesis, the committee recommends further research:

- **Recommendation 6: Foundations and federal agencies should support research programs designed to fill gaps in the evidence base on teaching and assessment for deeper learning and transfer. One important target for future research is how to design instruction and assessment for transfer in the intrapersonal and interpersonal domains. Investigators should examine whether, and to what extent, instructional design principles and methods shown to increase transfer in the cognitive domain, are applicable to instruction targeted to the development of intrapersonal and interpersonal competencies. Such programs of research would benefit from efforts to specify more uniform, clearly defined constructs and produce associated measures of cognitive, intrapersonal, and interpersonal competencies.**

OPPORTUNITIES AND CHALLENGES

Current educational policies and associated accountability systems rely on assessments that focus primarily on recall of facts and procedures, posing a challenge to wider teaching and learning of transferable 21st century competencies. However, recent policy developments offer opportunities to address this challenge (see Chapter 7). In particular, as noted above, the Common Core State Standards and the NRC science framework provide a deeper conceptualization of the knowledge and skills to be mastered in each discipline, including various facets of 21st century competencies.

While new national goals that encompass 21st century competencies have been articulated in the standards and the NRC science framework, the extent to which these goals are realized in educational settings will be strongly influenced by the nature of their inclusion in district, state, and national assessments. Because educational policy emphasizes the results of summative assessments within accountability systems, teachers and administrators will focus instruction on what is included in state assessments. Thus, as new assessment systems are developed to reflect the new standards in English language arts, mathematics, and science, significant attention will need to be given to the design of tasks and situations that call on students to apply a range of 21st century competencies that are relevant to each discipline.

Although improved assessments would facilitate wider uptake of interventions that support the process of deeper learning, developing such assessments faces several challenges. First, research to date has focused on a plethora of different constructs in the cognitive, intrapersonal, and interpersonal domains. Our taxonomy offers a useful starting point, but further research is needed to more carefully organize, align, and define these constructs. Second, there are psychometric challenges. Progress has been made in assessing a range of simple and complex cognitive competencies, yet much further research is needed to develop assessments of intrapersonal and interpersonal competencies. Such research should initially focus on developing assessments for research purposes, and later on assessments for formative purposes. If these efforts are successful, then summative assessments of intrapersonal and interpersonal competencies could possibly be developed for later use in educational settings. Experiences during the 1980s and 1990s in the development and implementation of performance assessments and assessments with open-ended tasks offer valuable insights, but assessments must be reliable, valid, and fair if they are to be widely used in formal and informal learning environments.

A third challenge is posed by political and economic forces that influence assessment development and use. Policy makers have favored standardized, on-demand, end-of-year tests that are easily scored and quantified for accountability purposes. Composed largely of selected response items, these tests are relatively cheap to implement but are not optimal for assessing 21st century competencies (see Chapter 7). In the face of current fiscal constraints at the federal and state levels, assessment systems may seek to minimize costs by using these types of tests, rather than incorporating the richer, performance- and curriculum-based assessments that can better support the development and assessment of 21st century competencies.

The fourth challenge is teacher capacity. The principles of instruction we outline above are rarely reflected in the knowledge and practices of teachers, students, and school administrators and in administrators' expectations of teachers and teacher evaluation rubrics. Teacher preparation programs will need to help teacher candidates develop specific visions of teaching and learning for transfer and also the knowledge and skills to put these visions into practice. Both novice and experienced teachers will need time to develop new understandings of the subjects they teach as well as understanding of how to assess 21st century competencies in these subjects, making ongoing professional learning opportunities a central facet of every teacher's job. Certainly, teachers will need support from administrators as they struggle with the complexity and uncertainty of revising their teaching practice within the larger effort to institutionalize a focus on deeper learning and effective transfer.

- **Recommendation 7: Foundations and federal agencies should support research to more clearly define and develop assessments of 21st century competencies. In particular, they should provide sustained**

support for the development of valid, reliable, and fair assessments of intrapersonal and interpersonal competencies, initially for research purposes, and later for formative assessment. Pending the results of these efforts, foundations and agencies should consider support for development of summative assessments of these competencies.

Two large consortia of states, with support from the U.S. Department of Education, are currently developing new assessment frameworks and methods aligned with the Common Core State Standards in English language arts and mathematics. If these assessment frameworks include the facets of 21st century competencies represented in the Common Core State Standards, they will provide a strong incentive for states, districts, schools, and teachers to emphasize these competencies as part of disciplinary instruction. Next Generation Science Standards based on the NRC science framework are under development, and assessments aligned with these standards have not yet been created. When new science assessments are developed, inclusion of facets of 21st century competencies will provide a similarly strong incentive for states, districts, schools, and teachers to emphasize those facets in classroom science instruction (see Chapter 7).

- **Recommendation 8: As the state consortia develop new assessment systems to reflect the Common Core State Standards in English language arts and mathematics, they should devote significant attention to the design of tasks and situations that call upon a range of important 21st century competencies as applied in each of the major content areas.**

- **Recommendation 9: As states and test developers begin to create new assessment systems aligned with new science standards, they should devote significant attention to designing measures of 21st century competencies properly reflecting a blend of science practices, crosscutting concepts, and core ideas.**

Because 21st century competencies support deeper learning of school subjects, their widespread acquisition could potentially reduce disparities in educational attainment, preparing a broader swathe of young people for successful adult outcomes at work and in other life arenas. However, important challenges remain. For educational interventions focused on developing transferable competencies to move beyond isolated promising examples and flourish more widely in K-12 schooling, larger systemic issues and policies involving curriculum, instruction, assessment, and professional development will need to be addressed. In particular, new types of assessment systems, capable of accurately measuring and supporting acquisition of these competencies, will be needed. A sustained program of research and development will be required to create assessments that are capable of measuring cognitive, intrapersonal, and interpersonal competencies. In addition, it will be important for researchers and publishers to develop new curricula that incorporate the research-based design principles and instructional methods we describe above. Finally, new approaches to teacher preparation and professional development will be needed to help current and prospective teachers understand these instructional principles and methods, as well as the role of deeper learning and 21st century competencies in mastering core academic content. If teachers are to not only understand these ideas but also translate them into their daily instructional practice, they will need support from school and district administrators, including time for learning, shared lesson planning and review, and reflection (see Chapter 7).

- **Recommendation 10: The states and the federal government should establish policies and programs—in the areas of assessment, accountability, curriculum and materials, and teacher education—to support students' acquisition of transferable 21st century competencies. For example, when reauthorizing the Elementary and Secondary Education Act, the Congress should facilitate the systemic development, implementation, and evaluation of educational interventions targeting deeper learning processes and the development of transferable competencies.**

1

Introduction

Americans have long recognized that investments in public education can contribute to the common good, enhance national prosperity, and support stable families, neighborhoods, and communities. In the face of economic, environmental, and social challenges, education is even more critical today than it has been in the past. Today's children can meet future challenges if they have opportunities to prepare for their future roles as citizens, employees, managers, parents, volunteers, and entrepreneurs. To achieve their full potential as adults, young people will need to learn a full range of skills and knowledge that facilitate mastery of English, mathematics, and other school subjects. They will need to learn in ways that support not only retention but also the use and application of skills and knowledge—a process called "transfer" in cognitive psychology.

Today's educational policies and practices will need updating to help all children develop transferable knowledge and skills. American students' performance is not impressive when they are tested through the Programme for International Student Assessment (PISA) for their ability to not only understand but also apply their knowledge. PISA tests are designed to measure students' capacity to apply knowledge and skills in key subject areas as well as their ability to analyze, reason, and communicate effectively as they pose, interpret, and solve problems. On the 2009 PISA reading and science tests, the scores of U.S. 15-year-olds were only average when compared to students from the other industrialized nations making up the OECD; in mathematics, the scores of U.S. 15-year-olds were below the OECD average.[1] Part of the reason for the weak average performance of American students is uneven learning and achievement among different groups of students. Disparities in the relative educational attainment of children from high-income versus low-income families have grown enormously since the 1970s (Duncan and Murnane, 2011). In a related trend, the gap between average incomes of the wealthiest and poorest families has grown.

Business leaders, educational organizations, and researchers have begun to call for new education policies that target the development of broad, transferable skills and knowledge, often referred to as "21st century skills." For example, the Partnership for 21st Century Skills[2] argues that student success in college and careers requires four essential skills: critical thinking and problem solving, communication, collaboration, and creativity and innovation (Partnership for 21st Century Skills, 2010, p. 2).

Although these skills have long been valuable (for example, Thomas Alva Edison observed in 1903 that "Genius is 1 percent inspiration, 99 percent perspiration"), they are particularly salient today, and education officials are beginning to focus on them. Sixteen states have joined the Partnership for 21st Century Skills, based on a commitment to fuse 21st century skills with academic content (Partnership for 21st Century Skills, 2011) in their standards, assessments, curriculum, and teacher professional development. Some state and local high school reform efforts have begun to focus on a four-dimensional framework of college and career readiness that includes not only academic content but also cognitive strategies, academic behaviors, and contextual skills and awareness (Conley, 2011). At the international level, the U.S. secretary of education participates on the executive board of the Assessment and Teaching of 21st Century Skills (ATC21S) project, along with the education ministers of five other nations and the vice presidents of Cisco, Intel, and Microsoft. This project aims to expand the teaching and learning of 21st century skills globally, especially by improving assessment of these skills. In a separate effort, a large majority of 16 OECD nations surveyed in 2009 reported that they are incorporating 21st century skills in their education policies, such as regulations and guidelines (Aniandou and Claro, 2009).

COMMITTEE CHARGE

To increase understanding of the research related to deeper learning, 21st century skills, and related educational goals, the Carnegie Corporation of New York, the William and Flora Hewlett Foundation, the John D. and

[1] OECD (2010).
[2] This nonprofit organization includes business, education, community, and governmental groups.

Catherine T. MacArthur Foundation, the National Science Foundation, the Nellie Mae Education Foundation, the Pearson Foundation, the Raikes Foundation, the Susan Crown Enchange Fund, and the Stupski Foundation charged the National Research Council (NRC) as follows:

> An ad hoc committee will review and synthesize current research on the nature of deeper learning and 21st century skills and will address the following:
>
> - Define the set of key skills that are referenced by the labels "deeper learning," "21st century skills," "college and career readiness," "student centered learning," "next generation learning," "new basic skills," and "higher order thinking." These labels are typically used to include both cognitive and noncognitive skills—such as critical thinking, problem solving, collaboration, effective communication, motivation, persistence, and learning to learn that can be demonstrated within core academic content areas and that are important to success in education, work, and other areas of adult responsibility. The labels are also sometimes used to include other important capacities—such as creativity, innovation, and ethics—that are important to later success and may also be developed in formal or informal learning environments.
> - Describe how these skills relate to each other and to more traditional academic skills and content in the key disciplines of reading, mathematics, and science. In particular, consider these skills in the context of the work of the National Governors Association and the Council of Chief State School Officers in specifying Common Core State Standards for English language arts and mathematics, and the work of the NRC in specifying a *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (hereafter referred to as the NRC science framework).
> - Summarize the findings of the research that investigates the importance of such skills to success in education, work, and other areas of adult responsibility and that demonstrates the importance of developing these skills in K-16 education.
> - Summarize what is known—and what research is needed—about how these skills can be learned, taught, and assessed. This summary should include both the cognitive foundations of these skills in learning theory and research about effective approaches to teaching and learning these skills, including approaches using digital media.
> - Identify features of educational interventions that research suggests could be used as indicators that an intervention is likely to develop the key skills in a substantial and meaningful way. In particular, for learning in formal school-based environments, identify features related to learning these skills in educational interventions in (a) teacher professional development, (b) curriculum, and (c) assessment. For learning in informal environments, identify features related to learning these skills in educational interventions in (d) after-school and out-of-school

programs and (e) exhibits, museums, and other informal learning centers. For learning in both formal and informal environments, identify features related to learning these skills in education interventions in (f) digital media.

HOW THE COMMITTEE APPROACHED THE CHARGE

To address these five areas of concern, the committee reviewed research literature across several disciplines, including cognitive science, educational and social psychology, economics, child and adolescent development, literacy, mathematics and science education, psychometrics, educational technology, and human resource development. The committee drew on recent NRC workshops focusing on demand for 21st century skills, the intersection of science education and 21st century skills, and the assessment of 21st century skills, as well as on papers commissioned for an NRC planning process on behalf of the Hewlett Foundation. It considered the work of the ATC21S project and emerging research on the relationship between cognitive and noncognitive skills and abilities and adult outcomes (see Chapter 3).

The committee met three times. The first meeting included an open session with representatives of the FrameWorks Institute, which focused on how the public thinks about education and early childhood development. In the closed session of the first meeting, teams of committee members focusing on each topic in the study charge delivered brief presentations summarizing relevant research findings. These presentations and discussions provided the basis for a preliminary draft of this report. At its second meeting, the committee deliberated on the preliminary draft and decided to focus the report on learning for transfer. Following the second meeting, the committee and staff revised the preliminary draft extensively, and this new draft was discussed at the committee's third meeting. At the third meeting, the committee also developed preliminary conclusions and recommendations based on the draft. Following this meeting, the committee and staff again revised the report. In a final teleconference, the committee discussed and reached consensus on the conclusions and recommendations. The draft report entered the NRC review process in February 2012. Following receipt of review comments it was revised and publicly released in July 2012.

ORGANIZATION OF THE REPORT

Following this introductory chapter, Chapter 2 begins to address the question of how to define deeper learning and 21st century skills, proposing a preliminary taxonomy with clusters of competencies. Chapter 3 summarizes several different strands of research on the importance of these competencies to success in education, work, and other areas of adult responsibility. Chapter 4 focuses on deeper learning, which the committee views as learning for transfer. Chapter 5 discusses deeper learning and 21st century competencies in the disciplines of English language arts, science, and mathematics. Chapter 6 discusses teaching and assessing transferable knowledge and skills, in both formal and informal learning environments, and identifies research-based methods and instructional design principles for effectively developing the desired knowledge and skills. Chapter 7 considers key elements within the larger educational system that may help or hinder wider implementation of educational interventions to support the process of deeper learning and the development of 21st century competencies. Chapters 3 through 7 end with conclusions and recommendations, and all of the conclusions and recommendations are included in the Summary.

2

A Preliminary Classification of Skills and Abilities

This chapter presents an initial classification of skills and abilities, including various terms used to describe "21st century skills." The committee found this preliminary classification scheme useful in addressing each question in the study charge, and the scheme is used to varying degrees throughout the report. At the same time, the committee hopes that the preliminary scheme proves useful for further research to develop shared definitions of these skills.

THREE DOMAINS OF COMPETENCE

As a first step toward describing 21st century skills, the committee identified three domains of competence: cognitive, intrapersonal, and interpersonal. These three domains represent distinct facets of human thinking and build on previous efforts to identify and organize dimensions of human behavior. For example, Bloom's 1956 taxonomy of learning objectives included three broad domains: cognitive, affective, and psychomotor. Following Bloom, we view the cognitive domain as involving thinking and related abilities, such as reasoning, problem solving, and memory.[1] Our intrapersonal domain, like Bloom's affective domain, involves emotions and feelings and includes self-regulation—the ability to set and achieve one's

[1]In Bloom's taxonomy of the cognitive domain, knowledge is at the lowest level (or "order"), with comprehension and application of information above. The higher orders include analysis and synthesis, and the highest level is evaluation (Bloom, 1956). The influence of the taxonomy is seen in current calls for schools to teach "higher-order skills."

goals (Hoyle and Davisson, 2011). The interpersonal domain we propose is not included in Bloom's taxonomy but rather is based partly on a recent National Research Council (NRC) workshop that clustered various 21st century skills into the cognitive, intrapersonal, and interpersonal domains (National Research Council, 2011a). In that workshop, Bedwell, Fiore, and Salas (2011) proposed that interpersonal competencies are those used both to express information to others and to interpret others' messages (both verbal and nonverbal) and respond appropriately.

Distinctions among the three domains are reflected in how they are delineated, studied, and measured. In the cognitive domain, knowledge and skills are typically measured with tests of general cognitive ability (also referred to as *g* or IQ) or with more specific tests focusing on school subjects or work-related content. Research on intrapersonal and interpersonal competencies often uses measures of broad personality traits (discussed further below) or of child temperament (general behavioral tendencies, such as attention or shyness). Psychiatrists and clinical psychologists studying mental disorders use various measures to understand the negative dimensions of the intrapersonal and interpersonal domains (Almlund et al., 2011).

Although we differentiate the three domains for the purpose of understanding and organizing 21st century skills, we recognize that they are intertwined in human development and learning. Research on teaching and learning has begun to illuminate how intrapersonal and intrapersonal skills support learning of academic content (e.g., National Research Council, 1999) and how to develop these valuable supporting skills (e.g., Yeager and Walton, 2011). For example, we now know that learning is enhanced by the intrapersonal skills used to reflect on one's learning and adjust learning strategies accordingly—a process called "metacognition" (National Research Council, 2001; Hoyle and Davisson, 2011). At the same time research has shown that the development of cognitive skills, such as the ability to stop and think objectively about a disagreement with another person, can increase positive interpersonal skills and reduce antisocial behavior (Durlak et al., 2011). And the interpersonal skill of effective communication is supported by the cognitive skills used to process and interpret complex verbal and nonverbal messages and formulate and express appropriate responses (Bedwell, Fiore, and Salas, 2011).

A DIFFERENTIAL PERSPECTIVE ON 21ST CENTURY SKILLS

To address our charge to define 21st century skills and describe how they relate to each other, we turn to the research in differential psychology. This research has focused on understanding human behavior by examining systematic ways in which individuals vary and by using relatively stable patterns of individual differences as the basis for structural theories of cognition and personality. Much of this work is rooted in efforts to identify and define skills and competencies through a process of measurement, with inferences drawn about the significance and breadth of a construct by analyzing patterns of correlations.

We view 21st century skills as knowledge that can be transferred or applied in new situations. This transferable knowledge includes both content knowledge in a domain and also procedural knowledge of how, why, and when to apply this knowledge to answer questions and solve problems. The latter dimensions of transferable knowledge (how, why, and when to apply content knowledge) are often called "skills." We refer to this blend of content knowledge and related skills as "21st century competencies." In Chapter 4, we propose that deeper learning is the process through which such transferable knowledge (i.e., 21st century competencies) develops.

Our use of "competencies" reflects the terminology used by the OECD in its extensive project to identify key competencies required for life and work in the current era. According to the OECD (2005), a competency is

> more than just knowledge and skills. It involves the ability to meet complex demands, by drawing on and mobilizing psychosocial resources (including skills and attitudes) in a particular context. For example, the ability to communicate effectively is a competency that may draw on an individual's knowledge of language, practical IT skills, and attitudes towards those with whom he or she is communicating. (OECD, 2005, p. 4)

Differential psychology has traditionally focused on identifying characteristics of individuals, including general cognitive ability and personality traits, that are thought to persist throughout an individual's life. In contrast, the committee views cognitive, intrapersonal, and interpersonal competencies as malleable and subject to change in response to life experience, education, and interventions. In the cognitive domain, for example, the view of intelligence as a single, unitary ability that changes little over a lifetime has been superseded by research indicating that intelligence includes multiple dimensions (Carroll, 1993) and that these dimensions change over time. Horn (1970) found that fluid intelligence (a construct that includes verbal and quantitative reasoning abilities) decreases from adolescence to middle age, while crystallized intelligence (accumulated skills, such as verbal comprehension and listening ability) increases over the same period. McArdle et al. (2000) observed similar patterns of change, finding that fluid intelligence tended to peak in very early adulthood and then to decline, while crystallized intelligence tended to increase over the life cycle. Findings from a series of studies conducted over four decades, summarized by Almlund et al. (2011), indicate that how well individuals perform on intelligence tests is influenced not only by cognitive abilities but also by how much effort they exert, reflecting their motivation and related intrapersonal competencies.

This growing body of evidence showing that dimensions of intelligence are malleable has important implications for teaching and learning. Recent research on interventions designed to increase motivation has found that a learner who views intelligence as changeable through effort is more likely to exert effort in studying (Yaeger and Walton, 2011; see further discussion in Chapter 4).

In the intrapersonal and interpersonal domains, Roberts, Walton, and Viechtbauer (2006) found that both the intrapersonal competency of conscientiousness (sometimes called self-direction or self-management in lists of 21st century skills) and the interpersonal competency of social assertiveness increase with age. Srivastava et al. (2003) analyzed data from the "big five" personality inventories completed by a large sample of over 130,000 adults, finding that both conscientiousness and the interpersonal skill of agreeableness increased throughout early and middle adulthood. The authors also found that neuroticism declined with age among women, but not among men. Reflecting on these various patterns of change, Srivastava et al. (2003) concluded that personality traits are complex and subject to a variety of developmental influences.

In contrast to the prevailing view of personality traits as fixed, some researchers have argued that individual human behavior demonstrates no consistent patterns and instead changes continually in response to various situations (e.g., Mischel, 1968). Based on a review of the research related to both points of view, Almlund and colleagues concluded that "although personality traits are not merely situation-driven ephemera, they are also not set in stone," and suggested that these traits can be altered by experience, education, parental investments, and targeted interventions (Almlund et al., 2011, p. 9). They proposed that interventions to change personality are promising avenues for reducing poverty and educational disadvantage.

With this view of malleability in mind, the committee reviewed lists of 21st century skills included in eight recent reports and papers (see Appendix B). We selected reports and papers for review if they built on, synthesized, or analyzed previous work on 21st century skills. For example, we included a report that reviewed 59 international papers on 21st century skills and found that the skills most frequently referred to were collaboration, communication, information and communications technology (ICT) literacy, and social or cultural competencies (Voogt and Pareja Roblin, 2010). We selected a white paper commissioned by the Assessment and Teaching of 21st Century Skills project that synthesized many previous lists of 21st century skills and organized them into a taxonomy of skills (Binkley et al., 2010). We also included a document from the Hewlett Foundation that lists 15 skills based on previous research by the OECD (Ananiadou and Claro, 2009). In addition, we included papers commissioned by the NRC to more clearly define 21st century skills (e.g., Finegold and Notabartolo, 2010; Hoyle and Davisson, 2011) and a list of college outcomes developed by Oswald and colleagues (2004) based on an analysis of college mission statements.

The reports and papers on 21st century skills used different language to describe the same construct, an instance of the "jangle fallacy" (Coleman and Cureton, 1954). Early in the history of mental measurement, Kelly (1927) observed that investigators sometimes used different measures—and the names associated with these measures—to study and describe a single psychological construct or competency. This problem, which he referred to as the "jangle fallacy," caused waste of scientific resources, as multiple tests were used to study the same construct, and investigators who used one measure to study the construct sometimes ignored the research results of other investigators who used other measures to study the same construct. Today measurement experts continue to struggle with the question of whether various constructs represent different names for the same underlying psychological phenomenon or are truly different dimensions of human competence. A 2002 paper, for example, addressed the question of whether separate measures of self-esteem, neuroticism, locus of control, and generalized self-efficacy were in fact focusing on a single core construct (Judge et al., 2002). The committee identified the "jangle fallacy" in reports that listed, for example, both teamwork and collaboration and both flexibility and adaptability as individual 21st century skills (see Appendix A).

To address this problem, the committee clustered various terms for 21st century skills around a small number of constructs, creating a preliminary taxonomy that may be useful in future research. To identify this small number of constructs, we turned to extant taxonomies of human abilities that have a solid basis in the differential psychology research. Research-based taxonomies are available covering both cognitive (Carroll, 1993) and noncognitive (Goldberg, 1992) competencies. Based on a content analysis, we assigned different 21st century skills from the recent reports into domains within those taxonomies. In addition, we compared the recent reports with earlier reports on workplace skill demands, including the Secretary's Commission on Achieving Necessary Skills (SCANS) report (1991) and the Occupational Information Network (O*NET) report (Peterson et al., 1997).

Skills as Latent Variables and Two Kinds of Latent Variables

It is useful to differentiate between a construct, such as a competency, and its measurement. Social scientists and human resource managers routinely measure a competency, such as leadership, in a variety of ways, ranging from a self-report Likert scale to a workplace performance appraisal or an inbox test. Separating the construct from its measurement is valuable conceptually because a construct may be important even if its measurement is poor. In psychometric modeling, constructs viewed as separate from their measures are referred to as latent (as opposed to observed or measured) variables. There are two types of latent variables: reflective latent variables and formative latent variables (see Figure 2-1).

Following a concept proposed by Spearman (1904, 1927), a reflective latent variable is identified based on correlations among scores from a set of tasks. Differential psychologists discover reflective latent variables using factor analysis and related methods to identify the patterns of correlations among a set of "indicator variables"—scores on tests and rating instruments used to measure cognitive and noncognitive competencies. A reflective latent variable—such as general cognitive ability or one of the "big five" personality factors (McCrae and Costa, 1987)—is thought to reflect the essence of, or the commonality among, the various competencies measured. In psychometric modeling, a reflective latent variable (also called a *factor* because it is discovered through factor analysis) is said to cause the relationships among the set of indicator variables (see Figure 2-1). For example, extraversion, a personality factor, is thought to cause relatively high scores on instruments measuring warmth, gregariousness, and assertiveness. Within a reflective latent variable, the importance or weighting of an individual indicator variable is a function of how highly that particular indicator variable correlates with other indicator variables for the reflective latent variable (Bollen and Lennox, 1991).

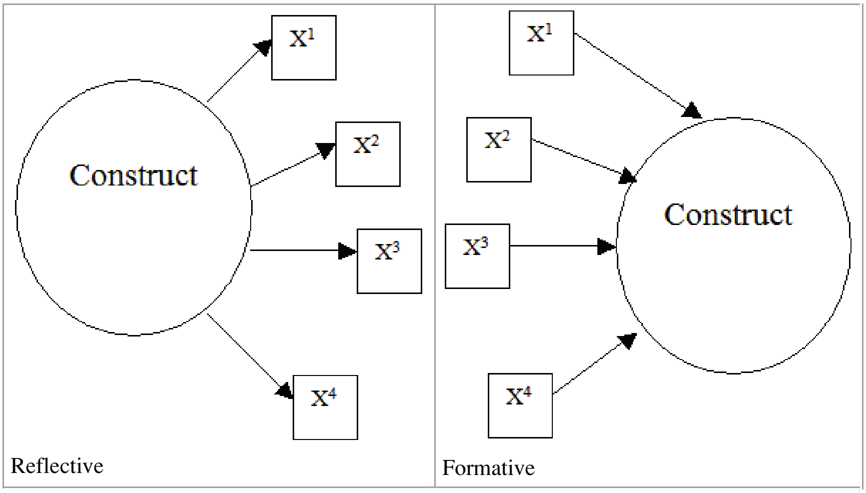

FIGURE 2-1 Casual structures in reflective and formative latent variables.
SOURCE: Stenner, Burdick, and Stone (2008). Reprinted with permission.

A formative latent variable is very different from a reflective latent variable in that the direction of causality runs from the observed indicator variable to the formative latent variable. The indicator variables may be positively correlated, uncorrelated, or even negatively correlated, and patterns of correlations among them are not used to identify formative latent variables. Instead, experts identify formative latent variables through a variety of other means, such as through consensus opinion or traditions in a field. Formative latent variables can be thought of as a "stew"—a mixture of elements that might or might not be related. The various lists of 21st century skills that have been proposed to date are formative variables, identified by consensus opinion and through reviews of earlier reports and standards documents (e.g., Secretary's Commission on Achieving Necessary Skills, 1991; American Association of School Libararians and Association for Educational Communications and Technology, 1998).

Reflective Latent Variables: Taxonomies of Cognitive and Noncognitive Competencies

Because reflective latent variables (factors) are based on empirical research, they provide a strong framework for organizing the formative variables included in lists of 21st century skills. Taxonomies of reflective latent variables are available for both cognitive (Carroll, 1993) and noncognitive (Goldberg, 1992) competencies.

Cognitive Abilities Taxonomy

Carroll (1993) conducted a secondary analysis of over 450 correlation matrices of cognitive test scores that had been produced between 1900 and 1990. He sought to identify a common structure to characterize the pattern of correlations among tests and thereby to identify the factors of human cognition. He found that the data were consistent with a "three stratum" hierarchical model with a general cognitive ability factor at the top, eight second-order abilities (factors) at the middle level, and 45 primary abilities at the bottom of the taxonomy. The second-order factors identified were as follows (with the corresponding primary abilities shown in parentheses):

- Fluid intelligence (reasoning, induction, quantitative reasoning, and Piagetian reasoning, a collection of abstract reasoning abilities described in Piaget's 1963 theory of cognitive development, such as the ability to organize materials that possess similar characteristics into categories and an awareness that physical quantities do not change in amount when altered in appearance)

- Crystallized intelligence (verbal comprehension, foreign language aptitude, communication ability, listening ability, and the ability to provide missing words in a portion of text)
- Retrieval ability (originality/creativity, the ability to generate ideas, and fluency of expression in writing and drawing)
- Memory and learning (memory span, recall by association, free recall, visual memory, and learning ability)
- Broad visual perception (visualization, spatial relations, speed in perceiving and comparing images, and mental processing of images)
- Broad auditory perception (hearing and speech, sound discrimination, and memory for sound patterns)
- Broad cognitive speediness (rate of test taking [tempo] and facility with numbers)
- Reaction time (computer) (simple reaction time to respond to a stimulus, reaction time to choose and make an appropriate response to a stimulus, and semantic retrieval of general knowledge)

We focused the content analysis on the first three factors—fluid intelligence, crystallized intelligence, and retrieval ability—because the primary abilities they included were most closely related to the 21st century skills discussed in the reports and documents. It is important to note that our content analysis did not address how valuable any of the 21st century skills may be for influencing later success in employment, education, or other life arenas. To carry out the content analysis we simply took lists of competencies that other individuals and groups have proposed are valuable and aligned them with research-based taxonomies of cognitive and noncognitive competencies. In the following chapter, we discuss research on the relationship between various competencies and later education and employment outcomes.

Personality Taxonomy

For the past two decades, the "big five" model of personality has been widely accepted as a way to characterize competencies in the interpersonal and intrapersonal domains (McCrae and Costa, 1987; Goldberg, 1993). It is based on the *lexical hypothesis*, which suggests that language evolves to characterize the most salient dimensions of human behavior, and so by analyzing language and the way we use it to describe ourselves or others it is possible to identify the fundamental ways in which people differ from one another (Allport and Odbert, 1936). Based on a review of English dictionaries, psychologists identified personality-describing adjectives and developed many instruments to measure these characteristics. Multiple, independent factor–analytic studies of scores on these instruments, using different samples, converged on five personality factors (Almlund et al., 2011).

This taxonomy has been replicated in many languages, yielding approximately the same five dimensions,[2] defined as follows (American Psychological Association, 2007):

- Openness to experience: the tendency to be open to new aesthetic, cultural, or intellectual experiences
- Conscientiousness: the tendency to be organized, responsible, and hardworking
- Extroversion: an orientation of one's interests and energies toward the outer world of people and things rather than toward the inner world of subjective experience
- Agreeableness: the tendency to act in a cooperative, unselfish manner
- Neuroticism: a chronic level of emotional instability and proneness to psychological distress. The opposite of neuroticism is emotional stability, defined as predictability and consistency in emotional reactions, with absence of rapid mood changes.

Reflecting the fact that they were derived from factor analysis, the five factors are intended to be orthogonal, or uncorrelated with one another. Each can be broken down further into personality facets, which are sets of intercorrelated factors. Facets are not as stable across cultures as the major five dimensions are, but they nevertheless prove useful ways to characterize individual differences more precisely (Paunonen and Ashton, 2001). When various proposals for facets are combined with the five factors, the result is a hierarchical taxonomy. Although no clear consensus has emerged on exactly which facets should be used to further characterize the five personality dimensions, the facets suggested by Costa and McCrae (1992) are widely used and are presented here to illustrate the range of individual characteristics encompassed by each of the five factors:

- Conscientiousness (competence, order, dutifulness, achievement striving, self-discipline, deliberation)
- Agreeableness (trust, straightforwardness, altruism, compliance, modesty, tender-mindedness)
- Neuroticism (anxiety, angry hostility, depression, self-consciousness, impulsiveness, vulnerability)

[2]Some languages identify a sixth factor related to honesty (e.g., Ashton, Lee, and Son, 2000).

- Extroversion (warmth, gregariousness, assertiveness, activity, excitement seeking, positive emotions)
- Openness to experience (fantasy, aesthetics, feelings, actions, ideas, values)

To the facets of the neuroticism/emotional stability factor proposed by Costa and McCrae (1992) we added "core self-evaluation," based on a proposal by Judge and Bono (2001). This additional proposed construct is based on empirical findings of correlations between measures of self-esteem, generalized self-efficacy, locus of control,[3] and emotional stability. Almlund et al. (2011) also found that self-esteem and locus of control are related to emotional stability.

The five major factors provided a small number of research-based constructs onto which various terms for 21st century skills could be mapped. The facets helped to define the range of skills and behaviors encompassed within each major factor to serve as a point of comparison with the various 21st century skills.

Formative Latent Variables: Occupational Skills and Other Examples

Unlike reflective latent variables that are discovered, formative latent variables are constructed. Relationships between variables do not constrain the development of formative latent variables; rather, formative latent variables can be whatever a person or community defines them to be. Classic examples appear in economics, such as the consumer price index; in health, such as the stress index; and in business research, such as leadership or positive experience with a product (Jarvis, Mackenzie, and Podsakoff, 2003).

One set of formative latent variables that may be particularly relevant for defining 21st century competencies was identified through expert consensus in the O*NET project (Peterson et al., 1999). O*NET is a large database of information on 965 occupations that is organized around a "content model," which describes occupations along several dimensions, including worker characteristics (abilities, interests, work values, and work styles) and requirements (skills, knowledge, and education). The skills included in the O*NET content model are similar to those in current lists of 21st century lists, as shown in Table 2-1.

[3]In differential psychology, *locus of control* refers to the extent to which individuals believe that they can control their own lives (an internal locus of control) or that outside influences control what happens (an external locus of control), as measured by the Rotter scale (Rotter, 1990). The "locus of control" construct has been criticized as being too general, and most researchers currently differentiate beliefs about causality as delineated in attribution theory.

TABLE 2-1 Skills in the O*NET Content Model

Basic Skills	
Content Skills	**Process Skills**
Active listening	Active learning
Reading comprehension	Learning strategies
Writing	Monitoring
Speaking	Critical thinking
Mathematics	
Science	
Cross-Functional Skills	
Complex Problem Solving	**Social Skills**
Complex problem solving	Social perceptiveness
	Coordination
	Persuasion
	Negotiation
	Instruction
	Service orientation
Technical Skills	**Systems Skills**
Operations analysis	Systems analysis
Technology design	Judgment and decision making
Equipment selection	Systems evaluation
Installation	
Programming	
Quality control analysis	
Operation monitoring	
Equipment maintenance	
Troubleshooting	
Repairing	
Resource Management Skills	
Time management	
Management of financial resources	
Managing material resources	
Managing personnel resources	

SOURCE: Adapted from Peterson et al. (1997). Copyright 1999 by the American Psychological Association. Reproduced with permission. The use of APA information does not imply endorsement by APA.

Aligning Lists of 21st Century Skills with Ability and Personality Factors

As a first step toward aligning various lists of competencies included in the reports and documents on 21st century skills with ability and personality factors, the committee compared the eight reports and documents mentioned above, identifying areas of overlap and differences. Another useful step was to divide the various competencies into the three domains

TABLE 2-2 Clusters of 21st Century Competencies

	Cluster	Terms Used for 21st Century Skills	O*NET Skills	Main Ability/ Personality Factor
COGNITIVE COMPETENCIES	***Cognitive Processes and Strategies***	Critical thinking, problem solving, analysis, reasoning/argumentation, interpretation, decision making, adaptive learning, executive function	System skills, process skills, complex problem-solving skills	Main ability factor: fluid intelligence (Gf)
	Knowledge	Information literacy (research using evidence and recognizing bias in sources); information and communications technology literacy; oral and written communication; active listening	Content skills	Main ability factor: crystallized intelligence (Gc)
	Creativity	Creativity, innovation	Complex problem-solving skills (idea generation)	Main ability factor: general retrieval ability (Gr)

INTRA-PERSONAL COMPETENCIES	***Intellectual Openness***	Flexibility, adaptability, artistic and cultural appreciation, personal and social responsibility (including cultural awareness and competence), appreciation for diversity, adaptability, continuous learning, intellectual interest and curiosity	[none]	Main personality factor: openness
	Work Ethic/ Conscientiousness	Initiative, self-direction, responsibility, perseverance, productivity, grit, Type 1 self-regulation (metacognitive skills, including forethought, performance, and self-reflection), professionalism/ ethics, integrity, citizenship, career orientation	[none]	Main personality factor: conscientiousness
	Positive Core Self-Evaluation	Type 2 self-regulation (self-monitoring, self-evaluation, self-reinforcement), physical and psychological health	[none]	Main personality factor: emotional stability (opposite end of the continuum from neuroticism)

continued

TABLE 2-2 Continued

	Cluster	Terms Used for 21st Century Skills	O*NET Skills	Main Ability/ Personality Factor
INTER-PERSONAL COMPETENCIES	***Teamwork and Collaboration***	Communication, collaboration, teamwork, cooperation, coordination, interpersonal skills, empathy/perspective taking, trust, service orientation, conflict resolution, negotiation	Social skills	Main personality factor: agreeableness
	Leadership	Leadership, responsibility, assertive communication, self-presentation, social influence with others	Social skills (persuasion)	Main personality factor: extroversion

SOURCE: Created by committee.

of cognitive, intrapersonal, and interpersonal competence. Using this approach we found that some of the documents that dealt with 21st century skills focused primarily on one category. For example, Conley's 2007 list of college readiness skills deals mainly with cognitive competencies, while Hoyle and Davisson's 2011 analysis of self-regulation focuses on intrapersonal competencies.

Next, the committee conducted a content analysis, comparing the various competencies included in the eight documents with the reflective latent variables at the top of the cognitive abilities and personality taxonomies. Based on the comparative content analysis, we aligned the various 21st century skills with each other and with the two taxonomies. In addition, we also aligned O*NET skills and additional noncognitive competencies with the two taxonomies. Through these steps we created clusters of closely related competencies within each of the three broad domains (see Table 2-2). Each competency cluster contains the main factor (personality or ability) and the associated 21st century skills and O*NET skills. The result is a preliminary taxonomy of 21st century competencies, which we offer as a starting point for further research.

Based on the committee's content analysis, some of the competencies that appeared in the eight documents and reports were not included in any of the clusters. These included life and career skills (Binkley et al., 2010), social and cultural competencies (Voogt and Pareja Roblin, 2010), study skills and contextual skills (Conley, 2007), and nonverbal communication and intercultural sensitivity (Bedwell, Fiore, and Salas, 2011). These particular competencies were excluded because they did not align well with any of the clusters, rather than because of any judgment that they were less valuable for later life outcomes. In the following chapter, we discuss the question of whether various competencies predict success in education, the workplace, or other areas of adult life.

We offer the proposed taxonomy of competency clusters as an initial step toward addressing the "jangle fallacy." It provides a starting point for further research that may more clearly define each construct and establish its relationship with the other constructs. However, research to date on the importance of 21st century competencies uses a variety of terms for these skills, coined by investigators in the different disciplines. Our review of this research in the following chapter reflects this variety of terms.

SUMMARY

Although many lists of 21st century skills have been proposed, there is considerable overlap among them. Many of the constructs included in such lists trace back to the original SCANS report (Secretary's Commission on Achieving Necessary Skills, 1991), and some now appear in the O*NET database. Aligning the various competencies with extant, research-based personality and ability taxonomies illuminates the relationships between them and suggests a preliminary new taxonomy of 21st century competencies. Much further research is needed to more clearly define the competencies at each level of the proposed taxonomy, to understand the extent to which various competencies and competency clusters may be malleable, to elucidate the relationships among the competencies, and to identify the most effective ways to teach and learn these competencies.

3

Importance of Deeper Learning and 21st Century Skills

This chapter summarizes research on the importance of deeper learning and "21st century skills" to success in education, work, and other areas of adult responsibility. The first section focuses on educational achievement and attainment, the second section on work, the third on health and relationship skills, and the fourth on civic participation. Overall, the research reviewed in these sections finds statistically significant, positive relationships of modest size between various cognitive, intrapersonal, and interpersonal competencies and desirable adult outcomes. However, these relationships are based on correlational research methods.

We also reviewed evidence on the role of formal schooling in adult success, which we include in the sections on work and health. We found statistically significant, positive relationships between years of educational attainment and labor market success, not only in research using correlational methods, but also in studies using stronger research methods (see discussion below). Measured cognitive, intrapersonal, or interpersonal competencies appeared to account for surprisingly little of these relationships between years of educational attainment and labor market success. In the fifth section, we show that the benefits of additional years of formal schooling for individuals include not only higher wages but also somewhat greater adaptability to changes in workplace technology and in jobs.

The literature discussed in this chapter comes from a variety of disciplines, including industrial-organizational psychology, developmental psychology, human resource development, and economics. Researchers in these disciplines have investigated the relationship between a range of different skills and abilities and later outcomes, using a variety of methods and data sets. Some of the evidence we present is correlational in nature, and we call these "simple correlations." Other evidence is longitudinal, in which competencies and other capacities measured at one point are related to outcomes measured years later, often after adjusting for individuals' differences in family backgrounds. We call these "adjusted correlations" and view this evidence as more suggestive of causal connections than the evidence from simple correlations, but still prone to biases from a variety of sources. The strongest causal evidence, particularly the evidence of the impacts of years of completed schooling on adult outcomes, comes from statistical methods that are designed to approximate experiments.

IMPORTANCE TO EDUCATIONAL SUCCESS

Many more studies of school success have focused on the role of general cognitive ability (IQ) than specific interpersonal and intrapersonal competencies (see Table 3-1). Economists tend to lump all competencies other than IQ into the category of "noncognitive skills." Personality and developmental psychologists have developed a much more refined taxonomy of them.

Most personality psychologists have centered their work on the "big five" personality traits—conscientiousness, openness, agreeableness, emotional stability, and extroversion—plus general cognitive ability. Although these traits have traditionally been viewed as relatively stable across the life span, a growing body of evidence indicates that that personality traits change in response to general life experiences (e.g., Roberts, Walton, and Viechtbauer, 2006; Almlund et al., 2011) and to structured interventions (see Chapters 4 and 5).

Developmental psychologists have a dynamic view of competence and behavioral development, with children's competencies and behaviors determined by the interplay between their innate abilities and dispositions and the quality of their early experiences (National Research Council, 2000). Both groups have investigated associations among cognitive, intrapersonal, and interpersonal competencies and children's success in school.

Personality Factors and School Success

The comprehensive Almlund et al. (2011) study of personality and attainment offers the following summary of "prediction" evidence on correlations and, in some cases, adjusted correlations between personality traits and educational attainment (see also Table 3-1):

> Measures of personality predict a range of educational outcomes. Of the Big Five, Conscientiousness best predicts overall attainment and achieve-

> ment. Other traits, such as Openness to Experience, predict finer measures of educational attainment, such as attendance and course difficulty. Traits related to Neuroticism also affect educational attainment, but the relationship is not always monotonic. Conscientiousness predicts college grades to the same degree that SAT scores do. Personality measures predict performance on achievement tests and, to a lesser degree, performance on intelligence tests. (p. 127)

It is important to note that while these associations are large enough to pass conventional thresholds of statistical significance, they almost never account for more than a nominal amount of the variation in the educational attainment outcomes under study.

The most noteworthy meta-analysis of these kinds of data is by Poropat (2009), who examined studies of the simple correlations between personality factors and school grades in primary, secondary, and higher education.[1] He found a significant positive association between conscientiousness and grades in primary school through college (see top half of Table 3-2). The simple correlations between conscientiousness and grades in high school and college were in the 0.20-0.25 range, about as high as the correlations between measures of general cognitive ability and grades in high school and college.[2] In comparison with other correlates of grades identified in previous studies, these two correlations are at approximately the same level as socioeconomic status (Sirin, 2005) and slightly lower than the correlations found for conscientiousness in industry training programs (Arthur et al., 2003).

In elementary school, general cognitive ability is the strongest correlate of grades, although all five personality factors are positively correlated with grades. Correlations between personality factors and grades generally fall over the course of high school and college. In higher education, among the five personality factors, only conscientiousness is correlated with grades.

Three studies of the correlations between "big five" personality traits and completed schooling have included at least some regression controls (Goldberg et al., 1998; van Eijck and de Graaf, 2004; Almlund et al., 2011). All find positive adjusted associations for concientiousness that range from 0.05 to 0.18, and all find modest negative adjusted associations for extroversion, agreeableness, and neuroticism.

[1] The Poropat (2009) analysis included many more studies focused on grades in secondary (24-35 studies) and higher education (75-92 studies) than in elementary school (8 studies).

[2] In social science research, such correlations are generally interpreted following rules of thumb developed by Cohen (1988), in which a correlation of 0.20 is considered small, a correlation of 0.50 is considered medium, and a correlation of 0.80 is considered large.

TABLE 3-1 Key Studies Cited in Chapter 3: The Importance of Deeper Learning and 21st Century Skills

Reference	Key Findings/Conclusions	Research Methods	Measures of Skills
Studies of Personality Factors			
Almlund et al. (2011)	Conscientiousness has strong correlations with outcomes from a number of adult domains.	Research synthesis	"Big five" personality traits measured using a variety of direct and indirect methods
Studies of the Relationship Between Skills and Educational Attainment			
Duncan et al. (2007)	Reading, math, and attention skills at school entry predict subsequent reading and math achievement. Neither behavior problems nor mental health problems were associated with later achievement, holding constant achievement as well as child and family characteristics.	Formal meta-analysis of standardized regression coefficients emerging from the 236 individual study regressions analyzing the relationship between school-entry reading and math achievement and noncognitive skills and later reading and math achievement. Controls for general cognitive ability, behavior and temperament and parent education and income were included in the regressions.	<u>Cognitive Skills:</u> Measures of school-entry reading and math achievement <u>Interpersonal and Intrapersonal Skills:</u> The six longitudinal data sets included measures of attention (intrapersonal), antisocial behavior (both intrapersonal and interpersonal), and mental health (intrapersonal).
Duncan and Magnuson (2011)	Although school-entry reading and math achievement skills predicted later school achievement, single point-in-time assessments of primary school skills were relatively weakly predictive of later outcomes. Children with persistent math or behavior problems were much less likely to graduate from high school or attend college and those with	Review of theory and empirical studies of the relationship between young children's skills and behaviors and their later attainments. The studies included measures of individual students' skills at multiple points in time to identify persistent patterns.	<u>Cognitive Skills:</u> Measures of school-entry reading and math achievement <u>Interpersonal and Intrapersonal Skills:</u> The studies included measures of attention (intrapersonal), antisocial behavior (both intrapersonal and interpersonal), and mental health (intrapersonal).

	persistent behavior problems were much more likely to be arrested or jailed.		
Poropat (2009)	At the elementary school level, cognitive ability is the strongest predictor of grades. At the high school and college levels, cognitive ability is a weaker predictor of grades and conscientiousness is the only personality factor that predicts grades. Where tested, correlations between conscientiousness and academic performance were largely independent of measures of cognitive ability. Studies controlling for secondary academic performance found conscientiousness predicted college grades at about the same level as measures of cognitive ability.	Meta-analysis of studies of the correlation between personality traits and academic performance. Most of the studies came from higher education, with a smaller sample from primary education.	Cognitive Skills: Some of the studies included tests of general cognitive ability. Interpersonal Skills: Measures of agreeableness and extroversion Intrapersonal Skills: Measures of conscientiousness, emotional stability, and openness

continued

TABLE 3-1 Continued

Reference	Key Findings/Conclusions	Research Methods	Measures of Skills
Studies of the Relationship Between Skills and Income/Earnings/Job Performance			
Autor, Levy, and Murnane (2003)	From 1970 to 1988, across the U.S. economy, computerization reduced routine cognitive and manual tasks and increased nonroutine cognitive and interactive tasks. This model explains 60% of the growth in college-educated labor from 1970-1988. Conclusion: Demand is growing for nonroutine problem-solving and complex communication skills.	Paired representative data on job task requirements from the Dictionary of Occupational Titles (DOT) with samples of employed workers from the Census and CPS to create a consistent panel of industry and occupational task input from 1960 to 1998.	<u>Cognitive:</u> DOT measures of: nonroutine cognitive tasks: (1) level of direction, control, and planning of activities; and (2) quantitative reasoning <u>Manual Tasks:</u> DOT measures of routine manual tasks: finger dexterity and nonroutine tasks: eye-hand-foot coordination <u>Interpersonal and Intrapersonal:</u> No direct measures
Barrick, Mount, and Judge (2001) (job performance)	Conscientiousness is a valid predictor of job performance across all performance measures in all occupations studied, with average correlations ranging from the mid .20s to low .30s.	Second-order meta-analysis of the results of 11 prior meta-analyses of the relationship between Five Factor Model personality traits and job performance.	<u>Cognitive:</u> No measures <u>Interpersonal:</u> Measures of extroversion, agreeableness <u>Intrapersonal:</u> Measures of emotional stability, conscientiousness, and openness to experience
Cunha and Heckman (2008) (earnings and high school graduation)	Increased parental investments in their children's skills impact adult earnings and high school graduation rates through effects on both cognitive and noncognitive	Dynamic factor model used to address endogeneity of inputs and multiplicity of parental inputs relative to instruments. Estimated the scale of the factors by estimating	<u>Cognitive Skills:</u> Tests of mathematics and reading recognition <u>Interpersonal and Intrapersonal:</u> Several subscores of the Behavioral Problems

	skills. Improvements in noncognitive skills raised both cognitive and noncognitive skills.	their effects on high school graduation and earnings at age 23. Data: Sample of 1,053 white males from the CNLSY/79 data set	Index were combined into a single measure of noncognitive skills. <u>Measures of Parental Investments:</u> Number of books, number of musical instruments, newspaper subscriptions, special lessons, trips to the museum, trips to the theater
Lindqvist and Vestman (2011)	Conclusion: Noncognitive ability is considerably more important than cognitive ability for success in the labor market.	Multiple regression analysis. Authors used ordinary least squares to estimate the effect of cognitive and noncognitive skills on wages, earnings, and unemployment. They matched a dataset on socioeconomic outcomes for a representative sample of the Swedish population with data from the military enlistment.	<u>Cognitive Skills:</u> Test of general intelligence <u>Intrapersonal and Interpersonal Skills:</u> Authors used the overall score and the sum of the subscores assigned by a certified psychologist on the basis of a semi-structured, 25-minute interview. The interview is designed to measure the ability to function during armed combat. A high score reflects both intrapersonal and interpersonal skills
Studies of the Relationship Between Skills and Health			
Cutler and Lleras-Muney (2010a)	The effect of education on health increases with increasing years of education and appears to be related to critical thinking and decision-making patterns.	1990, 1991, and 2000 waves of the National Health Interview Survey, National Death Index	Completed years of schooling

SOURCE: Created by the committee.

TABLE 3-2 Correlations and Regression-Adjusted Associations Among Skills, Behaviors, and School Performance

	Concurrent (simple) Correlations			Longitudinal (simple) Correlations	Regression-Adjusted Correlations
	Primary school	Secondary	Tertiary	Primary	Primary
Personality Factors	Outcome is school grades.				
Conscientiousness	.28	.21	.23		
Openness	.24	.12	.07		
Agreeableness	.30	.05	.06		
Emotional stability	.20	.01	–.01		
Extroversion	.18	–.01	–.03		
Cognitive ability	.58	.24	.23		
Skills and Behaviors	Outcome is reading achievement.			Outcomes are later reading and math achievement.	
	Kindergarten	5th grade		Kindergarten	Kindergarten
Reading achievement	—			.44	.13
Math achievement	—			.47	.33
Attention	.29	.38		.25	.07
Antisocial behavior	–.07	–.25		–.14	–.01
Mental health	–.12	–.20		–.10	.00

NOTE: Concurrent correlations for personality factors and cognitive ability come from Poropat (2009). Concurrent correlations for skills and behaviors in kindergarten and fifth grade come from Duncan and Magnuson (2011). Longitudinal and regression-adjusted correlations are from Duncan et al. (2007). Regression controls in the final column include family background, child temperament, and IQ.
SOURCE: Created by the committee.

Skills, Behaviors, and School Success

There are many ways that developmental psychologists classify competencies in the cognitive, intrapersonal, and interpersonal domains, and some of their categories correspond to some of the "big five" personality traits. One recent review classified important competencies into four groups: achievement, attention, behavior problems, and mental health (Duncan and Magnuson, 2011).

Achievement, in the cognitive domain, refers to concrete academic competencies such as literacy (e.g., for kindergarteners, decoding skills such as beginning to associate sounds with letters at the beginning and end of words) and basic mathematics (e.g., ability to recognize numbers and shapes and to compare relative sizes). Although scores on tests of cognitive ability and achievement tend to have substantial correlations, there is an important conceptual difference between cognitive ability as a relatively stable trait and the concrete achievement competencies that develop in response to schooling and other environmental inputs.

Attention, in the intrapersonal domain, refers to the ability to control impulses and focus on tasks (e.g., Raver, 2004). Developmental psychologists often distinguish between two broad dimensions of behavior problems that reflect the domains of interpersonal and intrapersonal competencies—externalizing and internalizing. Externalizing behavior refers to a cluster of related behaviors, including antisocial behavior, conduct disorders, and more general aggression (Moffitt, 1993; Campbell, Shaw, and Gilliom, 2000). Internalizing behavior refers to a similarly broad set of mental health constructs, including anxiety and depression as well as somatic complaints and withdrawn behavior (Bongers et al. ,2003).[3]

Many studies have established simple and, in some cases, adjusted correlations between this set of intrapersonal and interpersonal competencies and academic outcomes in the early grades (e.g., Vitaro et al., 2005, and Currie and Stabile, 2007, for attention; Pianta and Stuhlman, 2004, for antisocial behavior; and Fantuzzo et al., 2003, for depressive symptoms). Duncan and Magnuson (2011) use nationally representative data on kindergarteners and fifth graders to compute the simple correlations shown in the bottom left panel of Table 3-2. Since letter grades are rarely recorded in the early grades, the table shows correlations between reading achievement and measures of attention, antisocial behavior and mental health. All are substantial by fifth grade, with the expected positive achievement

[3]Cutting across the attention and externalizing categories is the idea of self-regulation, which current theory and research often subdivides into separate cognitive (cool) and emotional components (hot) (Raver, 2004; Eisenberg et al., 2005; Raver et al., 2005). Cognitive self-regulation fits into our "attention" category while emotional self-regulation fits into our "behavior problems" category.

associations for attention and negative associations for antisocial behavior and mental health problems. All of these associations are smaller in kindergarten, which, in contrast with the research on personality factors (Poropat, 2009), suggests increasing correlations as children grow older.

Averaging across six longitudinal data sets, Duncan et al. (2007) calculate the bivariate correlations shown in the "longitudinal correlations" column of Table 3-2. Shown here are simple correlations among kindergarten entry achievement, attention and behavioral competencies, and math and reading test scores measured 2-8 years later. Correlations between later achievement and the three measures of attention, antisocial behavior, and mental health problems are similar to what was found for corresponding correlations with kindergarten achievement shown in the first column. As might be expected, correlations between math and reading competencies at school entry and later in the elementary school years are quite high.

To more accurately assess the importance of any one of these competencies and behaviors for school and career success, some studies have gone beyond these simple correlations to account for the fact that children with different levels of a given competency or behavior are likely to differ in many other ways as well. Children with, say, higher math scores may also have higher IQs, be better readers, exhibit less antisocial behavior, or come from more advantaged families. When adjustments for differences in these other conditions are made, the size of the relationship between early competencies and behaviors and later outcomes tends to shrink. This is shown in the fifth and sixth columns of numbers in Table 3-2. A clear conclusion from these columns of numbers is that only three of the five school-entry competencies have noteworthy adjusted correlations with subsequent reading and math achievement: reading, math, and attention. Neither behavior problems nor mental health problems demonstrated a statistically significant positive correlation with later achievement, once achievement and child and family characteristics are held constant.[4]

Studies estimating bivariate correlations between high school completion and measures of early competencies and behaviors—including achievement, attention, behavior problems, and mental health—find them to be quite modest (.05 to .10; Entwisle, Alexander, and Olson, 2005; Duncan and Magnuson, 2011, Appendix Table 3.A9). Even when these competencies and behaviors are measured at age 14, none of the correlations with high school completion is stronger than .20.

Much larger correlations are observed for early indications that children have *persistent* deficits in some of these competencies and behaviors. In particular, children with persistently low mathematics achievement and

[4] A replication and extension analysis by Grissmer et al. (2010) also found predictive power for measures of fine motor skills.

persistently high levels of antisocial behavior across elementary school were 10-13 percentage points less likely to graduate high school and about 25 percentage points less likely to attend college than children who never have these problems (Duncan and Magnuson, 2011). In contrast, persistent reading and attention problems had very low adjusted correlations with these attainment outcomes.[5]

IMPORTANCE TO WORKPLACE SUCCESS

Technological advances, globalization, and other changes have fueled demand for more highly educated workers over the past four decades. Across much of the 1980s, the inflation-adjusted earnings of high school graduates plunged by 16 percent, while the earnings of college-educated workers rose by nearly 10 percent. In the following two decades, low-skill worker earnings continued to fall, while the earnings of college-educated workers continued their modest rise.[6]

How these occupation and education-related changes in the labor market affect the demand for cognitive, intrapersonal, and interpersonal competencies is the subject of this section. We begin with a brief review of the large literature on the economic payoff to years of formal education, and of the remarkably modest extent to which prior cognitive, intrapersonal, and interpersonal skills account for that payoff. We then turn to a more detailed discussion of trends in demand for 21st century competencies.

Educational Attainment and Employment Outcomes

From the pioneering work in the 1960s and 1970s of Schultz (1961), Becker (1964), and Mincer (1974) to the present, studies have shown that investments in education produce rates of monetary return that are comparable or higher than market rates on investment in physical capital. Remarkable in this literature is that the estimates have changed little as increasingly sophisticated studies have eliminated likely sources of bias in the estimation of the economic payoff to education, the most prominent of which is the self-selection of more able or motivated into higher levels of completed schooling.[7]

[5]These results come from an analysis in which the predictive power of any given skill or behavior was assessed after adjusting for the others and for family background characteristics.

[6]Autor, Katz, and Kearney (2008, Table 1). Data are based on weekly earnings for full-time workers with 5 years of experience. Earnings of high school dropouts fell even more than the earnings of high school graduates (see also Levy and Murnane, 2004).

[7]An overview of the efforts to address these bias issues is provided in Card (1999). One strategy for reducing bias from genetic factors is to use siblings or even identical twins to relate earnings and employment differences to schooling differences pairs of otherwise ¨similar¨

In most studies, the so-called private rate of return to added years of schooling (which relates the after-tax earnings benefits enjoyed by workers to the portion of the education costs they have borne) for the United States has varied between 7 and 11 percent, with even higher rates in many other countries (Psacharoupoulos and Patrinos, 2004). The social rate of return tends to be lower than the private rate of return because it includes the full resource costs of schooling provision, much of which is paid through government subsidies rather than the students themselves.

Barrow and Rouse (2005) have concluded that each additional year of schooling generates additional income of about 10 percent, a return that is about the same across the races. And Autor, Katz, and Kearney (2008, Figure 2A) estimate that the earnings advantage for college as opposed to high school graduates rose from about 50 percent higher in the mid-1970s to close to twice as high in 2005. In their summary of evidence on education curriculum, Altonji, Blom, and Maghir (2012) find greater labor market returns to more advanced high school courses and to engineering, business, and science majors in college.

Looking beyond earnings, Oreopoulos and Salvanes (2011) find that workers with higher educational attainment enjoy more nonmonetary employment advantages, including a higher sense of achievement, work in more prestigious occupations, and greater job satisfaction than comparable workers with lower levels of education. Those with more formal education are more likely to be selected for jobs that require further training and that merit training investment. Presumably, the rationale for basing selection decisions on the candidate's level of education is that the costs of training for reaching job proficiency are reduced when more educated persons are chosen for training programs (Thurow, 1975; Lynch, 1994). Finally, evidence suggests that one person's added years of schooling benefits others by raising the productivity of other workers at all levels of education (Moretti, 2004).[8]

In short, the economic importance of a highly educated workforce is impressive and, if anything, increasing. Since the schooling process

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individuals. For example, using Norwegian data, Oreopoulos and Salvanes (2011) find that, in comparison with their siblings, siblings with 1 additional year of education have annual incomes that are about 5 percent higher and lower probabilities of being unemployed or on welfare. Another is to use instrumental variable strategies based on, for example, compulsory schooling laws, where the obligatory age of school attendance determines the number of years and the permissible date at which students can leave. Since years of schooling under the compulsory attendance requirements are not subject to voluntary choice, differences in education are exogenous to other influences that might affect the amount of education obtained. None of these strategies is free from all potential biases, however.

[8]Using a different estimation strategy that focuses only on the returns to secondary schooling for individuals subject to compulsory school attendance laws, Acemoglu and Angrist produce a smaller, but still positive, estimate of external returns than Moretti (2004).

presumably imparts the competencies and behaviors that are responsible for these productivity advantages, it is important to know how cognitive, intrapersonal, and interpersonal competencies are connected to education's high rates of return.

Test Scores, Education, and Employment Outcomes

Cognitive competencies (as measured by standardized test scores) have the potential to play an important role in accounting for the links between schooling and earnings. First, since smarter people are more likely to acquire more schooling, failure to control for differences in prior cognitive competencies may bias estimates of the role of education *per se*. But second, even if two graduating high school seniors with identical cognitive competencies make different decisions about whether to attend college, the college experience itself might develop capabilities that command higher earnings from employers.

Surprisingly, empirical studies show that cognitive competencies are able to account for only a small fraction of the association between education and earning. Bowles, Gintis, and Osborne (2001) summarized 25 studies conducted over four decades, which yielded 58 estimates of earnings functions that incorporated test scores. They found that the estimated effect of schooling on earnings retained about 82 percent of its value, on average, after accounting for prior test scores, suggesting that most of the impact of years of educational attainment on earnings was attributable to determinants other than the cognitive competencies.

A second, more direct, approach to investigating the role of cognitive competencies on labor market outcomes does not involve the intervening role played by schooling. An extensive literature, including meta-analyses (e.g., Schmidt and Hunter, 1998, 2004) has examined the simple, unadjusted correlations between cognitive ability, personality factors, and job performance. Schmidt and Hunter (2004) reviewed several studies and meta-analyses, finding that measures of general cognitive ability were strongly correlated (the magnitude of these correlations was higher than 0.53) with occupational level, income, job performance, and job training performance. Comparing these correlations with those found in studies of the association between personality traits and job outcomes, they concluded that general cognitive ability was more important for later job success than conscientiousness or any other intrapersonal or interpersonal competency.

It is worth noting that an NRC committee (1989) reanalyzed the data from over 700 criterion-related studies of the concurrent correlations between scores on a test of general cognitive ability and measures of job performance (typically supervisor ratings, but in some cases, grades in a training course) in about 500 jobs. They found that, despite claims of much higher predictive validities (i.e., correlations) in the literature (U.S. Department of Labor, 1983), the average correlation in studies that had been conducted since 1972 was about .25 after correction for sampling error. Cognitive test scores explained about 6 percent of the variance in performance, leaving 94 percent to be explained by other factors. Estimates of predictive validities in one subsequent review of the empirical literature also reflected this modest range (Sackett et al., 2001).

Economists have favored prospective longitudinal studies of the relationship between cognitive competencies and earnings (Hanushek and Woessman, 2008). In their examination of the associations between earnings and the cognitive skills of 15-18-year-olds as measured by the Armed Forces Qualifying Test, Neal and Johnson (1996) found that, with no controls for family background, a one-standard deviation increase in test scores was associated with roughly a 20 percent increase in earnings for both men and women. Using data from the National Child Development Survey (NCDS), which has followed a cohort of British children born in 1958 through midlife, Currie and Thomas (1999) related scores on reading and math tests administered at age 7 to wages and employment at age 33. Even in the presence of extensive family background controls, their models show 10-20 percent earnings differentials when comparing both males and females in the top and bottom quartiles of the two test score distributions. Murnane, Willett, and Levy (1995) show links between the mathematics tests scores of two cohorts of high school seniors and their wages at age 24.

Intrapersonal and Interpersonal Competencies and Employment Outcomes

In an effort to understand the large amount of variation in earnings and other employment outcomes that cannot be attributed to cognitive competencies, researchers have begun to examine the role of a variety of intrapersonal and interpersonal competencies. As with our earlier review of the determinants of achievement and attainment, research divides into a focus on personality factors and on other competencies and behaviors.

Personality Factors

Almlund et al. (2011) summarize their review of correlational evidence on the role of "big five" personality traits for labor market outcomes as follows:

> Personality measures also predict a variety of labor market outcomes. Of the Big Five traits, Conscientiousness best predicts overall job performance but is less predictive than measures of intelligence. Conscientiousness,

> however, predicts performance and wages across a broad range of occupational categories, whereas the predictive power of measures of intelligence decreases with job complexity. Additionally, traits related to Neuroticism (e.g. locus of control and self-esteem) predict a variety of labor market outcomes, including job search effort. Many traits predict sorting into occupations, consistent with the economic models of comparative advantage. . . . Personality traits are valued differentially across occupations. (p. 127)

A key study in this literature is Barrick, Mount, and Judge (2001), which conducts a second-order meta-analysis of the results of 11 prior meta-analyses of the simple associations between Five Factor Model personality traits and job performance. They find that conscientiousness is a valid correlate of job performance across all performance measures studied, with average correlations ranging from the mid .20s to low .30s. Emotional stability was correlated with overall work performance although not with all of the work performance criteria examined. The remaining factors—extroversion, openness and agreeableness—failed to correlate consistently with overall work performance.

Skills, Behaviors, and Earnings

The literature on links between earnings and specific achievement and behavioral skills has employed prospective longitudinal data and well-controlled regression models, yielding stronger evidence than that provided by studies of simple correlations. For example, Heckman, Stixrud, and Urzua (2006), using data from the National Longitudinal Study of Youth (NLSY) estimate substantial adjusted correlations between earnings and a scale combining adolescent self-esteem and sense of personal effectiveness.

Carneiro, Crawford, and Goodman (2007) use data from the British NCDS to relate a wide variety of achievement and behavioral measures assessed when the sample children were 11 years old to later earnings. The diversity of their behavioral measures is reflected in their names: "anxiety for acceptance," "hostility toward adults," "withdrawal," and "restlessness." When summed into a single index, a standard deviation increase in this collection of antisocial skills and behaviors is found to be associated (net of parental background) with a 3.3 percent decrease in age-42 earnings, about one-fifth of the estimated positive association for a one standard-deviation increase in achievement tests scores. Ironically, an examination of the social and behavioral subscales found the greatest explanatory power for "inconsequential behavior"—a heterogeneous mixture of items related to inattention ("too restless to remember for long"), antisocial behavior ("in informal play starts off with others in scrapping and rough play"), and inconsistency ("sometimes eager, sometimes doesn't bother").

In more recent work, Cunha and Heckman (2008) used longitudinal data to study cognitive and noncognitive development over time as it affects high school completion and earnings. They developed a battery of noncognitive scores focused on an antisocial construct using student anxiety, headstrongness, hyperactivity, and peer conflict to go along with cognitive test scores in this analysis. Based upon the psychological, neurological, social, and other aspects of child development, they modeled the developmental path and estimated the impact of investments in cognitive and noncognitive competencies on high school graduation and earnings (at age 23) at three different periods during the age span from 6 to 13. The parental investments studied included purchases of books and musical instruments, newspaper subscriptions, special lessons, trips to the museum, and trips to the theater.

The authors found that the impact of investment returns shifts markedly as the child ages, from cognitive competencies at the earlier ages (6 and 7 to 8 and 9) to noncognitive competencies during the later period (9-13). They also found evidence that noncognitive outcomes contribute to cognitive test results, but little evidence that test scores affect noncognitive outcomes. This finding suggests that investments in noncognitive competencies may contribute to economic productivity not only directly but also by increasing cognitive achievement.

One difficulty in research evaluating and comparing the relative associations between labor market outcomes and both cognitive and noncognitive competencies is the lack of strong measures of noncognitive competencies. Cognitive competencies are measured using well-established and validated standardized testing methods. By contrast, noncognitive competencies are almost always measured by ratings rather than tests—either self-ratings or ratings by observers who are not experts.

Better measurement methods, for example, by trained psychologist observers, might result in more valid measurement and therefore an increase in the estimated importance of noncognitive competencies. This apparently is the finding of a study by Lindqvist and Vestman (2011), which analyzed data on military enlistees in Sweden, where enlistment is compulsory for male 18-year-olds. These individuals complete a cognitive ability test and an extensive questionnaire. A trained psychologist combined the latter with results from a 30-minute clinical interview to assess the individual's noncognitive competencies, particularly, responsibility, independence, outgoingness, persistence, emotional stability, and initiative. The researchers examined a Swedish database and were able to match labor market outcomes of 14,703 32- to 41-year-olds who had earlier been tested through the enlistment. Comparing the impact of cognitive and noncognitive measures on wages, unemployment, and annual earnings, they found that, in general, the adjusted correlations between these outcomes and their noncognitive variable were larger than the correlations of earnings with their cognitive variable. Men who did poorly in the labor market were especially likely to lack noncognitive abilities. In contrast, cognitive ability was a stronger correlate of wages and earnings for workers with earnings above the median.

But while this body of research on intrapersonal and interpersonal competencies is growing rapidly, there is little consensus emerging from it. The prospective studies reviewed above capitalize on the haphazard availability of measures in their data sets. Much further investment is needed to specify such competencies and measure them in a streamlined way. Such specification will be useful in understanding how best to teach noncognitive skills to students (Durlak and Weissberg 2011; see Chapter 6) and how mastery of such competencies may, in turn, affect employment, earnings, and other adult outcomes. The European Commission has begun to examine how noncognitive competencies and personality traits contribute to workplace success (Brunello and Schlotter, 2010).

Trends in Demand for 21st Century Competencies

Clearly, labor market demand for increased years of schooling has risen over the past four decades. There is also some evidence that employers currently value and reward a poorly identified mix of cognitive, intrapersonal and interpersonal competencies. As noted in previous chapters, the committee views 21st century skills as dimensions of human competence that have been valuable for many centuries, rather than skills that are suddenly new, unique, and valuable today. One change from the past may lie in society's desire that all students now attain levels of mastery—across multiple areas of skill and knowledge—that were previously unnecessary for individual success in education and the workplace. Another change may lie in the pervasive spread of digital technologies to communicate and share information. Although the underlying communications and information-processing competencies have not changed, they are applied at an increasing pace to accomplish tasks across various life contexts, including the home, school, workplace, and social networks. According to recent press reports, over half of the estimated 845 million Facebook users around the globe log on daily; among those aged 18 to 34, nearly half check Facebook within minutes of waking up and 28 percent do so before getting out of bed (Marche, 2012). An estimated 400 million people use Twitter to send or receive brief messages. Even in the world of print media, the pace of communication has quickened, as newspapers adopt a "digital first" strategy and publish fresh information online as news stories break (Zuckerman, 2012). Here, we review research addressing the question of whether such changes are increasing demand for cognitive, intrapersonal, and interpersonal competencies, and, if so, whether this will continue in the future.

The economy's need for different kinds of worker competencies has shifted over time due to a variety of factors, including shifts in the distribution of occupations. Blue collar jobs have shrunk dramatically over the past 40 years, declining from nearly one-third of all jobs in 1979 to only one-fifth of all jobs in 2009. Over the same time period, white collar administrative support jobs, such as filing clerks and secretaries, also declined. This rapid decline in middle-skill, middle-wage jobs has been accompanied by rapid growth at the top and bottom of the labor market, with a trend toward increasing polarization in wages and educational requirements (Autor, Katz, and Kearney, 2008).

The growth jobs at the top and bottom of the labor market is illustrated by Bureau of Labor Statistics (BLS) data, which organizes all occupations in 10 large clusters, three of which—professional/related, service, and sales—constitute fully half of the labor force. The two largest clusters—professional/related (e.g., computer science, education, healthcare professions) and service (e.g., janitorial, food service, nursing aids, home healthcare workers)—are at the opposite ends of the spectrum in terms of education and wages. These two clusters are projected to create more new jobs than all of the other 8 occupational clusters combined over the period 2008 to 2018 (Lacey and Wright, 2009).

Autor, Levy, and Murnane (2003) conducted a study that analyzed not only the mix of occupations but also the competencies demanded within occupations. Drawing on the *Dictionary of Occupational Titles* (a large catalogue of occupations and their characteristics), they developed measures of the routine and nonroutine cognitive tasks and routine and nonroutine manual tasks required by various occupations. Comparing tasks over time, from 1960 to 1998, they concluded that beginning in 1970 computers reduced routine cognitive and manual tasks and increased nonroutine cognitive and interactive tasks. Their model explained 60 percent of the growth in demand for college-educated labor over the period from 1970-1988. The authors concluded that computers substitute for workers in performing routine tasks and complement workers in performing nonroutine tasks.

Building on this study, Levy and Murnane (2004) argued that demand is growing for expert thinking (nonroutine problem solving) and complex communication competencies (nonroutine interactive skills). Levy and Murnane (2004) also proposed, that demand is growing for verbal and quantitative literacy. They view reading, writing, and mathematics as essential enabling competencies that supported individuals in mastering tasks that require expert thinking and complex communication production processes. Predicting that jobs requiring low or moderate levels of competence will continue to decline in the future, the authors recommended that schools teach complex communication and nonroutine problem-solving competencies, along with verbal and quantitative literacy, to all students.

More recently, Autor, Katz, and Kearney (2008) analyzed data on wages and education levels from 1962 to 2005. The analysis supports the argument that computers complement workers in performing abstract tasks (nonroutine cognitive tasks) and substitute for workers performing routine tasks. However, it also suggests that the continued growth of low-wage service jobs can be explained by computers' lack of impact on nonroutine manual tasks. Noting that these tasks, performed in service jobs such as health aides, security guards, cleaners, and restaurant servers, require interpersonal and environmental adaptability that has proven difficult to computerize, Autor, Katz, and Kearney (2008) suggest that low-wage service work may grow as a share of the labor market.

Goos, Manning, and Salomons (2009) reached a similar conclusion, based on an analysis of occupational and wage data in Europe. They concluded that technology was the primary cause of polarization in European labor markets, eliminating routine tasks concentrated in mid-level manufacturing and clerical work while complementing nonroutine tasks in both high-wage professional jobs and low-wage service jobs.

These two studies both suggest that low-wage service work involves nonroutine tasks that cannot be readily replaced by computers. There is debate in the literature about the level of cognitive, intrapersonal, and interpersonal competencies required to perform such work. Some case studies and surveys suggest that successful performance in low-wage service jobs requires complex communications skills and nonroutine problem solving (Gatta, Boushey, and Appelbaum, 2007). However, the low levels of education required to enter these jobs, together with their low wages and a plentiful supply of unskilled labor, suggests that their competency demands are—and will remain—low (Autor, 2007). Yet another view is that the competencies required by these and other jobs depend largely on management decisions about how the job is structured and the level and type of training provided (National Research Council, 2008).

Borghans, ter Weel, and Weinberg (2008) studied the role of interpersonal competencies in the labor market and concluded that "people skills" are an important determinant of occupations and wages. They argue that interpersonal competencies vary both with personality and across occupations, and that individuals are most productive in jobs that match their personality. They also found evidence that youth sociability affects job assignment in adulthood, and that interpersonal interactions are consistent with the assignment model. This study built on earlier, unpublished work which suggested that technological and organizational changes have increased the importance of interpersonal competencies in the workplace (Borghans, ter Weel, and Weinberg, 2005).

While these studies propose that demand for cognitive, intrapersonal, and interpersonal competencies has grown in recent decades and will continue to grow in the future, some experts disagree. For example, Bowles, Gintis, and Osborne (2001) analyzed longitudinal studies that presented 65 different correlational estimates of the relationship between cognitive test scores and earnings over a 30-year period. The authors found no increase in the estimates over time, indicating that labor market demand for cognitive competencies had not grown. Based on responses to a new national survey of skills, technology, and management practices, Handel (2010) argues that, for most jobs in the U.S. economy, education and academic skill demands are low to moderate, noting that large numbers of workers report educational attainments that exceed the requirements of their jobs.

All efforts to predict future competency demands are, of necessity, based on past trends. For example, BLS has often been criticized for using past trends to project detailed occupational requirements and competency needs a decade into the future (National Research Council, 2000). Similarly, Levy and Murnane (2004) call for schools to teach complex communications skills and nonroutine problem solving based on the assumption that the trends identified by Autor, Levy, and Murnane (2003) will continue for decades.

IMPORTANCE TO HEALTH AND RELATIONSHIP SKILLS

Education, Competencies, and Health Outcomes

There is a long history of research on the associations between education and health. Researchers statistically analyze data from self-reports on health status, behavior, and challenges in terms of explanatory variables, including gender, race, age, education, and income. Based on these analyses, they construct a health gradient demonstrating the conditional relation between education and health status. The overwhelming finding is that general health status, specific health outcomes, and healthy behaviors are strongly and positively correlated with educational attainment.

Cutler and Lleras-Muney (2010a) summarized the literature in which educational attainment is linked both statistically and substantively to health outcomes and behaviors. They found higher levels of educational attainment were associated with an array of reductions in adverse health events and increases in healthy eating and exercise. For example, the age-adjusted mortality rate of high school dropouts was found to be about twice that of those with some college in the 25-64-year-old age group in 1999.

Although these findings are widely accepted, two important questions dominate the literature. The first is to what degree is this relation causal as opposed to the explanation that those with better health are more likely to succeed educationally? That is, to what degree is the coefficient or gradient for health by level of educational attainment biased upward by reverse causation or omitted determinants of both education and health. The second question refers to the mechanism by which education improves health results. While the simplest explanation is that more educated persons are more knowledgeable about how to improve and maintain their health status and are better able to respond to health problems, there are other explanations. These include the effects of education on access to the health-care system (for example, through higher income) or effects of education on increasing consideration for the long-run consequences of present behavior and taking preventative measures.

To answer the first question, health economists have relied increasingly on the use of instrumental variables techniques to isolate the exogenous effects of education on health outcomes. Following the studies on education and labor market outcomes, they have used externally imposed differences in compulsory schooling such as changes in compulsory attendance requirements that affect the amount of education attained. To control for genetic factors and family backgrounds, they have also compared the health of siblings who have different educational attainments. Lochner (2011) provides a recent review of the latest set of studies employing these sophisticated methodologies. His preferred set of 39 estimates shows a wide range of estimates of education effects on mortality, self-reported health, and disability, as well as two health-related behaviors—smoking and obesity. Not all of the estimates are statistically significant, and some have the wrong signs. By and large, the links tend to be stronger in U.S. than European studies.

With respect to trying to isolate the mechanisms by which education influences health outcomes and behavior, the relations are less clear. There is some evidence that both the general cognitive capabilities of more educated persons as well as specific knowledge contributes to this relation. Cutler and Lleras-Muney (2010b) have also attempted to decompose the education-health nexus into major components including differences associated with education, socioeconomic status and income, and access to social networks. They find that about 30 percent of the education-health gradient is due to a combination of the advantages of income, health insurance, and family background associated with more education; 10 percent is due to the advantages of social networks; and about 30 percent is due directly to education. They also explore the educational mechanisms that might account for the relationship. They conclude that it may not be the specific health knowledge conferred by education as much as greater interest and trust of science and general skills such as critical thinking and decision-making abilities, analytic abilities, and information processing skills that enable educated individuals to make better health-related decisions. Such mechanisms as risk aversion and longer-range time considerations (low time discount rate) do not seem to have substantial support in explaining the health gradients.

A few studies have attempted to estimate links between health and cognitive, intrapersonal, and interpersonal competencies. The Almlund et al. (2011) review reaches the following conclusions regarding personality traits:

> All Big Five traits predict some health outcomes. Conscientiousness, however, is the most predictive and can better predict longevity than does intelligence or background. Personality measures predict health both through the channel of education and by improving health-related behavior, such as smoking. (pp. 127-128)

Many of these conclusions are based on the meta-analysis of Roberts et al. (2007), who review evidence from 34 different studies on links between longevity and the "big five" personality traits. They find that conscientiousness was the strongest predictor among the "big five" traits and a stronger predictor than either IQ or socioeconomic status. openness to experience and agreeableness were also associated with longevity, while neuroticism was associated with shorter life spans.

Among individual studies, Conti, Heckman, and Urzua (2010a, 2010b) estimate a multifactor model of schooling, earnings, and health outcomes using data from the British Cohort Study. They find that cognitive ability is not a very important determinant of smoking decisions or obesity but that noncognitive competencies are generally more important for smoking, obesity, and self-reported health. More recently, Hauser and Palloni (2011) studied the relationship between high school class ranking, cognitive ability, and mortality in a large sample of American high school graduates. They found that the relationship between cognitive ability (IQ) and survival was entirely explained by a measure of cumulative academic performance (rank in high school class) that was only moderately associated with IQ. Moreover, the effect of class ranking on survival was three times greater than that of IQ. The authors' interpretation of these findings is that higher cognitive ability improves the chances of survival by encouraging responsible, well-organized, timely behaviors appropriate to the situation—both in terms of high school academics and in later-life health behaviors.

COMPETENCIES AND HEALTHY RELATIONSHIPS IN ADULTHOOD

Insights into the importance of transferable competencies for healthy marriages and other relationships in adulthood can be gleaned from the literature in a number of areas. Our review concentrates on three: (1) studies of couple satisfaction and marriage duration, (2) programs designed to promote healthy marriages, and (3) programs targeting teen relationship building.

A literature review by Halford et al. (2003; see also Gonzaga, Campos, and Bradbury, 2007) suggests four broad classes of variables that impact the trajectory of relationship satisfaction over time: couple interaction, life events impinging upon the couple, enduring individual characteristics of the partners, and contextual variables. Most relevant to the committee charge are the enduring individual characteristics and interactions.

Behavioral genetic studies show substantial heritabilities for divorce in adulthood (McGue and Lykken, 1992; Jockin, McGue, and Lykken, 1996). A handful of studies have examined early childhood correlates of adult relationship stability. Two of the most relevant drew data from the Dunedon birth cohort study. Newman et al. (1997) found that undercontrolled temperament observed at age 3 predicted greater levels of conflict in romantic relationships at age 21. Relatedly, Moffitt et al. (2011) found that childhood self-control predicts the likelihood of being a single parent.

Most personality traits are not very predictive of relationship satisfaction (e.g., Gottman, 1994; Karney and Bradbury, 1995). However, low neuroticism (i.e., high ability to regulate negative affect) as an adult has been found to predict high relationship satisfaction (Karney and Bradbury, 1997). In addition, Davila and Bradbury (2001) find that low anxiety over abandonment and comfort with emotional closeness are also predictive.

Among the elements of couple interaction, effective communication competencies has predicted relationship satisfaction in numerous studies although, interestingly enough, prospectively and not concurrently (Karney and Bradbury, 1995).

Insights into needed skills can also be gleaned from the curricula of effective adult couple relationship education programs. Many such programs attempt to boost couples' positive communication, conflict management, and positive expressions of affection (Halford et al., 2003). In contrast, curricula for teen relationship programs promote positive attitudes and beliefs rather than skills, although, as with adult programs, some also target relationship behavior (Karney et al., 2007).

IMPORTANCE TO CIVIC PARTICIPATION

Civic engagement is variously understood to include involvement in activities focused on improving one's community, involvement in electoral activities (voting, working on campaigns, etc.), and efforts to exercise voice and opinion (e.g., protests, writing to elected officials, etc.) (Zukin et al., 2006). Academics, foundations, and policy makers have expressed concern about decreasing levels of political engagement in the United States, particularly among youth. For example, political scientist Robert Putnam (2000) drew attention to Americans' lack of connection through clubs, civic associations, and other groups in his influential book *Bowling Alone*.

In response to these concerns, there has been a resurgence of interest in the development of the knowledge, skills, and dispositions that facilitate civic engagement—this cluster of knowledge, skills, and dispositions is sometimes referred to as "civic literacy." Studies are looking at the roles played by peers, schools, the media, and other factors in civic literacy and engagement (Delli Carpini and Keeter, 1997; Niemi and Junn, 1998). A recent review of this literature (Garcia Bedolla, 2010) finds that schools have a greater impact on civic literacy than was previously thought, and it has also pointed to the importance of parents and neighborhoods. However, these studies have focused on young people's attitudes, dispositions, or intentions about future political behavior, and have not linked school-based civics programs with later voting behavior and other civic activities in adulthood.

Prevalence of Civic Participation

Recent survey data suggest that some forms of engagement are fairly widespread (e.g., voting in general elections, volunteerism, consumer boycotts). A majority of young people report that they regularly follow public affairs (Lopez et al., 2006). But upward of 60 percent of young people are unable to describe activities that they can attribute to civic or political engagement, and a significant percentage is "highly disengaged." These young people do not generally believe their civic or political actions are likely to make much difference. Another type of civic participation is direct political action—protest, work on political campaigns, and the like. Overall, just 13 percent of young people are reported as being intensely involved in politics at this level—survey data indicate they are motivated by a desire to address a social or political problem.

Factors Associated with Civic Participation

Studies have shed light on the factors that correlate with political engagement, focusing on the role of family, schools, and peers in the development of children's political attitudes and behaviors. Early studies found that families tend to be more important than schools, as political orientations and other attitudes and perspectives appeared to be socially inherited from parents to children (Abramowitz, 1983; Achen, 2002). Indeed, research over four decades has demonstrated that socioeconomic status (SES) is a strong predictor of engagement and participation (Garcia Bedolla, 2010). More recent studies underscore the importance of parents and neighborhoods in the socialization process; they also indicate that schools can play a more important role than was previously believed (Niemi and Junn, 1998; Kahne and Sporte, 2008).

The literature linking years of schooling with civic outcomes is extensive. However, as with labor market and health outcomes, studies providing convincing causal estimates are relatively rare. Lochner (2011) provides a review of these rigorous studies and concludes that this literature suggests important effects of completed schooling on a wide range of political behaviors in the United States, but not in the United Kingdom or Germany. The U.S. impacts are found for voting registration and behavior, political interest, and the acquisition of political information.

Smith (1999) examined the effects of early investments in young people's social capital on political involvement and "civic virtue" in young adulthood. Using longitudinal data, she examined parental involvement, youth religious involvement, and participation in voluntary associations. She found that early extensive connections to others, close family relationships, and participation in religious activities and extracurricular activities during adolescence were significant predictors of greater political and civic involvement in young adulthood.

EDUCATIONAL ATTAINMENT AND TRANSFER IN THE LABOR MARKET

A general theme of the evidence presented in this chapter is that measurable cognitive competencies, personality traits, and other intrapersonal and interpersonal competencies developed in childhood and adolescence are, at best, modestly predictive of adult successes, particularly labor market productivity. Cognitive ability does appear to matter and, among personality traits, so, apparently, does conscientiousness. But, in the research to date, their predictive power is modest. In terms of "transfer," we are unable to point to a particular set of competencies or behaviors that have been shown to transfer well to the labor market. (Boosting these skills may increase educational attainment, however, as discussed in the following chapters.)

Education attainment, in contrast, is strongly predictive of labor market success, even in research approaches designed to approximate random assignment experiments. Measurable cognitive, intrapersonal, and interpersonal competencies account for surprisingly little of the impact of education on future productivity. But even if we do not know exactly what it is about spending an additional year in school that makes people more productive, a policy approach designed to promote attainment might be promising, particularly if it can be shown that attainment promotes competencies that are transferable across jobs or across an individual's entire career.

Prior to the human capital revolution of the 1960s, the manpower planning approach assumed that each job and occupation required a specific level and type of education. Education policy planners produced projections of economic output by sector multiplied by a fixed formula of occupational requirements per unit of output that was further translated into a rigid formula of educational needs of a future labor force. Needless to say, the manpower forecasts failed, largely because of the rigid assumptions relating educational requirements to occupation and occupational requirements to economic output. Changes in technology, organization, and the market prices of labor and capital, and error-prone projections of sectoral output all undermined the accuracy of the projections of educational need.[9]

Becker's (1964) early work on human capital took a more general approach by distinguishing between general and specific human capital. He proposed that education developed "general" human capital that was valuable across different firms, while training and experience within a firm work developed "specific" human capital, valuable only in a particular firm. Becker's (1964) human capital model depended upon market dynamics in which adjustments would take place through responses to the costs and productivity of different kinds of labor. Labor supply and demand were expected to adapt, as any changes in demand for human capital resulting from changes in the firm's organization, technology, and mix of outputs would be met by individual and company investments in education, job training, and on-the-job learning.

There is considerable evidence that labor supply, allocation, and productivity are widely adaptable to changes in the economy, especially over the long run. This is because education increases the capacity of workers to learn on the job, benefit from further training, and respond to productive needs as they arise. Workers with more education are generally able to learn their jobs more quickly and do them more proficiently. They can work more intelligently and with greater precision and can accomplish more within the same time period. Greater levels of education increase their ability to benefit from training for more complex job situations, and this is evidenced in the literature on training.[10] The research demonstrating the overall impact of education on productivity and economic outcomes did not address precisely what competencies were developed by educational investments. However, an important insight was established by Nelson and Phelps (1966), who suggested that a major contribution of education was to enable workers to adapt to technological change.

Welch (1970) and Schultz (1975) generalized this insight to suggest that investments in more educated workers had an even greater impact on a firm's ability to adapt to technological change. They argued that hiring more educated workers can improve a firm's productivity not only because, relative to less educated workers, these workers are more productive in

[9]See Blaug (1975) for a trenchant critique of this type of approach.
[10]See Lynch (1992); Leuven and Oosterbeek (1997); Blundell et al. (1999).

their current jobs and can be more quickly and easily trained for complex jobs, but also because they can allocate their time and other resources more efficiently in their own jobs and in related jobs in ways that increase the overall productivity of the firm. In this way, the contributions of more educated workers go beyond their own job performance to impact the overall performance of the organization. For both Welch and Schultz, these benefits represent the greatest opportunity for investments in more educated workers to pay off for the firm.

More education, and higher education in particular, appears to develop workers' abilities to master an understanding of the production process and to tacitly make adjustments to changes in prices, technology, the productivity of inputs, or mix of outputs. These continuous adjustments allow the firm to "return to equilibrium" (in economic terms), maximizing productivities and profits. Neither Welch nor Schultz addressed which specific aspects of schooling contributed to the ability of workers to make the tacit adjustments to production that will increase productivity and profitability. It is possible that schooling develops not only cognitive competencies but also intrapersonal and interpersonal competencies that enable workers to make decisions that benefit the firm.

Welch (1970) and Schultz (1975) provide many examples of how investments in more educated workers may help firms adjust to optimize their productivity and profits, but there are also many examples of adjustments to disequilibria in the overall labor market. During the Second World War, women replaced males in the labor force in what had been male occupations, continuing the high rates of productivity needed to support both the war effort and the economy (Goldin, 1991). Chung (1990) studied vocationally trained workers for particular occupations who had been employed in those occupations or in occupations that were not matched specifically to their training. He found that workers who had received vocational training for a declining manufacturing industry, textiles, were substantially switching to a growing and thriving manufacturing industry, electronics, and were receiving considerably higher earnings in the latter than in the former. That is, the supply of workers was adapting in the short run to the changes in demand, and in the longer run the occupational training choice of workers was adapting too.

The historical evidence suggests that education is transferable across occupations because many occupations require common skills. For example, Gathmann and Schonberg (2010) found that competencies developed at work (which Becker viewed as "specific" and not valuable outside the firm) were more portable than previously thought. Analyzing data on the complete job histories and wages of over 100,000 German workers, along with detailed information on the tasks used in different occupations, they found that workers developed task-specific knowledge and skills and were rewarded accordingly, with higher wages as they gained experience in an occupation. On average, workers who changed occupations—whether voluntarily or because they were laid off—were more likely to move to an occupation requiring similar tasks (and attendant competencies) to their previous occupation than to a "distant" occupation requiring very different competencies. Laid-off workers who were unable to find work in similar occupations and were forced to move to a distant occupation experienced higher wage losses than those who were able to find work in similar occupations.

The authors found that university graduates appeared to gain more task-specific knowledge and skills than less educated workers and to be rewarded accordingly with higher wages. However, when more highly educated workers were required to move to distant occupations, their wages declined more than did the wages of less highly educated workers who had to move to a distant occupation. This suggests that the deep task-specific competencies developed by the highly educated workers were less transferable than the shallower competencies developed by the less educated workers. Overall, the study suggests that workers are more easily able to transfer competencies developed on the job to a similar occupation, involving similar tasks, than to a dissimilar occupation. This is analogous to research findings from the learning sciences, which have found that transfer of learning to a new task or problem is facilitated when the new task or problem has similar elements to the learned task (see Chapter 4).

Other evidence suggests that even workers with relatively lower levels of education may be able to adapt to the demands of complex jobs. One measure of adaptability is the substitutability among workers with different levels of education. Economists measure employers' ability to substitute workers at one level of education for jobs that normally are associated with a higher level of education by examining how the mix of more and less educated workers changes as relative wages for different educational levels change. Historical studies in the United States suggest that each 10 percent increase in the labor costs of a higher level of education is associated with a 15 percent decrease in employment at that educational level and increase in workers with less education to replace them (Ciccone and Peri, 2005). This implies that employers view workers as highly adaptable to perform jobs that traditionally require more education, when relative wages encourage such substitution.

CONCLUSIONS AND RECOMMENDATIONS

The research evidence related to the relationship between various cognitive, intrapersonal, and interpersonal competencies is limited and uneven in quality. Some of the evidence reviewed in this chapter is correlational in nature and should be considered, at best, suggestive of possible causal linkages. Other evidence, from longitudinal studies, is more suggestive of causal connections than the correlational evidence, but it is still prone to biases from a variety of sources. The strongest causal evidence, particularly the evidence of the impacts of years of completed schooling on adult outcomes, comes from statistical methods that are designed to approximate experiments.

- **Conclusion: The available research evidence is limited and primarily correlational in nature; to date, only a few studies have demonstrated a causal relationship between one or more 21st century competencies and adult outcomes. The research has examined a wide range of different competencies that are not always clearly defined or distinguished from related competencies.**

Many more studies of the relationships between various competencies and outcomes (in education, the labor market, health, and other domains) have focused on the role of general cognitive ability (IQ) than on specific intrapersonal and interpersonal skills (see Table 3-1). Economists who conduct such studies tend to lump all competencies other than IQ into the category of "noncognitive skills," while personality and developmental psychologists have developed a much more refined taxonomy of them. All three groups have investigated the relationships between cognitive, intrapersonal, and interpersonal competencies and outcomes in adolescence and adulthood.

- **Conclusion: Cognitive competencies have been more extensively studied than intrapersonal and interpersonal competencies, showing consistent, positive correlations (of modest size) with desirable educational, career, and health outcomes. Early academic competencies are also positively correlated with these outcomes.**

- **Conclusion: Among intrapersonal and interpersonal competencies, conscientiousness (staying organized, responsible, and hardworking) is most highly correlated with desirable outcomes in education and the workplace. Antisocial behavior, which has both intrapersonal and interpersonal dimensions, is negatively correlated with these outcomes.**

Across the available studies, the relative size of the correlations with the three different domains of skills is mixed. There is some evidence that better measurement of noncognitive competencies might result in a higher estimate of their importance in education and in the workplace.

A general theme of the evidence presented in this chapter is that measurable cognitive skills, personality traits, and other intrapersonal and interpersonal competencies developed in childhood and adolescence are, at best, modestly predictive of adult successes, particularly in the labor market. Educational attainment, in contrast, is strongly predictive of labor market success, even in research approaches designed to approximate random assignment experiments. Measurable cognitive, intrapersonal, and interpersonal competencies account for surprisingly little of the impact of education on future wages (wages, in economic theory, reflect productivity).

Studies by economists have found that more highly educated workers are more productive than those with less years of schooling are because more highly educated workers are better able to accomplish a given set of work tasks and are also more able to benefit from training for more complex tasks. In addition, more highly educated workers have the capacity to allocate resources more efficiently in their own work activities and in behalf of the enterprise in which they work than do workers with fewer years of schooling.

- **Conclusion: Educational attainment—the number of years a person spends in school—strongly predicts adult earnings, and also predicts health and civic engagement. Moreover, individuals with higher levels of education appear to gain more knowledge and skills on the job than do those with lower levels of education and they are able, to some extent, to transfer what they learn across occupations. Since it is not known what mixture of cognitive, intrapersonal, and interpersonal competencies accounts for the labor market benefits of additional schooling, promoting educational attainment itself may constitute a useful complementary strategy for developing 21st century competencies.**

The limited and uneven quality of the research reviewed in this chapter limits our understanding of the relationships between various cognitive, intrapersonal, and interpersonal competencies and adult outcomes.

- **Recommendation 1: Foundations and federal agencies should support further research designed to increase our understanding of the relationships between 21st century competencies and successful adult outcomes. To provide stronger causal evidence about such relationships, the programs of research should move beyond simple correlational studies to include more longitudinal studies with controls for differences in individuals' family backgrounds and more studies using statistical methods that are designed to approximate**

experiments. Such research would benefit from efforts to achieve common definitions of 21st century competencies and an associated set of activities designed to produce valid and reliable assessments of the various individual competencies.

4

Perspectives on Deeper Learning

This chapter returns to the discussion begun in Chapter 2 about the nature of deeper learning and 21st century skills. It opens with an introduction that includes a brief discussion of the goals of deeper learning and a brief discussion of the history of theory and research on transfer. The second and longest section of the chapter discusses cognitive perspectives on deeper learning, reviewing work in cognitive and educational psychology in support of our argument that deeper learning is the process of developing durable, transferable knowledge that can be applied to new situations. In the third section, we offer an example of a learning environment that promotes the processes of deeper learning and develops cognitive, intrapersonal, and interpersonal competencies. In the fourth and fifth sections, we discuss the intrapersonal and interpersonal domains, considering how 21st century competencies in these two domains support the process of deeper learning. The sixth section briefly discusses the implications of the research reviewed throughout the chapter for teaching of deeper learning and 21st century competencies, and the chapter ends with conclusions.

A CLASSIC CONCERN: LEARNING FOR TRANSFER

The committee views the broad call for deeper learning and 21st century skills as reflecting a long-standing issue in education and training—the desire that individuals develop transferable knowledge and skills. Associated with this is the challenge of creating learning environments that support development of the cognitive, intrapersonal, and interpersonal competencies that enable learners to transfer what they have learned to new situations and new problems. These competencies include both knowledge in a domain and knowledge of how, why, and when to apply this knowledge to answer questions and solve problems—integrated forms of knowledge that we refer to as 21st century competencies and discuss further below.

If the goal of instruction is to prepare students to accomplish tasks or solve problems exactly like the ones addressed during instruction, then deeper learning is not needed. For example, if someone's job calls for adding lists of numbers accurately, that individual needs to learn to become proficient in using the addition procedure but does not need deeper learning about the nature of number and number theory that will allow transfer to new situations that involve the application of mathematical principles. As discussed in the previous chapter, today's technology has reduced demand for such routine skills (e.g., Autor, Levy, and Murnane, 2003). Success in work and life in the 21st century is associated with cognitive, intrapersonal, and interpersonal competencies that allow individuals to adapt effectively to changing situations rather than to rely solely on well-worn procedures.

When the goal is to prepare students to be able to be successful in solving new problems and adapting to new situations, then deeper learning is called for. Calls for such 21st century skills as innovation, creativity, and creative problem solving can also be seen as calls for deeper learning—helping students develop transferable knowledge that can be applied to solve new problems or respond effectively to new situations. Before turning to a discussion of the relationship between deeper learning and 21st century competencies in terms of theories and research on learning and knowing and the implications for transfer, we briefly discuss some of the rich history of work on the nature and extent of transfer.

Brief Historical Overview of Theory and Research on Transfer

Transfer was one of the first topics on the research agendas of both psychology and education, and it has remained as perhaps the central topic in the research on learning and instruction for more than 100 years. Research to date suggests that despite our desire for broad forms of transfer, knowledge does not transfer very readily, but it also illuminates instructional conditions that support forms of transfer that are desirable and attainable.

Specific transfer is the idea that learning A affects one's learning of B only to the extent that A and B have elements in common. For example, learning Latin may help someone learn Spanish solely because some of the vocabulary words are very similar and the verb conjugations are very similar. In contrast, general transfer is the idea that learning A affects one's learning of B because learning A strengthens general characteristics or knowledge in the learner that are broadly relevant (such as mental discipline or general principles). On the general transfer side of the controversy was the *doctrine of formal discipline,* which held that learning certain school subjects such as Latin and geometry would improve the mind in general (i.e., teach *proper habits of mind*) and thereby improve learning and performance in other unrelated subjects. On the specific transfer side of the controversy was E.L. Thorndike, largely recognized as the founder of educational psychology, who sought to put the issue to an empirical test. In a famous set of early studies, Thorndike and Woodworth (1901) found that students who were taught a cognitive skill showed a large improvement on the taught tasks but not on other tasks. Thorndike was able to claim strong support for specific rather than general transfer: "Improvement in any single mental function rarely brings about equal improvement in any other function, no matter how similar" (Thorndike, 1903, p. 91).

This was not a good outcome for those dedicated to helping students develop the ability to exhibit general transfer—that is, to apply what they have learned in one situation to a novel situation. Subsequent work by Judd (1908) offered some hope by showing that transfer to new situations depended on the instructional method used during initial learning, with some instructional methods supporting transfer to new situations and others not. An important aspect of Judd's finding is that transfer was restricted to new situations that required the same general principles as required in the original task, although it could be applied to situations requiring different behaviors.

Judd's finding has been replicated in many contexts. For example, Singley and Anderson (1989) report on an experiment designed to study the acquisition and transfer of skills in text editing. A group of 24 young women (aged 18-30) from a secretarial school were first taught to use either one or two line editors (text editing software used to change individual lines of text) and then a screen editor (text editing software used to scroll throughout a page of text), while control groups spent similar amounts of time either learning and using one of the screen editors or simply typing a manuscript. The authors observed positive transfer, both from one line editor to the next and from the line editors to the screen editor, as indicated by reductions in total learning time, keystrokes, residual errors, and other measures in comparison to the control groups. They proposed that the very high level of transfer from one line editor to the next line editor was due to the fact that, although the surface features of the commands used in the two editors were different, the underlying principles were nearly identical. In addition, they proposed that the moderate level of transfer from the line editors to the screen editor reflected the fact that the procedures used in the two line editors are largely different from those used by the screen editor. Nevertheless, the two line editors and the screen editor do share several decision rules, enabling the moderate level of transfer. It is important to note that this research examined transfer within a single subject or topic area—text editing. Research to date has not found evidence of transfer across subjects or disciplines.

Although there is little support in the research literature for general transfer in the broadest sense, there is encouraging evidence for what could be called "specific transfer of general principles" within a subject area or topic when effective instructional methods are used. Understanding how to promote this type of specific transfer is a continuing goal of research. Much of contemporary work continues to follow a line of thinking originally developed by the gestalt psychologists (e.g., Katona, 1942; Wertheimer, 1959) working in the first half of the 20th century. They were the first to propose a distinction between reproductive thinking (i.e., applying a previously learned procedure to solve a new problem) and productive thinking (i.e., inventing a new solution method to solve a new problem). Insight—moving from a state of not knowing how to solve a problem to a state of knowing how to solve it—is at the heart of productive thinking and was a major research theme of gestalt psychology (Duncker, 1945; Mayer, 1995). The gestaltists also emphasized the distinction between rote learning (which involved learning to blindly follow a procedure) and meaningful learning (which involved deeper understanding of the structure of the problem and the solution method), and they provided evidence that meaningful learning leads to transfer, whereas rote learning does not (Katona, 1940). For example, Wertheimer showed that in learning to solve for the area of a parallelogram, students could be taught how to apply the formula *area* = *height* × *base* (learning by rote), or they could be shown that they could cut off a triangle from one end and place it on the other end to form a rectangle (learning by understanding). According to Wertheimer, both kinds of instruction enabled students to perform well on problems like those given during instruction (i.e., retention tests), but only learning by understanding could promote problem solving on unusually shaped parallelograms and related nonparallelogram shapes (i.e., transfer tests).

Overall, one of the continuing goals of research and theory is to elucidate what is meant by learning with understanding—the processes that produce such learning as well as the outcomes in terms of knowledge representations—as well as how the products of such "deeper learning" processes lead to productive thinking in the context of transfer situations (see, e.g., Schwartz, Bransford, and Sears, 2005). In the next section, we consider the relationship between deeper learning and 21st century skills from the perspective of contemporary research and theory on the nature of the mental structures and cognitive processes associated with learning as well as the sociocultural nature of learning and knowing.

THE RELATIONSHIP BETWEEN DEEPER LEARNING AND COGNITIVE COMPETENCIES

To clarify the meaning of "deeper learning" and illuminate its relationship to 21st century competencies in the cognitive domain, the committee turned to two important strands of research and theory on the nature of human thinking and learning, the *cognitive* perspective and the *sociocultural* perspective, also referred to as the "situated" perspective (Greeno, Pearson, and Schoenfeld, 1996). In contrast to the differential perspective discussed in Chapter 2, which focuses on differences among individuals in knowledge or skill, the cognitive perspective focuses on types of knowledge and how they are structured in an individual's mind, including the processes that govern perception, learning, memory, and human performance. Research from the cognitive perspective investigates the mechanisms of learning and the nature of the products—the types of knowledge and skill—that result from those mechanisms, as well as how that knowledge and skill is drawn upon to perform a range of simple to complex tasks. The goal is theory and models that apply to all individuals, accepting the fact that there will be variation across individuals in execution of the processes and in the resultant products.

The sociocultural perspective emerged in response to the perception that research and theory within the cognitive perspective was too narrowly focused on individual thinking and learning. In the sociocultural perspective, learning takes place as individuals participate in the practices of a community, using the tools, language, and other cultural artifacts of the community. From this perspective, learning is "situated" within, and emerges from, the practices in different settings and communities. A community may be large or small and may be located inside or outside of a traditional school context. It might range, for example, from colleagues in a company's Information Technology department to a single elementary school classroom or a global society of plant biologists.

Such research has important implications for how academic disciplines are taught in school. From the sociocultural perspective, the disciplines are distinct communities that engage in shared practices of ongoing knowledge creation, understanding, and revision. It is now widely recognized that science is both a body of established knowledge and a social process through which individual scientists and communities of scientists continually create, revise, and elaborate scientific theories and ideas (Polanyi, 1958; National Research Council, 2007). In one illustration of the social dimensions of science, Dunbar (2000) found that scientists' interactions with their peers, particularly how they responded to questions from other scientists, influenced their success in making discoveries.

The idea that each discipline is a community with its own culture, language, tools, and modes of discourse has influenced teaching and learning. For example, Moje (2008) has called for reconceptualizing high school literacy instruction to develop disciplinary literacy programs, based on research into what it means to write and read in mathematics, history and science and what constitutes knowledge in these subjects. Moje (2008) argues that students' understanding of how knowledge is produced in the subject areas is more important than the knowledge itself.

Sociocultural perspectives are reflected in new disciplinary frameworks and standards for K-12 education. In science, for example, *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (hereafter referred to as the NRC science framework; National Research Council, 2012) calls for integrated development of science practices, crosscutting concepts, and core ideas. The Common Core State Standards in English language arts (Common Core State Standards Initiative, 2010a) reflect an integrated view of reading, writing, speaking/listening, and language and also respond to Moje's (2008) call for disciplinary literacy by providing separate English language arts standards for history and science. Based on the view of each discipline as a community engaged in ongoing discourse and knowledge creation, the NRC science framework and the standards in English language arts and mathematics include expectations for learning of intrapersonal and interpersonal competencies along with cognitive competencies (see Chapter 5 for further discussion).

In the committee's view, and informed by both perspectives, the link between deeper learning and 21st century competencies lies in the classic concept of transfer—the ability to use prior learning to support new learning or problem solving in culturally relevant contexts. We define deeper learning not as a product but as processing—both within individual minds and through social interactions in a community—and 21st century competencies as the learning outcomes of this processing in the form of transferable knowledge and skills that result. The transferable knowledge and skills encompass all three domains of competency: cognitive, intrapersonal, and interpersonal, in part reflecting the sociocultural perspective of learning as a process grounded in social relationships.

To support our proposed definitions of deeper learning and 21st century competencies, we first draw on concepts and principles derived from work in cognitive psychology. Based on this review of the research, we describe the nature of deeper learning and briefly discuss instruction that supports deeper learning and transfer (we elaborate on teaching for transfer in Chapters 5 and 6).

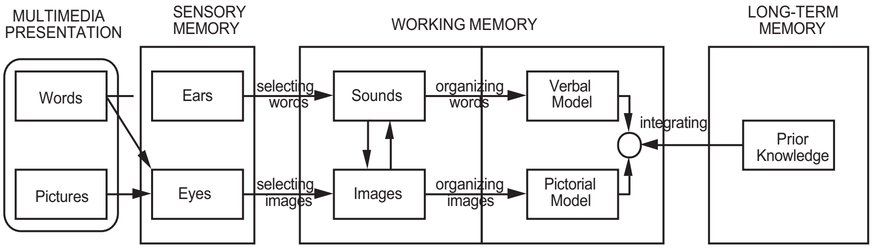

FIGURE 4-1 An information processing model memory.
SOURCE: Mayer, Heiser, and Lonn (2001). Copyright 2001 by the American Psychological Association. Reproduced with permission. The use of APA information does not imply endorsement by APA.

Components of Cognitive Architecture[1]

One of the chief theoretical advances to emerge from research and theory is the notion of *cognitive* architecture—the information processing system that determines the flow of information and how it is acquired, stored, represented, revised, and accessed in the mind. Figure 4-1 shows the main components of this architecture. Research has identified the distinguishing characteristics of the various types of memory shown in Figure 4-1 and the mechanisms by which they interact with each other.

Working Memory

Working memory is what people use to process and act on information immediately before them (Baddeley, 1986). Working memory is a conscious system that receives input from memory buffers associated with the various sensory systems. There is also considerable evidence that working memory can receive input from the long-term memory system.

The key variable for working memory is capacity—how much information it can hold at any given time. Controlled (also defined as conscious) human thought involves ordering and rearranging ideas in working memory and is consequently restricted by the finite capacity of working memory. Simply stated, working memory refers to the currently active portion of long-term memory. But there are limits to such activity, and these limits are governed primarily by how information is organized. Although few people can remember a randomly generated string of 16 digits, anyone with a slight knowledge of American history is likely to be able to recall the string 1492-1776-1865-1945. This is just one example of an important concept:

[1]This section of the chapter draws heavily on National Research Council (2001, pp. 65-68).

namely, that knowledge stored in long-term memory can have a profound effect on what appears, at first glance, to be the capacity constraint in working memory.

Long-Term Memory

Long-term memory contains two distinct types of information—semantic information about "the way the world is" and procedural information about "how things are done." Unlike working memory, long-term memory is, for all practical purposes, an effectively limitless store of information. It therefore makes sense to try to move the burden of problem solving from working memory to long-term memory. What matters most in learning situations is not the capacity of working memory—although that is a factor in speed of processing—but how well one can evoke the knowledge stored in long-term memory and apply it to address information and problems in the present.

Contents of Memory

Contemporary theories also characterize the types of cognitive content that are processed by the architecture of the mind. The nature and organization of this content is extremely critical for understanding how people answer questions and solve problems, and how they differ in this regard as a function of the conditions of instruction and learning. An important distinction in cognitive content is between domain-general knowledge, which is applicable to a range of situations, and domain-specific knowledge, which is relevant to a particular problem area.

Domain-General Knowledge and Problem-Solving Processes

Cognitive research has shown that general problem-solving procedures, not specific to a particular domain of knowledge, are generally slow and inefficient. Newell and Simon (1972) developed a computer program to test such general procedures, known as "weak methods," identifying their limitations as follows:

- Hill climbing: One solves a problem by taking one step at a time toward the overarching goal or task. This approach is inflexible and may be inefficient, as selecting whatever step takes one uphill (or in a particular direction) may cause the problem solver to climb a foothill, ignoring the much more efficient procedure of going around it. More sophisticated problem-solving strategies, such as those used by expert chess players, require one to *look ahead* many steps to see potential problems well in advance and avoid them.

- Means-ends analysis: One solves a problem by considering the obstacles that stand between the initial problem state and the goal state. The problem solver then identifies subgoals related to the elimination of each these obstacles. When all of the subgoals have been achieved (all of the obstacles have been eliminated), then the main goal of interest has been achieved. Because the subgoals have been identified through a focus on the main goal, means-ends analysis can be viewed as a strategy in which the long-range goal is always kept in mind to guide problem solving. It is not as near-sighted as other search techniques, like hill climbing.
- Analogy: One solves a problem by using the solution of a similar problem. However, evidence shows that, generally, people who have learned to solve a first problem are not better at solving a second problem analogous to the first. Even when given explicit instructions about the relationship between the two problems, individuals do not always find it easier to solve the second problem.
- Trial and error: One solves a problem by randomly trying out solutions until one has reached the goal. Trial-and-error approaches can be very inefficient, as many of the random solutions may be incorrect, and there is no boundary to narrow the search for possible solutions.

Problem solvers confronted by a problem outside their area of expertise use these weak methods to try to constrain what would otherwise be very large search spaces when they are solving novel problems. In most situations, however, learners are expected to use *strong methods*—relatively specific algorithms particular to the domain that will make it possible to solve problems efficiently. Strong methods, when available, find solutions with little or no search. For example, someone who knows calculus can find the maximum of a function by applying a known algorithm (taking the derivative and setting it equal to zero). As discussed further below, experts are able to quickly solve novel problems within their domain of expertise because they can readily retrieve relevant knowledge, including the appropriate, strong methods to apply. Paradoxically, although one of the hallmarks of expertise is access to a vast store of strong methods in a particular domain, both children and scientists fall back on their repertoire of weak methods when faced with truly novel problems (Klahr and Simon, 1999).

Knowledge Organization: Schemas and Expert-Novice Differences[2]

Although weak methods remain the last resort when one is faced with novel situations, people generally strive to interpret situations so that they can apply *schemas*—previously learned and somewhat specialized techniques (i.e., strong methods) for organizing knowledge in memory in ways that are useful for solving problems. Schemas help people interpret complex data by weaving them into sensible patterns. A schema may be as simple as "Thirty days hath September" or more complex, such as the structure of a chemical formula. Schemas help move the burden of thinking from working memory to long-term memory. They enable competent performers to recognize situations as instances of problems they already know how to solve; to represent such problems accurately, according to their meaning and underlying principles; and to know which strategies to use to solve them.

The existence of problem-solving schemas has been demonstrated in a wide variety of contexts. Extensive research shows that the ways students mentally "represent" (form a mental model of) the information given in a math or science problem or in a text that they read depends on the organization of their existing knowledge. As learning occurs, increasingly well-structured and qualitatively different organizations of knowledge develop. These structures enable individuals to build a representation or mental model that guides problem solution and further learning, avoid trial-and-error solution strategies, and formulate analogies and draw inferences that readily result in new learning and effective problem solving (Glaser and Baxter, 1999). The impact of schematic knowledge is powerfully demonstrated by research on the nature of expertise.

Research conducted over the past five decades has generated a vast body of knowledge about how people learn the content and procedures of specific subject domains. Researchers have probed deeply the nature of expertise and how people acquire large bodies of knowledge over long periods of time. Studies have revealed much about the kinds of mental structures that support problem solving and learning in various domains ranging from chess to physics; what it means to develop expertise in a domain; and how the thinking of experts differs from that of novices.

The notion of expertise is inextricably linked with subject-matter domains: experts must have expertise in *something*. Research on how people develop expertise has provided considerable insight into the nature of thinking and problem solving. Although every person cannot be expected to become an expert in a given domain, findings from cognitive science about the nature of expertise can shed light on what successful learning looks like and guide the development of effective instruction and assessment.

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[2]This section of the chapter draws heavily on National Research Council (2001, pp. 70-73).

What distinguishes expert from novice performers is not simply general mental abilities, such as memory or fluid intelligence, or general problem-solving strategies. Experts have acquired extensive stores of knowledge and skill in a particular domain, and perhaps more significantly, they have organized this knowledge in ways that make it readily retrievable and useful.

In fields ranging from medicine to music, studies of expertise have shown repeatedly that experts commit to long-term memory large banks of well-organized facts and procedures, particularly deep, specialized knowledge of their subject matter (Chi, Glaser, and Rees, 1982; Chi and Koeske, 1983). Most important, they have efficiently coded and organized this information into well-connected schemas. These methods of encoding and organizing help experts interpret new information and notice features and meaningful patterns of information that might be overlooked by less competent learners. These schemas also enable experts, when confronted with a problem, to retrieve the relevant aspects of their knowledge.

Of particular interest to researchers is the way experts encode, or chunk, information into meaningful units based on common underlying features or functions. Doing so effectively moves the burden of thought from the limited capacity of working memory to long-term memory. Experts can represent problems accurately according to their underlying principles, and they quickly know when to apply various procedures and strategies to solve them. They then go on to derive solutions by manipulating those meaningful units. For example, chess experts encode mid-game situations in terms of meaningful clusters of pieces (Chase and Simon, 1973).

The knowledge that experts have cannot be reduced to sets of isolated facts or propositions. Rather, their knowledge has been encoded in a way that closely links it with the contexts and conditions for its use. Because the knowledge of experts is "conditionalized," they do not have to search through the vast repertoire of everything they know when confronted with a problem. Instead, they can readily activate and retrieve the subset of their knowledge that is relevant to the task at hand (Simon, 1979; Glaser, 1992). These and other related findings suggest that teachers should place more emphasis on the conditions for applying the facts or procedures being taught, and that assessment should address whether students know when, where, and how to use their knowledge.

Practice and Feedback[3]

Every domain of knowledge and skill has its own body of concepts, factual content, procedures, and other items that together constitute the knowledge of that field. In many domains, including areas of literature,

[3]This section of the chapter draws heavily on National Research Council (2001, pp. 84-87).

history, mathematics, and science, this knowledge is complex and multifaceted, requiring sustained effort and focused instruction to master. Developing deep knowledge of a domain such as that exhibited by experts, along with conditions for its use, takes time and focus and requires opportunities for practice with feedback.

Whether considering the acquisition of some highly specific piece of knowledge or skill such as the process of adding two numbers, or some larger schema for solving a mathematics or physics problem, certain laws of skill acquisition always apply. The first of these is the *power law of practice:* acquiring skill takes time, often requiring hundreds or thousands of instances of practice in retrieving a piece of information or executing a procedure. This law operates across a broad range of tasks, from typing on a keyboard to solving geometry problems (Rosenbloom and Newell, 1987). According to the power law of practice, the speed and accuracy of performing a simple or complex cognitive operation increases in a systematic nonlinear fashion over successive attempts (see Figure 4-2). This pattern is characterized by an initial rapid improvement in performance, followed by subsequent and continuous improvements that accrue at a slower and slower rate.

The power law of practice is fully consistent with theories of cognitive skill acquisition, according to which individuals go through different stages in acquiring the specific knowledge associated with a given cognitive skill (e.g., Anderson, 1982). Early on in this process, performance requires effort because it is heavily dependent on the limitations of working memory. Individuals must create a representation of the task they are supposed to perform, and they often verbally mediate or "talk their way through the task" while it is being executed. Once the components of the skill are well represented in long-term memory, the heavy reliance on working memory, and the problems associated with its limited capacity, can be bypassed. As a consequence, exercise of the skill can become fluent and then automatic. In the latter case, the skill requires very little conscious monitoring, and thus mental capacity is available to focus on other matters. Evidence indicates that with each repetition of a cognitive skill, as in accessing a concept in long-term memory from a printed word, retrieving an addition fact, or applying a schema for solving differential equations, some additional knowledge strengthening occurs that produces continual small improvements.

Practice, however, is not enough to ensure that a skill will be acquired. The conditions of practice are also important. The second major law of skill acquisition involves *knowledge of results*. Individuals acquire a skill much more rapidly if they receive feedback about the correctness of what they have done. If incorrect, they need to know the nature of their mistake. It was demonstrated long ago that practice without feedback produces little learning (Thorndike, 1927). One of the persistent dilemmas in education

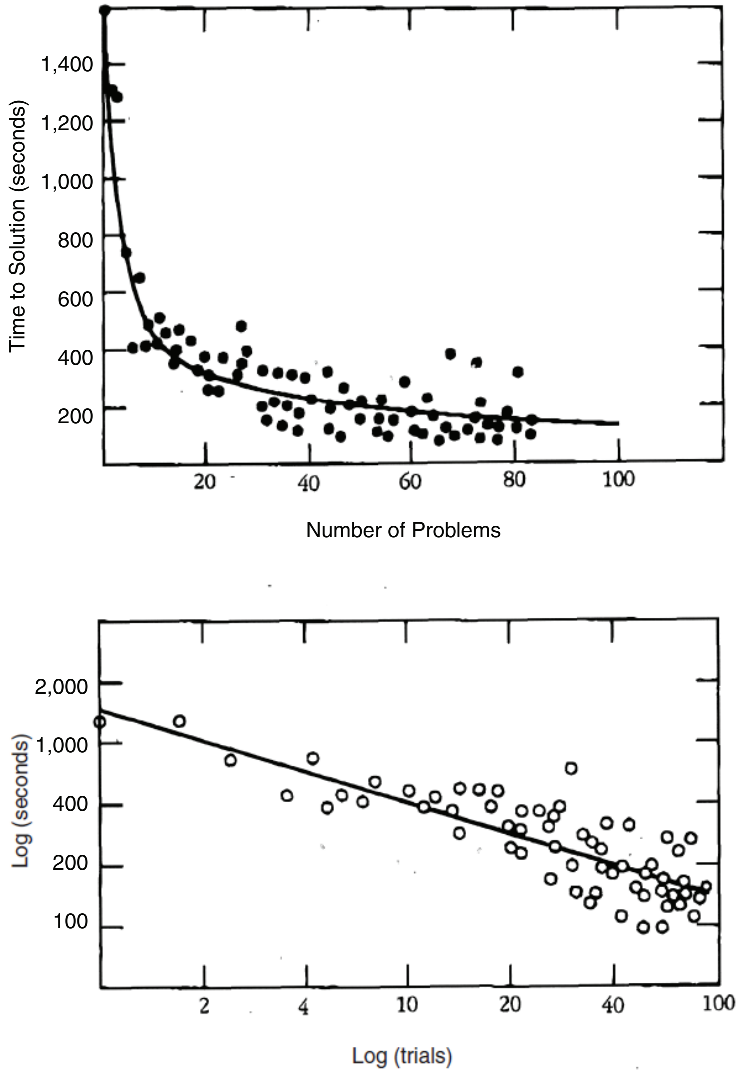

FIGURE 4-2 Skill acquisition curves.
SOURCE: Anderson (1990, p. 262). Reprinted with permission from W.H. Freeman and Company, from J.R. Anderson. *Cognitive psychology and its implications*. Permission conveyed through Copyright Clearance Center, Inc.

is that students often spend time practicing incorrect skills with little or no feedback. Furthermore, the feedback they ultimately receive is often neither timely nor informative. For the less able student, unguided practice (e.g., homework in math) can be practice in doing tasks incorrectly.

The timing and quality of feedback influences its effectiveness in speeding acquisition of skills or knowledge (Pashler et al., 2005; Shute, 2008). The optimal timing of feedback appears to differ depending on the type and complexity of the learning task and the characteristics of the learner. For example, immediate feedback can quickly prevent further incorrect practice, but it also has potential limitations, including posing a threat to motivation and reducing opportunities for learners to correct their own errors and develop self-regulated learning skills. There is growing evidence that feedback that explains why the practice is incorrect is more valuable for learning than feedback that simply flags errors (Roscoe and Chi, 2007; Shute, 2008; National Research Council, 2011a). The value of explanatory feedback has been demonstrated through research conducted in both digital and nondigital learning environments. For example, Moreno and Mayer (2005) compared two different versions of an interactive science learning game in which students traveled to different planets with different environmental conditions and were asked to design a plant that could survive in these conditions. The authors found that students who received explanatory feedback performed significantly better than did students who received only corrective feedback on a test designed to measure both retention of the targeted botany concepts and transfer of these concepts to new problems of plant design based on the same general principles.

The Nature of Deeper Learning

The review of research thus far in this chapter allows us to more clearly describe the nature of deeper learning. First, the history of research on transfer suggests that there are limits to how far the knowledge and skills developed through deeper learning can transfer. Transfer is possible within subject area or domain of knowledge, when effective instructional methods are used. Second, the research on expertise suggests that deeper learning involves the development of well-organized knowledge in a domain that can be readily retrieved to apply (transfer) to new problems in that domain. Third, the research suggests that deeper learning requires extensive practice, aided by explanatory feedback that helps learners correct errors and practice correct procedures, and that multimedia learning environments can provide such feedback. Fourth, the work of the gestalt psychologists discussed above allows us to distinguish between rote learning and meaningful learning (or deeper learning). Meaningful learning (which develops deeper understanding of the structure of the problem and the solution method) leads to transfer, while rote learning does not (Katona, 1940).

Building on the research of the Gestalt psychologists, we can distinguish between different types of tests and the learning they measure. Retention tests are designed to assess learners' memory for the presented material using recall tasks (e.g., "What is the definition of deeper learning?") or recognition tasks (e.g., "Which of the following is not part of the definition of deeper learning? A. learning that facilitates future learning, B. learning that facilitates future problem solving, C. learning that promotes transfer, D. learning that is fun."). While retention and recognition tests are often used in educational settings, experimental psychologists use transfer tests to assess learners' ability to use what they learned in new situations to solve problems or to learn something new (e.g., "Write a transfer test item to evaluate someone's knowledge of deeper learning.").

Although using the senses to attend to relevant information may be all that is required for success on retention tasks, success on transfer tasks requires deeper processing that includes organizing new information and integrating it with prior knowledge in one's mind (see Figure 4-1). This deeper cognitive process develops 21st century skills—knowledge in a learner's long-term memory that can be used in new situations.

Results from the two different types of assessments can be used to distinguish between three different types of learning outcomes—no learning, rote learning, and meaningful learning (see Table 4-1; also Mayer, 2010). No learning is indicated by poor performance on retention and transfer tests. Rote learning is indicated by good retention performance and poor transfer performance. Meaningful learning (which also could be called deeper learning) is indicated by good retention performance and good transfer performance. Thus the distinguishing feature of meaningful learning (or deeper learning) is the learner's ability to transfer what was learned to new situations.

TABLE 4-1 Three Types of Learning Outcomes

Type of Outcome	Retention Performance	Transfer Performance
No learning	Poor	Poor
Rote learning	Good	Poor
Meaningful (deeper) learning	Good	Good

SOURCE: R.E. Mayer, *Applying the science of learning, 1st edition*, © 2010. Reprinted (2010) by permission of Pearson Education, Inc., Upper Saddle River, NJ.

Components of Deeper Learning

Researchers have characterized the suite of knowledge and abilities that are used in the process of deeper learning in various ways. For example, when Anderson et al. (2001) updated Bloom's 1956 taxonomy of learning objectives, they included three types of knowledge and skills: (1) knowledge (e.g., facts and concepts); (2) skills (e.g., procedures and strategies); and (3) attitudes (e.g., beliefs). In Chapter 2, we proposed that knowledge and skills can be divided into three broad domains of competence: cognitive, intrapersonal, and interpersonal.

Mayer (2011a) suggested that deeper learning involves developing an interconnected network of five types of knowledge:

- Facts, statements about the characteristics or relationships of elements in the universe;
- Concepts, which are categories, schemas, models, or principals;
- Procedures, or step-by-step processes;
- Strategies, general methods; and
- Beliefs about one's own learning.

Earlier in this chapter, we noted that mentally organizing knowledge helps an individual to quickly identify and retrieve the relevant knowledge when trying to solve a novel problem (i.e., when trying to transfer the knowledge). In light of these research findings, Mayer (2010) proposed that the way in which a learner organizes these five types of knowledge influences whether the knowledge leads to deeper learning and transfer. For example, factual knowledge is more likely to transfer if it is integrated, rather than existing as isolated bits of information, and conceptual knowledge is more likely to transfer if it is mentally organized around schemas, models, or general principles. As the research on expertise and the power law of practice would indicate, procedures that have been practiced until they become automatic and embedded within long-term memory are more readily transferred to new problems than those that require much thought and effort. In addition, specific cognitive and metacognitive strategies (discussed later in this chapter) promote transfer. Finally, development of transferable 21st century skills is more likely if the learner has productive beliefs about his or her ability to learn and about the value of learning—a topic we return to later, in the section on the intrapersonal domain.

Table 4-2 outlines the cognitive processing of the five types of integrated knowledge and dispositions that, working closely together, support deeper learning and transfer.

Deeper learning involves coordinating all five types of knowledge. The learner acquires an interconnected network of specific facts, automates

TABLE 4-2 What Is Transferable Knowledge?

Type of Knowledge	Format or Cognitive Processing
Factual	Integrated, rather than separate facts
Conceptual	Schemas, models, principles
Procedures	Automated, rather than effortful
Strategies	Specific cognitive and metacognitive strategies
Beliefs	Productive beliefs about learning

SOURCE: Adapted from Mayer (2010).

procedures, refines schemas and mental models, and refines cognitive and metacognitive strategies, while at the same time developing productive beliefs about learning. Through this process, the learner develops transferable knowledge, which encompasses not only the facts and procedures that support retention but also the concepts, strategies, and beliefs needed for success in transfer tasks. We view these concepts, thinking strategies, and beliefs as 21st century skills.

This proposed model of transferable knowledge reflects the research on development of expertise, which, as noted above, has distinguished differences in the knowledge of experts and novices in domains such as physics, chess, and medicine (see Table 4-3). Novices tend to store facts as isolated units, whereas experts store them in an interconnected network. Novices tend to create categories based on surface features, whereas experts create categories based in structural features. Novices need to expend conscious effort in applying procedures, whereas experts have automated basic procedures, thereby freeing them of the need to expend conscious effort in applying them. Novices tend to use general problem-solving strategies such as means-ends analysis, which require a backward strategy starting from the goal, whereas experts tend to use specific problem-solving strategies tailored to specific kinds of problems in a domain, which involve a forward strategy starting from what is given. Finally, novices may hold unproductive beliefs, such as the idea that their performance depends on ability, whereas

TABLE 4-3 Expert-Novice Differences on Five Kinds of Knowledge

Knowledge	Novices	Experts
Facts	fragmented	integrated
Concepts	surface	structural
Procedures	effortful	automated
Strategies	general	specific
Beliefs	unproductive	productive

SOURCE: Adapted from Mayer (2010).

experts may hold productive beliefs, such as the idea that if they try hard enough they can solve the problem. In short, analysis of learning outcomes in terms of five types of knowledge has proven helpful in addressing the question of what expert problem solvers know that novice problem solvers do not know.

AN ILLUSTRATION OF DEEPER LEARNING AND THE DEVELOPMENT OF 21ST CENTURY COMPETENCIES

Before turning to discussions of deeper learning and 21st century competencies in the intrapersonal and interpersonal domains, we offer a description of a learning environment designed to develop mathematics competencies. Although the instruction focused on knowledge of high school mathematics, the teaching practices used to advance this goal led to development of intrapersonal and interpersonal competencies as well. We offer this case as illustrative (not definitive) of how learning and instruction in traditional school subjects might be organized in ways that produce multiple forms of transferable knowledge and skill (additional examples are provided in Chapter 5).

Our example is derived from Boaler and Staples' (2008) 5-year longitudinal study of approximately 700 students at three high schools. Railside was an urban, ethnically diverse school, where 30 percent of students were English language learners and 30 percent of students qualified for free or reduced meals. Hilltop was a more rural school where approximately half of the students were Latino and half white, 20 percent of students were English language learners, and 20 percent qualified for free or reduced meals. Greendale was a predominantly white school in a small coastal community, with no English language learners, and only 10 percent of students qualifying for free or reduced meals. The sample of schools was chosen intentionally to allow the researchers to observe different mathematics teaching approaches, and the research team gathered a wide range of data over 4 years, including videotapes of classroom activities, assessments of mathematics content, and interviews with students and teachers.

The mathematics teachers at Railside worked collaboratively to develop and implement a mixed-ability curriculum in algebra and geometry classes and made more modest changes to advanced algebra classes. They had high expectations for all students and engaged them in a common, cognitively challenging curriculum. Students spent most of their time working together small, mixed-ability groups to address complex problems. Students at the other two high schools experienced more traditional mathematics instruction, including teacher lectures, whole-class, question-and-answer sessions, and individual practice solving relatively short, closed-ended problems.

At the beginning of the study, when incoming freshmen at all three schools took an assessment of middle school mathematics knowledge, Railside students scored significantly lower than students from the other two schools. Nevertheless, all Railside students were placed in algebra classes, with a curriculum organized around themes, such as "What is a linear function?" The teachers restructured the traditionally rigid sequence of mathematics classes so that students could take two courses within a single year (e.g., algebra and geometry). They also implemented many teaching practices designed to create a new culture of learning within the algebra classrooms. For example, teachers explicitly and publicly valued many different dimensions of mathematical work, recognized the intellectual contributions of students within a group who might otherwise be thought of as low status, and modeled for students the importance of asking good questions. The teachers conveyed to the students that there were many different methods and paths to solve the complex problems and required students to justify their answers.

One important teaching practice focused on encouraging students to be responsible for each other's mathematics learning. Teachers did this in several ways. First, when placing students into groups, they assigned them to particular roles—such as facilitator, team captain, recorder, or resource manager—to convey the idea that all students have important contributions to make. As they circulated around the classroom, teachers frequently emphasized the different roles, for example, by reminding facilitators to help group members check their answers or show their work. In addition, the teachers encouraged students to be responsible for each other's learning through their assessment practices, which included, at times, assigning grades based on the quality of a group's conversations. At other times, teachers asked one member of the group a question and, if that group member could not answer, gave the group some time to help that member find the solution (without providing hints or the answer, so that the group members were required to struggle through to the answer).

At the end of each of school year, all students took content-focused assessments designed by researchers to include topics that had been addressed across the three different schools and teaching approaches (algebra at the end of year 1, geometry at the end of year 2, and advanced algebra and geometry at the end of year 3). In addition, the researcher administered open-ended project assessments in each year of the study, with longer, more applied problems that students worked on in groups. By the end of year 1, the Railside students were approaching comparable levels in algebra to students at the other two schools. By the end of year 2, the Railside students' scores were significantly higher than those of the students in the traditional mathematics classes. At the end of year 3, the Railside students' scores were higher, but not significantly so (perhaps because the year 3 curriculum had not been developed as much by the teachers). In year 4, 41 percent of seniors at Railside were enrolled in calculus, compared with approximately 27 percent in the two other schools.

Railside students also scored higher than students at the other two schools on the California Standards test, a curriculum-aligned test, although they did not do as well on the CAT 6, a standardized state test, perhaps because that test requires strong English language skills and cultural knowledge. In addition, the Railside approach was successful at improving equity. Significant disparities in the mathematics achievement of incoming white, black, and Latino students at Railside disappeared over the course of the study period, although achievement differences between different ethnic groups continued at the other two schools.

These findings begin to illuminate both the process of deeper learning and its role in developing transferable skills and knowledge. Clearly, the innovative approach led to gains in cognitive competencies in mathematics. At the same time, interview data showed that students developed positive dispositions towards mathematics and conscientiousness in addressing mathematics problems—important intrapersonal competencies. For example, 84 percent of Railside students agreed with the statement, "Anyone can be really good at math if they try," compared to 52 percent of students in the traditional classes at the other two schools. Data from the videotaped project assessments showed that Railside students persisted in working through difficult problems for longer time periods than students from the other two schools. Railside students also gained important interpersonal skills, learning to value group work not only for how it aided their own learning but also for helping others. In interviews, they expressed enjoyment in helping others and did not describe others as smart or dumb, slow or quick. Although the focus of their conversations was on mathematics, they learned to appreciate the different perspectives, insights, methods, and approaches offered by students from different cultures and circumstances.

THE INTRAPERSONAL DOMAIN[4]

The model of the suite of knowledge and skills developed through deeper learning shown in Table 4-2 above (Mayer, 2010) includes intrapersonal facets—specifically, productive beliefs about learning—as well as cognitive dimensions. Here, we further explore the intrapersonal dimensions of learning.

The intrapersonal domain encompasses a broad range of competencies that reside within an individual and operate across a variety of different life contexts and situations, including learning situations. We have

[4]This section of the chapter draws heavily on National Research Council (2001, pp. 88-89).

proposed in Chapter 2 that this domain includes three clusters of 21st century competencies:

- Intellectual openness (aligned with the personality factor of openness to experience), including such skills as flexibility, adaptability, artistic and cultural appreciation, and personal and social responsibility
- Work ethic (aligned with the personality factor of conscientiousness), including such skills as initiative and self-direction, responsibility, Type 1 self-regulation (metacognition, including forethought, performance, and self-reflection), and perseverance
- Core self-evaluation (aligned with the personality factor of neuroticism and its opposite, emotional stability), including such skills as Type 2 self-regulation (self-monitoring, self-evaluation, self-reinforcement), and physical and psychological health

Below, we discuss research and theory by investigating how these competencies support learning, including evidence suggesting that they support deeper learning and transfer. We also briefly describe the broader construct of self-regulation and research in child and adolescent development and economics that suggest that competence in self-regulation transfers across a variety of life situations.

The Role of Beliefs and Motivation in Learning

In our discussion of the cognitive domain above, we noted that motivation helps learners to mentally organize and integrate information in the cognitive processing that is central to deeper learning (this is sometimes referred to as "generative processing"). We also argued that productive beliefs about learning are an essential component of transferable knowledge. Here, we explore further how beliefs and motivation support deeper learning.

The beliefs students hold about learning can significantly affect learning and performance (e.g., Dweck and Leggett, 1988). For example, many students believe, on the basis of their typical classroom and homework assignments, that any math problem can be solved in 5 minutes or less, and if they cannot find a solution in that time, they will give up. Many young people and adults also believe that talent in mathematics and science is innate, which gives them little incentive to persist if they do not understand something in these subjects immediately. Conversely, people who believe they are capable of making sense of unfamiliar things often succeed because they invest more sustained effort in doing so.

A recent review of research on social-psychological interventions designed to change students' beliefs and feelings of self-efficacy as learners provides evidence that motivation and related intrapersonal skills enhance deeper learning (Yaeger and Walton, 2011). The authors found that relatively brief interventions can lead to large and sustained gains in student achievement, as students develop durable, transferable intrapersonal skills and apply them to new learning challenges in a positive, self-reinforcing cycle of academic improvement.

Some of the experiments target students' "attributions"—how they explain the causes of events and experiences. Research in social psychology shows that if students attribute poor school performance to traits they view as fixed (such as general low intelligence or a more specific lack of aptitude in mathematics), they will not invest time and effort to improve their performance. This leads to an "exacerbation cycle" of negative attributions and poor performance (Storms and Nisbett, 1970).

Wilson and Linville (1982, 1985) studied a brief intervention designed to change attributions among college freshmen. They brought two groups of struggling freshmen into the laboratory to view videos of upperclassmen discussing their transition to the college. In the videos viewed by the experimental group, upperclassmen said that their grades were low at first, due to transient factors such as a lack of familiarity with the demands of college, but that their grades improved with time. In the videos viewed by the control group, upperclassmen talked about their academic and social interests but did not mention first-year grades. One year later, students in the treatment group had earned significantly higher grade point averages (0.27 percent higher) than students in the control group, and the effect increased over the following semesters. Ultimately, students in the treatment group were 80 percent less likely to drop out of college than the control group.

In another example, Blackwell, Trzesniewski, and Dweck (2007) studied an intervention designed to change attributions among low-income minority seventh-grade students in an urban school. In an 8-week period at the beginning of the school year, the students took part in eight workshops on brain function and study skills. Students in the experimental group were taught that the brain can get stronger when a person works on challenging tasks, while those in the control group learned only study skills. At the end of the academic year, the students in the experimental group earned significantly higher mathematics grades than those in the control group (a mean increase of 0.30 grade points), reversing the normal pattern of declining mathematics grades over the course of seventh grade. Noting that the effectiveness of interventions targeting attributions has been replicated with different student populations, Yaeger and Walton (2011) observe that these studies support the hypothesis that changes in attributions can lead to a positive, self-reinforcing cycle of improvement. Students who attribute a low grade to transitory factors, such as a temporary lack of effort, rather than to a lack of general intelligence or mathematics ability, are more motivated to work harder in their classes. This leads to improved grades, which, in turn, reinforce students' view that they can succeed academically and make them less likely to attribute any low grades to factors beyond their control.

Other experiments are designed to reduce "stereotype threat," the worry that one is perceived as having low intelligence as a member of a stereotyped group, which has been shown to negatively affect academic performance. Yaeger and Walton (2011) describe an intervention based on self-affirmation theory, which posits that people who reflect on their positive attributes will view negative events as less threatening, experience less stress, and function more effectively than they otherwise would. Cohen et al. (2006, 2009) asked white and black seventh-grade students to complete a brief, 15-20-minute writing exercise at the beginning of the school year. The experimental group wrote about why two or three values were personally important to them, while the control group wrote about values that were not personally important. By the end of the first semester, black students in the experimental group had significantly higher grade point averages than their peers in the control group, reducing the black-white achievement gap by about 40 percent. With a few more of these exercises, the black students' gain relative to the control group persisted for 2 years.

These brief interventions appear to work by engaging students as active participants. For example, when students write about values that are important, they are actually generating the self-affirmation intervention. Although they are intentionally brief, to avoid conveying to students that they need intensive help or remediation, the interventions "can induce deep processing and prepare students to transfer the content to new settings" (Yaeger and Walton, 2011, p. 284). The study findings showing that the interventions have led to changes in students' academic trajectories demonstrate transfer of students' learning to new school or college assignments.

The Importance of Metacognition

In his book on unified theories of cognition, Newell (1990) points out that there are two layers of problem solving—applying a strategy to the problem at hand, and selecting and monitoring that strategy. Good problem solving, Newell observed, often depends as much on the selection and monitoring of a strategy as on its execution. The term *metacognition* (literally "thinking about thinking") is commonly used to refer to the selection and monitoring processes, as well as to more general activities of reflecting on and directing one's own thinking.

Experts have strong metacognitive skills (Hatano, 1990). They monitor their problem solving, question limitations in their knowledge, and avoid simple interpretations of a problem. In the course of learning and problem solving, experts display certain kinds of regulatory performance such as knowing when to apply a procedure or rule, predicting the correctness or outcomes of an action, planning ahead, and efficiently apportioning cognitive resources and time. This capability for self-regulation and self-instruction enables advanced learners to profit a great deal from work and practice by themselves and in group efforts.

Studies of metacognition have shown that people who monitor their own understanding during the learning phase of an experiment show better recall performance when their memories are tested (Nelson, 1996). Similar metacognitive strategies distinguish stronger from less competent learners. Strong learners can explain which strategies they used to solve a problem and why, while less competent students monitor their own thinking sporadically and ineffectively and offer incomplete explanations (Chi et al., 1989; Chi and VanLehn, 1991).

There is ample evidence that metacognition develops over the school years; for example, older children are better than younger ones at planning for tasks they are asked to do (Karmiloff-Smith, 1979). Metacognitive skills can also be taught. For example, people can learn mental devices that help them stay on task, monitor their own progress, reflect on their strengths and weaknesses, and self-correct errors. It is important to note, however, that the teaching of metacognitive skills is often best accomplished in specific content areas since the ability to monitor one's understanding is closely tied to domain-specific knowledge and expertise (National Research Council, 1999).

Self-Regulated Learning and Self-Regulation

Student beliefs about learning, motivation, and metacognition are all dimensions of the broader construct of self-regulated learning, which focuses on understanding how learners take an active, purposeful role in learning, by setting goals and working to achieve them.

In a recent review of the research on self-regulated learning, Wolters (2010) observes that, although there are several different models of such learning, the most prominent is that developed by Pintrich and colleagues (Pintrich, 2000, 2004). In this model, learners engage in four phases of self-regulation, not necessarily in sequential order: forethought or planning (setting learning goals); monitoring (keeping track of progress in a learning activity); regulation (using, managing, or changing learning strategies to achieve the learning goals; and reflection (generating new knowledge about the learning tasks or oneself as a learner). These phases overlap substantially with the elements of Type 1 self-regulation included in our proposed cluster of Work Ethic/Conscientiousness skills (see Table 2-2). As the learner engages in the different phases of self-regulation, he or she may regulate one or more of several interrelated dimensions of learning, including cognition (for example, by using cognitive and metacognitive learning strategies); motivation and affect (for example, by planning to reward himself or herself after studying); learning behavior; and the learning context or environment (such as deciding where to study, and who to study with).

Comparing these dimensions of self-regulated learning with a list of 21st century skills proposed by Ananiadou and Claro (2009), Wolters found a high degree of conceptual overlap. The 21st century skills of initiation and self-direction were congruent with self-regulated learning, as the ability to set learning goals and manage the pursuit of those goals is a hallmark of a self-regulated learner. The 21st century skill of adaptability, including the ability to respond effectively to feedback, is very similar (or identical) to what the learner does in the monitoring and reflection phases of self-regulated learning. Learners who are strong in self-regulated learning are seen as particularly adept at using different forms of feedback to continue and complete learning activities. Earlier in this chapter, we noted that development of expertise requires not only extensive practice but also feedback. Accordingly, development of self-regulated learning skills should aid development of expertise in a domain.

Wolters (2010) identified a moderate degree of overlap between self-regulated learning and the interpersonal skills of collaboration and communication. He notes that research on self-regulated learning has begun to explore the interpersonal dimensions of this "intrapersonal" skill, finding that the abilities and beliefs underlying self-regulated learning are developed through social processes. In addition, self-regulated learners are effective at seeking help from peers or teachers, working in groups, and other aspects of collaboration (Newman, 2008). Wolters (2010) concluded that the conceptual similarities between 21st century skills and dimensions of self-regulated learning lend support to the critical importance of competencies such as self-direction, adaptability, flexibility, and collaboration, and suggested drawing on the self-regulated learning research to improve understanding of the 21st century skills.

The construct of self-regulated learning has been used to design instructional interventions that have improved academic outcomes among diverse populations of students, from early elementary school through college. These interventions have led to improvements in class grades and other measures of achievement in writing, reading, mathematics, and science (Wolters, 2010).

Further research is needed to more clearly define the dimensions of self-regulated learning, the relationship between this construct and 21st century skills, and how development of self-regulated learning influences academic engagement and attainment for diverse groups of students (Wolters, 2010). Longitudinal research or other research to improve our understanding of the developmental trajectory of different dimensions of self-regulated learning, such as time management and goal-setting, would help to determine the age level at which students should begin to develop these dimensions. In addition, research is needed to develop more unified assessments of self-regulated learning. The currently available measures (using self-reports, observational, and other methods) suffer from shortcomings and are not fully aligned with current views of self-regulated learning.

Self-Regulation

Self-regulated learning is one facet of the broader skill of self-regulation, which is related to conscientiousness. Self-regulation encompasses setting and pursuing short- and long-term goals and staying on course despite internal and external challenges; it includes managing one's emotions (Hoyle and Davisson, 2011). What an individual uses to overcome internal challenges, such as counterproductive impulses, or external challenges that may arise in different situations requires a set of strategies that, taken together, comprise self-regulation.

Research on self-regulation is growing rapidly, with hundreds of articles and five major edited volumes published since 2000 (Hoyle and Davisson, 2011). Reflecting the breadth of the construct, researchers have studied self-regulation in various life contexts, such as emotion, chronic illness, smoking, exercise, eating, and shopping (Wolters, 2010). To date, there is no consensus in the research on how to define self-regulation. In a review of 114 chapters in edited volumes, Hoyle and Davisson (2011) found that some provided no definition at all, there was no evidence of a common definition, and the same authors sometimes proposed different definitions in different chapters. Because the different definitions include a large number of behavioral variables, further research is needed to more clearly delimit the construct and to exclude variables that are not a critical element of self-regulation.

In the previous chapter, we summarized research indicating that attention, a dimension of self-regulation, is related to reading and math achievement. Attention is the ability to control impulses and focus on tasks (e.g., Raver, 2004), and plays an important role in avoiding antisocial behavior. Specifically, we noted that attention, measured at school entry, predicts later reading and mathematics achievement in elementary school (Duncan et al., 2007). In addition, children who are weak in self-regulation, as indicated by persistently high levels of antisocial behavior across the elementary school years, are significantly less likely to graduate from high school and to attend college than children who never had these problems (Duncan and Magnuson, 2011). Developmental psychologists have developed measures of self-regulation in young children that focus on the ability to delay gratification. Longitudinal studies have found that measures of this dimension of self-regulation in early childhood predict academic and social competence in adolescence (Mischel, Shoda, and Peake, 1988; Shoda, Mischel, and Peake, 1990). Conversely, children who lacked self-regulation in early childhood are more likely at age 18 to be impulsive, to seek danger, to be aggressive, and to be alienated from others (Arsenault et al., 2000).

Given the importance of self-regulation, greater consensus on how to conceptualize this broad construct is needed. The current disagreement in the literature about how to define the foundations, process, and consequences of self-regulation poses a major barrier to the development of accurate assessments of it (Hoyle and Davisson, 2011). As we discuss in the following chapter, teaching for deeper learning and transfer begins with a model of student learning, representing the desired outcomes, and includes assessments to measure student progress toward these outcomes. Agreement on definitions is an essential first step toward teaching and learning of self-regulation.

THE INTERPERSONAL DOMAIN

The sociocultural perspective that learning is "situated" within unique social contexts and communities illuminates the importance of the interpersonal domain for deeper learning. This domain encompasses a broad range of skills and abilities that an individual draws on when interacting with others. We have proposed in Chapter 2 that it includes two skill clusters:

- Teamwork and collaboration (aligned with the personality factor of agreeableness), including such skills as communication, collaboration, teamwork, cooperation, interpersonal skills, and empathy
- Leadership (aligned with the personality factor of extroversion), including such skills as leadership and responsibility, assertive communication, self-presentation, and social influence

This preliminary taxonomy of the interpersonal domain represents an initial step toward addressing the problem of a lack of clear, agreed-upon definitions of interpersonal skills and processes. Below, we discuss the role of interpersonal skills in deeper learning, and then return to the definitional problem.

Much of what humans learn, beginning informally at birth and continuing in more structured educational and work environments, is acquired through discourse and interactions with others. For example, development of new knowledge in science, mathematics, and other disciplines is often shaped by collaborative work among peers (e.g., Dunbar, 2000). Through such interactions, individuals build communities of practice, test their own theories, and build on the learning of others. Individuals who are using a naive strategy can learn by observing others who have figured out a more productive one. The social nature of learning contrasts with many school situations in which students are often required to work independently. Yet the display and modeling of cognitive competence through group participation and social interaction is an important mechanism for the internalizing of knowledge and skill (National Research Council, 1999).

An example of the importance of social context can be found in the 1994 work of Ochs, Jacoby, and Gonzales. They studied the activities of a physics laboratory research group whose members included a senior physicist, a postdoctoral researcher, technical staff, and predoctoral students. They found that workers' contributions to the laboratory depended significantly on their participatory skills in a collaborative setting—that is, on their ability to formulate and understand questions and problems, to construct arguments, and to contribute to the construction of shared meanings and conclusions.

Lave and Wenger (1991) proposed that much of knowledge is embedded within shared systems of representation, discourse, and physical activity in "communities of practice" and that such communities support the development of identity—one is what one practices, to some extent. In this view, school is just one of the many contexts that can support learning. Several studies have supported the idea that knowledge and skills are developed and applied in communities of practice. For example, some researchers have analyzed the use of mathematical reasoning skills in workplace and other everyday contexts (Lave, 1988; Ochs, Jacoby, and Gonzales, 1994). One such study found that workers who packed crates in a warehouse applied sophisticated mathematical reasoning in their heads to make the most efficient use of storage space, even though they may not have been able to solve the same problem expressed as a standard numerical equation (Scribner, 1984). The rewards and meaning that people derive from becoming deeply involved in a community can provide a strong motive to learn.

Studies of the social context of learning show that, in a responsive social setting, learners observe the criteria that others use to judge competence and can adopt these criteria. Learners then apply these criteria to judge and perfect the adequacy of their own performance. Shared performance promotes a sense of goal orientation as learning becomes attuned to the constraints and resources of the environment. In school, students develop facility in giving and accepting help (and stimulation) from others. Social contexts for learning make the thinking of the learner apparent to teachers and other students so that it can be examined, questioned, and built on as part of constructive learning.

Social Dimensions of Motivation and Self-Regulated Learning

Earlier in this chapter, we discussed interventions designed to change students' beliefs about themselves as learners and also their motivation for learning (Yaeger and Walton, 2011). Although these interventions target intrapersonal skills and attitudes as a way to enhance cognitive learning, they are based on research and theory from social psychology. The interventions are carefully designed to tap into social communities and relationships that are important and meaningful to the targeted audiences. For example, the intervention by Wilson and Linville (1982, 1985) used videos of upperclassmen to convey an important message to struggling freshmen because upperclassmen are viewed as trusted sources of information by freshmen. Similarly, we noted that the abilities and beliefs underlying self-regulated learning are developed through social processes and that self-regulated learners are effective at seeking help from peers or teachers, working in groups, and other aspects of collaboration (Newman, 2008). In Chapter 3, we observed that children lacking interpersonal skills, as reflected in persistent patterns of antisocial behavior over the elementary school years, are significantly less likely to graduate from high school and to attend college than children who never had these problems (Duncan and Magnuson, 2011). Clearly, social and interpersonal skills support deeper learning that transfers to new classes and problems, enhancing academic achievement.

IMPLICATIONS FOR INSTRUCTION

Findings from the research reviewed in this chapter have important implications for how to organize teaching and learning to facilitate deeper learning and development of transferable 21st century competencies. Here, we briefly summarize some of the implications, and in Chapter 6, we discuss in greater detail how to design instruction to support deeper learning.

As summarized by a previous NRC committee, research conducted over the past century has (National Research Council, 2001, p. 87):

> clarified the principles for structuring learning so that people will be better able to use what they have learned in new settings. If knowledge is to be transferred successfully, practice and feedback need to take a certain form. Learners must develop an understanding of when (under what conditions) it is appropriate to apply what they have learned. Recognition plays an important role here. Indeed, one of the major differences between novices and experts is that experts can recognize novel situations as minor variants of situations to which they already know how to apply strong methods.

Experts' ability to recognize familiar elements in novel problems allows them to apply (or transfer) their knowledge to solve such problems. The research has also clarified that transfer is also more likely to occur when the person understands the underlying principles of what was learned. The models children develop to represent a problem mentally, and the fluency with which they can move back and forth among representations, are other important dimensions of transfer that can be enhanced through instruction.

The main challenge in designing instruction for transfer is to create learning experiences for learners that will prime appropriate cognitive processing during learning without overloading the learner's information-processing system. Research on learning with multimedia tools has led to the development of the cognitive theory of multimedia learning (Mayer, 2009, 2011a), derived from the cognitive load theory (Sweller, 1999; Plass, Moreno, and Brünken, 2010). This theory posits that learners experience cognitive demands during learning, but their limited processing capacity restricts the amount of cognitive processing they can engage in at any one time. According to both theories, learning experiences may place three different types of demands on learners' limited working memory: (1) extraneous processing, (2) essential processing, and (3) generative processing (Sweller, 1999; Mayer, 2009, 2011a; Plass, Moreno, and Brünken, 2010). Extraneous processing does not serve the learning goals and is caused by poor instructional design. Essential processing is necessary if a learner is to mentally represent the essential material in the lesson, and it is required to address the material's complexity. Generative processing involves making sense of the material (e.g., mentally organizing it and relating it to relevant prior knowledge) and depends on the learner's motivation to exert effort during learning.

Depending on how it is designed, instruction may lead to one of three types of cognitive processing: extraneous overload, essential overload, and generative underuse (Mayer, 2011a). If instruction creates an extraneous overload situation, the amount of extraneous, essential, and generative processing required by the instructional task exceeds the learner's cognitive capacity for processing in working memory. An appropriate instructional goal for extraneous overload situations is to reduce extraneous processing (thereby freeing up cognitive capacity for essential and generative processing). If instruction creates an essential overload situation, the amount of essential and generative processing required by the instructional task exceeds the learner's cognitive capacity, even though extraneous processing demands have been reduced or eliminated. An appropriate instructional goal for essential overload situations is to manage essential processing (as it cannot be cut because it is essential for the instructional objective). Finally, if instruction creates a situation of generative underuse, the learner does not engage in sufficient generative processing even though cognitive capacity is available. An appropriate instructional goal for generative underuse situations is to foster generative processing.

In Chapter 6, we discuss evidence-based instructional methods for reducing extraneous processing, managing essential processing, and promoting generative processing. That chapter describes examples of techniques that have been successful in teaching for transfer, including findings from specific educational interventions.

CONCLUSIONS

Deeper learning occurs when the learner is able to transfer what was learned to new situations. Research on teaching for transfer, which primarily reflects the cognitive perspective on learning, has a long history in psychology and education. This research indicates that learning for transfer requires knowledge that is mentally organized, understanding of the broad principles of the knowledge, and skills for using this knowledge to solve problems. Other, more recent research indicates that intrapersonal skills and dispositions, such as motivation and self-regulation, support deeper learning and that these valuable skills and dispositions can be taught and learned. Sociocultural perspectives on learning illuminate the potential for developing intrapersonal and interpersonal skills within instruction focused on cognitive mastery of school subjects; such perspectives provide further evidence that skills in all three domains play important roles in deeper learning and development of transferable knowledge.

- **Conclusion: The process of deeper learning is essential for the development of 21st century competencies (including both skills and knowledge), and the application of transferable 21st century competencies, in turn, supports the process of deeper learning in a recursive, mutually reinforcing cycle.**

In Chapter 3, the committee concluded that educational attainment is strongly predictive of positive adult outcomes in the labor market, health, and civic engagement. The research reviewed in this chapter indicates that individuals both apply and develop intertwined cognitive, intrapersonal, and interpersonal competencies in the process of deeper learning, including the learning of school subjects. Through deeper learning, individuals develop transferable 21st century competencies that facilitate improvements in academic achievement and that increase years of educational attainment. Thus the research reviewed in this chapter supports the argument that deeper learning and 21st century skills prepare young people for adult success.

At the same time, this chapter finds a lack of clear, agreed-upon definitions of specific cognitive, intrapersonal, and interpersonal competencies. This lack of shared definitions is greatest for competencies in the intrapersonal and interpersonal domains.

5

Deeper Learning of English Language Arts, Mathematics, and Science

This chapter addresses the second question in the study charge by analyzing how deeper learning and 21st century skills relate to academic skills and content in the disciplines of reading, mathematics, and science,[1] especially as the content and skill goals are described in the Common Core State Standards for English language arts and mathematics and NRC's *A Framework for K-12 Science Education* (hereafter referred to as the NRC science framework; National Research Council, 2012).

The existing Common Core State Standards, as well as the Next Generation Science Standards that are under development in 2012 based on the NRC science framework (National Research Council, 2012), are expected to strongly influence teaching and learning in the three disciplines, including efforts to support deeper learning and development of 21st century skills. The English language arts and mathematics standards were developed by state education leaders, through their membership in the National Governors Association and the Council of Chief State School Officers, and have been adopted by nearly all (45) states, along with 2 territories and the District of Columbia. The Next Generation Science Standards are being developed through a similar process and are also likely to be widely adopted by the states.

[1]In keeping with its charge, the committee explored deeper learning in the individual disciplines of reading, mathematics, and science. It only briefly addressed integrated approaches to teaching across disciplines (see Box 5-2), as this topic lay outside its charge. A separate NRC committee has been charged to review the relevant research and develop a research agenda for integrated teaching of science, technology, engineering, and mathematics (STEM).

The first, second, and third sections of the chapter focus, respectively, on English language arts, mathematics, and science and engineering. For each discipline we

- discuss how "deeper learning" has been characterized in the discipline, including issues and controversies that have played out over time;
- describe the relevant parts of the Common Core State Standards or the NRC science framework (along with selected other reports outlining expectations for student learning) in light of the historical context; and
- analyze how the new standards and framework map to our characterization of deeper learning and to the clusters of 21st century skills defined in Chapter 2.

In the final section of the chapter, we present conclusions and recommendations based on a broad look across all three disciplines. In this broad look, we compare the expectations included in the Common Core State Standards and the NRC science framework with deeper learning (as characterized within each discipline) and 21st century skills.

ENGLISH LANGUAGE ARTS

The Context: A History of Controversy

Discussions of how to teach reading and writing in the United States have a reputation for contentiousness, reflected in the military metaphors used to describe them, such as "the reading wars" or "a curricular battleground." The public debates surrounding the fairly regular pendulum swings of the curriculum reveal fundamental differences in philosophy and widely variant interpretations of a very large but sometimes inconsistent research base.

Divergent Positions on Reading for Understanding

Beliefs about how to develop reading for understanding diverge greatly, with the spectrum of opinions defined by two extreme positions. One position, which we will refer to as the simple view of reading, holds that reading comprehension is the product of listening comprehension and decoding. Proponents of this position argue that students in the early grades should learn all of the letters of the alphabet and their corresponding sounds to a high degree of accuracy and automaticity. Agile decoding combined with a strong oral language (i.e., listening vocabulary) base will lead to fluent reading for understanding, limited only by the reader's store of knowledge and language comprehension. After the code is mastered, further development of reading for understanding is expected through either or both of (a) a wide reading of literature and nonfiction to gather new ideas and insights about the natural and social world and (b) solid instruction in the disciplines—the sciences, the social sciences, mathematics, and the humanities.

The polar opposite position, which might best be labeled a utilitarian view of reading, writing, and language, contends that from the outset of kindergarten, educators should engage children in a systematic quest to make sense of their world through deep engagement with the big ideas that have puzzled humankind for centuries. These are, of course, the very ideas that prompted humans to develop the disciplinary tools we use to understand and improve the natural and social world in which we live. Proponents of the utilitarian view argue that students will need to use, and hence refine, their reading and writing skills as they seek information to better understand and shape their worlds. Once students feel the need to learn to read, it will be much easier to teach students the lower-level skills needed to transform print into meaning. A side benefit is that students will have learned an important lesson about the purpose of reading—that it is always about making meaning and critiquing information on the way to acquiring knowledge.

Disagreements Over Curricular Focus, Integration, and Complexity

Disagreements on curriculum and epistemology both confound and intensify the polarized views on teaching reading for understanding. One area of disagreement is curricular focus. Instructional approaches based on the simple view tend to be curriculum centered. All students are expected to march through the same lessons and assessments, and whole-class instruction is commonplace. By contrast, instructional approaches based on the utilitarian view tend to be student centered, and each student may consume a slightly different pedagogical diet. Teachers differentiate activities and assignments for individual students based on feedback about how they are progressing, and instruction is more likely to be delivered in small groups or individualized settings.

A second area of disagreement focuses on whether the English language arts curriculum should be integrated with or separate from instruction in other disciplines. In the simple view, reading, writing, and language skills should be taught separately from the disciplinary curriculum, at least in the early stages of reading, until these fundamental skills become highly automatic. Then and only then, the argument goes, will students be ready to meet the challenges of disciplinary learning from text. The utilitarian view, by contrast, calls for integration between English language arts and disciplinary learning from the earliest stages. Acquiring disciplinary knowledge plus discourse and inquiry skills is the goal to which reading, writing, and language skills are bound, even as they are still being acquired.

A third area of disagreement centers on strategies for coping with complexity. Advocates for the simple view argue for decomposing complex processes into component parts. For example, to help students learn to read words in connected text, they propose that teachers should first focus on teaching the parts of reading—the correspondences between individual letters (or groups of letters) and sounds. Only when students have learned these correspondences to a high degree of accuracy and automaticity should they be asked to synthesize the letters and corresponding sounds into words by reading aloud. Similarly, in writing, advocates of the simple view argue that teachers should first help students learn the parts—the correspondences between the sounds within spoken words and letters that represent these sounds. Only after students have mastered these correspondences should teachers ask them to synthesize the sounds and corresponding letters into the spelling of words.

In contrast, advocates for the utilitarian view would cope with complexity through scaffolding. They argue that students should be encouraged to perform the ultimate target task, such as reading words in connected text. Teachers should scaffold students' performance of the task with various tools, such as reading aloud to convey the "whole of the story"; repeated readings (I'll read a sentence, then you read it); choral readings; and encouraging students to use context and picture cues to figure out pronunciations and word meanings. In writing, students would be encouraged to get their ideas on paper and to spell things the way they sound, with the expectation that later they would, with teacher guidance, transform their sound-based spellings into conventional spellings so that others will be able to read their stories. Students would also be expected to share their written pieces with peers even before they can write and spell fluently, in an effort to represent their attempts to communicate complex ideas.

A fourth area of disagreement centers on where the locus of meaning lies—in the text, the reader, the context in which the reading is completed, or a hybrid space involving all three. A committee chaired by Snow (2002) specified a hybrid space by defining reading comprehension as "the process of simultaneously extracting and constructing meaning through interaction and involvement with written language." The committee viewed the text as an important but insufficient determinant of reading comprehension. Kintsch (1998), in his widely accepted "construction–integration" model of reading comprehension, also discussed the importance of both extracting and constructing meaning, viewing the text as an important but insufficient resource for constructing a model of meaning. He proposed that readers construct a mental representation of what they thought the text said (a text base) and then integrate it with key concepts from memory to create a representation (what he called the situation model) of what they thought the text meant.

Pedagogical approaches reflect these different views of where meaning lies. Approaches based on the simple view tend to stay very close to the text. Teachers pose questions to lay out the "facts" of the text prior to any interpretation, critique, or application of what was learned through reading to accomplish a new task. Approaches based on the utilitarian view may engage students in using the text as a reservoir of evidence to evaluate the validity of different claims, interpretations, critiques, or uses of the text.

The research base for reading, as reflected in key summary documents in the field—such as the report of the National Institute of Child Health and Human Development (2000), the National Academy of Sciences' *Preventing Reading Difficulties in Young Children* (National Research Council, 1998), and the four volumes of the *Handbook of Reading Research* (Pearson et al., 1984; Barr et al., 1991; Kamil et al., 2000, 2011)—tend to provide consistent support for a balanced position that emphasizes both basic and more advanced processes. Such a balanced approach strongly emphasizes the basic skills of phonemic awareness, alphabet knowledge, and decoding for accurate word learning in the early stages of reading acquisition, but places an equal emphasis on reading for meaning at all stages of learning to read. As students mature and the demands of school curriculum focus more on the acquisition of disciplinary knowledge, the emphasis on reading for meaning increases. Thus the polar views that define the extremes of the continuum of views on reading acquisition and pedagogy ultimately converge in a more comprehensive view of written language acquisition. For the all-important early stages of reading, while there is strong support for early emphasis on the basics, there is no evidence that such an emphasis should preclude an equally strong emphasis on learning to use the range of skills and knowledge acquired early on to engage in transfer to new situations and in monitoring one's reading and writing to see if it makes sense.

Summary

Although all the parties in the debate share the goal of deeper learning in English language arts, they propose different routes. Some want to start with shallower or more basic tasks as a foundation for deeper or higher-order tasks. Others want to start with the deeper learning tasks and engage the more basic tasks and information as resources to help students complete the more challenging tasks. In the final analysis, the research supports a more balanced view that incorporates both the "basics" and the need to monitor reading and writing for sense-making and to apply whatever is learned about reading and writing to the acquisition of knowledge within disciplinary settings.

The Four Resources Model as an Approach to Defining Deeper Learning

In the early 1990s, Australian scholars Freebody and Luke took an important step forward in reconciling the various controversies described above (Freebody and Luke, 1990; Luke and Freebody, 1997). They created what is now known as the "four resources model." The model consists of a set of different stances that readers can take toward a text, each of which approaches reading from a different point of view: that of the text, the reader, the task, or the context. Taken together, the stances constitute a complete "theory" of a reader who is capable of managing all of the resources at his or her disposal. The authors propose that any reader can assume any one of these four stances in the quest to make meaning in response to a text. The confluence of reader factors (how much a reader knows or is interested in a topic), text (an assessment of the complexity and topical challenge of the text), task (what a reader is supposed to do with the topic), and context (what is the purpose or challenge in dealing with this text) will determine the particular stance a reader assumes when reading a particular text. That stance can change from text to text, situation to situation, or even moment to moment when reading a given text. The various stances (resources) and the key questions associated with each are

- The reader as decoder, who asks: What does the text say? In the process, the reader builds a coherent text base where each idea is tested for coherence with all of the previous ideas gleaned from a close reading of the text.
- The reader as meaning maker, who asks: What does the text mean? In answering that question, the reader seeks to develop meaning based on: (a) the ideas currently in the text base and (b) the reader's prior knowledge.
- The reader as text analyst, who asks: What tools does the author use to achieve his or her goals and purposes? The text analyst considers how the author's choice of words, form, and structure shape our regard for different characters or our stance toward an issue, a person, or a group. The text analyst reads through the texts to get to the author and tries to evaluate the validity of the arguments, ideas, and images presented.
- The reader as text critic, who asks questions about intentions, subtexts, and political motives. The text critic assumes that no texts are ideologically neutral, asking such questions as: Whose interests are served or not served by this text? Who is privileged,

> marginalized, or simply absent? What are the political, economic, epistemological, or ethical goals of the author?

When the stances of the text critic and the text analyst are combined, the goals of truly critical reading can be achieved. The reader can examine both the assumptions (what knowledge base is required to make sense of the text) and consequences (whose views are privileged and whose are ignored) of a text.

All four stances are in play as well when a writer creates texts for others to read. Writers have various conceptual intentions toward their readers—to inform, for example, or to entertain, persuade, or inspire. They sometimes focus on the code in getting the words on paper. They always employ the two standards of the meaning maker—that what they write in any given segment is consistent with the ideas in the text up to this point, and that it is consistent with the assumed knowledge of the ideal reader. Writers are most expert at handling the form-function (or purpose-structure) relationship of the text analyst; in fact, the crux of the author's craft is to seek and find just the right formal realization of each particular conceptual intention toward the reader. Finally, writers have ulterior motives along with transparent ones. They privilege, marginalize, omit, or focus—sometimes intentionally and other times unwittingly as agents of the cultural forces that shape their work.

The four resources model allows us to define deeper learning in English language arts in a way that recognizes the controversies in the discipline yet meets the need for a balanced approach that equips the reader or writer to take different stances toward the reading or writing of a text depending on the purposes, the context, and the actual task confronting the reader or writer. Reading and writing are simultaneously code-breaking, meaning making, analytic, and critical activities; which stance dominates at a particular moment in processing depends upon the alignment of reader, text, task, and contextual factors. This perspective on deeper learning, recognizing that the reader or writer may adopt various stances from moment to moment, contrasts sharply with the "simple view" of reading and writing. The simple view would limit beginning readers to the code-breaking stance and limit beginning writers to codifying language, by putting down letters and words.

Drawing on the four resources model, we can now define deeper learning in English language arts from two perspectives: (1) as privileging activities that are successively higher on the list—in which the reader acts as meaning maker, text analyst, or text critic; or (2) as privileging the management of all four stances in relation to the reader's assessment of the difficulty of the text or task and the reader's purpose and knowledge resources. In the first perspective on deeper learning, analysis and critique take precedence over making meaning, which takes precedence over decoding. Such a hierarchy is consistent with the research base we will discuss in Chapter 6, in which we will describe the pedagogy of deeper learning as encouraging generative processing, elaboration, and questioning—all of which would lead us down the pathway toward meaning making, analysis, and critique. Indeed, the research on discussion protocols in reading text suggests that the effects of discussion questions are highly specific—that unless one focuses directly on analysis and critique, it is not likely to emerge on its own (Murphy et al., 2009). In the second perspective on deeper learning, reflecting on and managing one's own knowledge matters most in shaping the particular stance that one takes toward the understanding or construction of a text. This perspective builds on other principles of deeper learning elaborated in Chapter 4, namely, the notions of developing metacognitive strategies, self-monitoring, and self-explanation—all dispositions that encourage the learner to intentionally engage in his or her own comprehension and learning processes. This view also suggests that deeper learning involves knowing when and why to privilege lower-order over higher-order skills in pursuit of understanding or problem solving.

These two perspectives on deeper learning in English language arts are not mutually exclusive. Deeper learning could involve the deliberate selection of a stance that elicits the skills and processes that best fit the situation and problem that a learner faces at any given moment *and* also suggest a procedural preference for always selecting the highest level among alternative stances when the situation or problem allows more than one approach. For example, if assuming either the meaning making stance or the analysis stance will allow the learner to solve a reading or writing problem, the learner should opt for an analytic stance to complete the task. From either perspective, beginning readers and writers as well as those who are more advanced, can engage in deeper learning.

Common Core State Standards

The widely adopted Common Core State Standards in English language arts (CCSS-ELA; Common Core State Standards Initiative, 2010a) are likely to shape any attempt to infuse deeper learning initiatives into school curricula. In other words, it is likely that whatever purchase deeper learning initiatives accrue in the next decade will be filtered through this set of standards. From this perspective, the prospects for reading and writing instruction aligned with the four resources model seem promising.

The full title of the CCSS-ELA, *Standards for English Language Arts and Literacy in History/Social Studies, Science, and Technical Subjects* (Common Core State Standards Initiative, 2010a), provides the first indication that these standards will be different from state English language arts

(ELA) standards created before 2010. The title signals the adoption of an integrated view of the topics of reading, writing, speaking/listening, and language. This integrated view is applied to two domains—literature and informational text—for reading and writing in grades K-5. The standards for grades 6-12 are first organized by ELA topic and then by subject matter (history and science) to distinguish which standards are the responsibility of the ELA teacher and which might better be addressed by science and history teachers. Within ELA, the four topics are again applied to the domains of literature and informational text. By contrast, the subject area sections address only the topics of reading and writing, broken down according to history/social studies and science/technical subjects.

This integrated view of ELA contrasts sharply with the heavy emphasis that in recent years has been placed on reading as a separate subject, almost to the exclusion of other language arts topics and other school subjects. The integration of reading with other topics and subjects represents a dramatic shift away from the "big five" approach—phonemic awareness, phonics, fluency, vocabulary, and comprehension—which has dominated reading instruction for over a decade (National Institute of Child Health and Human Development, 2000). The new standards present reading, writing, and oral language as tools for knowledge acquisition, effective argumentation, and clear communication across the disciplines of literature, science (and technical subjects), and history (and social studies). The standards address phonemic awareness, phonics, and fluency primarily in the foundational skills addendum to the K-5 standards. Vocabulary is highlighted in the language strand, and comprehension, alongside composition, is emphasized throughout. This combined with the standards' focus on reading and writing in the disciplines of history and science indicates that the CCSS-ELA can be interpreted as calling for a major shift from the current emphasis on decoding to comprehension of and learning with text.

The CCSS-ELA include 10 college and career readiness anchor standards, representing the "end state"—what high school graduates should know and be able to do if all of the specific grade-level and disciplinary variations of these 10 standards were to be successfully implemented. As shown in Box 5-1, the 10 anchor standards for reading are arranged in four clusters.

The mapping of these standards onto the four resources model (Luke and Freebody, 1997) is reasonably transparent. The three standards in Cluster 1, Key Ideas and Details, reflect the stance of the reader as decoder, with a hint of reader as meaning maker (because of the requirement of invoking prior knowledge to complete each task). The three standards in Cluster 2, Craft and Structure, reflect the stance of the reader as text analyst, focusing on form-function (or purpose-structure) relationships. The three standards in Cluster 3, Integration of Knowledge and Ideas, entail

BOX 5-1
College and Career Readiness Anchor Standards for Reading

Key Ideas and Details

1. Read closely to determine what the text says explicitly and to make logical inferences from it; cite specific textual evidence when writing or speaking to support conclusions drawn from the text.
2. Determine central ideas or themes of a text and analyze their development; summarize the key supporting details and ideas.
3. Analyze in detail where, when, why, and how events, ideas, and characters develop and interact over the course of a text.

Craft and Structure

4. Interpret words and phrases as they are used in a text, including determining technical, connotative, and figurative meanings, and explain how specific word choices shape meaning or tone.
5. Analyze the structure of texts, including how specific sentences, paragraphs, and larger portions of the text (e.g., a section or chapter) relate to each other and the whole.
6. Assess how point of view or purpose shapes the content and style of a text.

Integration of Knowledge and Ideas

7. Synthesize and apply information presented in diverse ways (e.g., through words, images, graphs, and video) in print and digital sources in order to answer questions, solve problems, or compare modes of presentation.
8. Delineate and evaluate the reasoning and rhetoric within a text, including assessing whether the evidence provided is relevant and sufficient to support the text's claims.
9. Analyze how two or more texts address similar themes or topics in order to build knowledge or to compare the approaches the authors take.

Range and Level of Text Complexity

10. Read complex texts independently, proficiently, and fluently, sustaining concentration, monitoring comprehension, and, when useful, rereading.

SOURCE: Common Core State Standards Initiative (2010a).

all four stances—decoder, meaning maker, analyst, and critic, but favor the text critic (especially 8) and meaning maker (especially 7 and 9). And, of course, the standard in Cluster 4, Range and Level of Text Complexity, involves all four stances in constant interaction.[2]

Relating the Standards to Deeper Learning and 21st Century Skills

The CCSS-ELA offer a policy framework that is highly supportive of deeper learning (as reflected in the four resources model) in English language arts. On the other hand, it remains to be seen whether the assessments that emerge from the two state assessment consortia, which have been funded by the Department of Education to develop next-generation assessments aligned to the Common Core State Standards, will be equally supportive of the goal of deeper learning, a question we will return to in Chapter 7.

In the previous chapters, we identified three broad domains of 21st century skills—cognitive, intrapersonal, and interpersonal. To examine the relationship between these clusters of 21st century skills and the various disciplinary standards documents, the committee created a list of some of the most frequently cited 21st century and deeper learning skills and then examined the standards for the degree of support provided for these skills.[3] The domain of cognitive 21st century skills, developed through deeper learning, is well represented in the CCSS-ELA. What is missing, both from the new CCSS and from the larger discussion of goals for reading and writing instruction presented above, is any serious consideration of the intrapersonal and interpersonal domains (see Figure 5-1).

Although the word "motivation" appears three times in the CCSS-ELA, the new standards do not seriously address the motivational factors (engagement, interest, identity, and self-efficacy) and dispositional factors (conscientiousness, stamina, persistence, collaboration) that we know

[2]It is fortunate that we can continue this mapping of cognitive constructs of CCSS onto the NAEP infrastructure for cognitive targets for reading assessment. NAEP's *locate and recall* target corresponds quite closely to the *key ideas and details* CCSS category. NAEP's *integrate and interpret* corresponds to CCSS's *integration of knowledge and ideas*, and NAEP's *critique and evaluate* incorporates much of what falls into CCSS's *craft and structure* (though it entails much more than craft and structure). This set of correspondences should facilitate longitudinal analyses of the course of reform engendered by the CCSS.

[3]The classifications in the figures in this chapter represent common sense judgments by an expert in each discipline who is familiar with the standards, with curriculum and practice, and with the cognitive and educational research literatures in the discipline. Undoubtedly other judges would classify some components differently. The study committee was not charged with conducting a more elaborate analytic study with multiple independent raters and assessments of reliability. Thus these diagrams and observations are meant to represent a plausible illustrative view rather than a definitive analysis.

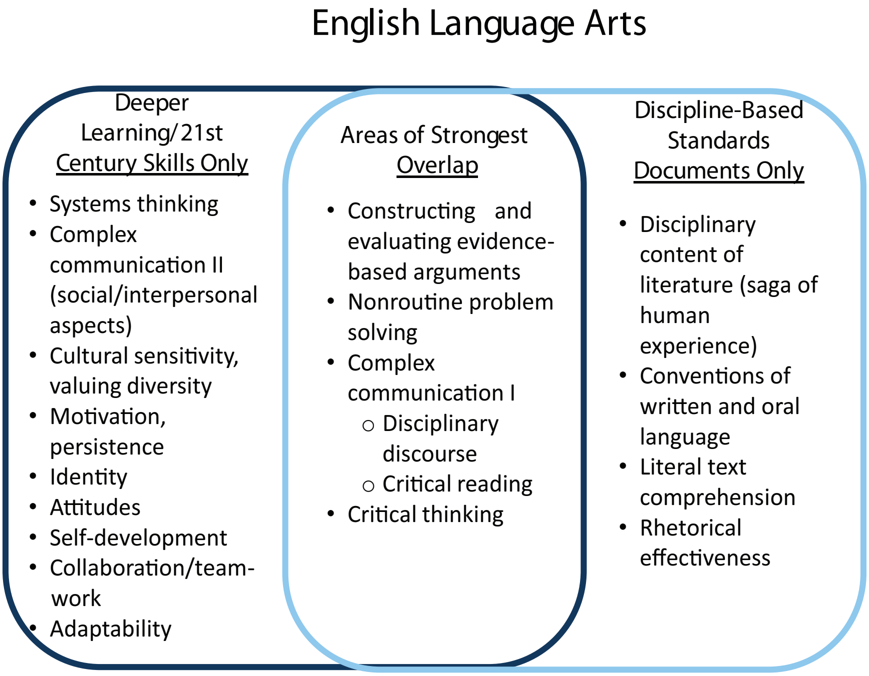

FIGURE 5-1 Overlap between ELA-CCSS standards and 21st century skills.
SOURCE: Created by the committee.

support deeper learning. However, recent research in English language arts illustrates the potential for developing these intrapersonal factors, as well as interpersonal factors. One example is described in Box 5-2 below, and another is found in the work of Guthrie, Wigfield, and You (2012). As noted in Chapter 4, the development of self-regulated strategies in writing—including motivation and feelings of self-efficacy—has been shown to improve writing performance among diverse groups of learners (Graham, 2006). The most probable explanation for the conspicuous absence of these factors from the standards is that, as noted in Chapter 6, they represent skills that are difficult to measure, at least without a very heavy reliance on human judgment. Therefore, these factors are unlikely candidates for systematic monitoring in accountability systems, which have traditionally relied on standardized measures that minimize reliance on human judgment. Presumably the authors of the standards were aware of research showing that reading and writing instruction focused on domain-specific learning goals can develop motivation and positive dispositions toward disciplinary learning, such as the example presented below, but felt that this was beyond the purview of the ELA standards.

MATHEMATICS

The Context: Typical Mathematics Instruction

Research studies provide a clear, consistent picture of typical school mathematics instruction in the United States. What we know is largely derived from two kinds of data and associated research analyses. One type of study that has been carried out over several decades has involved direct observation of classroom teaching (e.g., Stake and Easley, 1978; Stodolsky, 1988; Stigler et al., 1999; Hiebert et al., 2005), and another has used teacher self-report data from surveys (e.g., Weiss et al., 2001; Grouws, Smith, and Sztajn, 2004).

These studies present a remarkably consistent characterization of mathematics teaching in upper elementary school and middle-grade classrooms in the United States: Students generally work alone and in silence, with little opportunity for discussion and collaboration and little or no access to suitable computational or visualization tools. They focus on low-level tasks that require memorizing and recalling facts and procedures rather than tasks requiring high-level cognitive processes, such as reasoning about and connecting ideas or solving complex problems. The curriculum includes a narrow band of mathematics content (e.g., arithmetic in the elementary and middle grades) that is disconnected from real-world situations, and a primary goal for students is to produce answers quickly and efficiently without much attention to explanation, justification, or the development of meaning (e.g., Stodolsky, 1988; Stigler and Hiebert, 1999). As earlier chapters in this volume have indicated, reflecting research evidence regarding how people learn best when the goal is developing understanding (National Research Council, 1999), such pedagogy is at odds with goals aimed at deeper learning and transfer.

Although this pervasive approach to mathematics teaching has not been directly established as the cause of the generally low levels of student achievement, it is difficult to deny the plausibility of such a connection. In response, an array of reform initiatives has been aimed at changing what and how mathematics is taught and learned in American schools. Although reformers have disagreed on some issues, they share the goal of enhancing students' opportunities to learn mathematics with understanding and hence the attendant goal of promoting teaching mathematics for understanding. These goals reflect a focus on deeper learning in school mathematics.

Evolution of National Standards in Mathematics

School mathematics reform has a long history that cannot be adequately described in the limited space here, so we focus on the most recent

BOX 5-2
An Example of Deeper Learning in English Language Arts

The Common Core State Standards for English language arts (Common Core State Standards Initiative, 2010a) provide many opportunities to enact the principles of deeper learning embodied in this report. First, they promote a double vision of integration—(a) that reading, writing, and discourse ought to support one another's development, and (b) that reading, writing, and language practices are best taught and learned when they are employed as tools to acquire knowledge and inquiry skills and strategies within disciplinary contexts, such as science, history, or literature. Hence the standards for reading, writing, and language are unpacked in grades 6 through 12 within the three domains of literature, science and technology, and history. Further, a common criterion for rigorous thinking embedded in the standards centers on developing argumentation skill—the ability to understand, critique, and construct arguments that are valid within the norms of each discipline. Students are asked to deal with what counts as evidence, how arguments are constructed, what constitutes a counter claim and counter evidence—in short, both the structure and substance of reasoning is privileged. While not as ubiquitous as cognitive skills, interpersonal skills are strongly implicated in the speaking and listening standards, with an emphasis on collaboration and listening with care to understand and evaluate others' utterances as a part of rigorous discourse.

At the elementary level, project-based learning has a long history dating back to days of John Dewey and the progressive education movement in schools, a tradition in which the goal was to minimize the distance between school learning and the learning that occurs in the enactment of everyday life outside of school. In one (of many) modern instantiation of this tradition, literacy and science educational researchers at the University of California-Berkeley's Lawrence Hall of Science and in the Graduate School of Education have worked with elementary classroom teachers on an NSF-sponsored curriculum in which reading, writing, and academic language are used as tools to support the acquisition of science knowledge, inquiry strategies, and argumentation skills (Cervetti et al., 2012). Aptly named *Seeds of Science/Roots of Reading*, the program combines hands-on science activities (e.g., designing mixtures such as glue or hair gel from everyday household ingredients or using models to understand the formation of sand on a beach) with a host of reading, writing, and oral discourse activities to support and extend students' investigations and projects. Over the course of an 8-week unit, students read nine different types of books about various aspects of the topic (e.g., the science of sand, light, soil habitats) in a range of genres. These genres may include reference books, brief biographies of scientists, information pieces, books that model an aspect of either a scientific or a literacy process, and books that connect science to everyday life. All of the books are coordinated with specific subtopics within the unit. For example, a hands-on investigation of snails' preferred habitats is paired with a parallel trade book about a science class that collects and analyzes data about the same investigation. Similarly, the students' investigation of "mystery" sand is paired with a biography of a sand scientist that describes how he investigates the size, shape, color, texture, and origin of sand.

Students write in their science journals almost daily and engage in spirited discussions and debates (they call them discourse circles) about unsettled issues that arise from hands-on investigations and/or readings (e.g., they might hold a debate about the origin of a mystery sand). In a typical week in this approach, students will spend about 50 percent of their time in science activities and about 50 percent in reading, writing about their investigations, and talking about their reading, and their personal writing. Several times a week, students are asked to reflect on the quality and focus of their personal learning and participation as well as the learning and participation of their work groups—and even the class as a whole.

The curriculum is designed to foster deeper learning in the cognitive domain, through all of the reading, writing, and inquiry activities. At the same time, deeper learning of intrapersonal competencies is supported by the individual and group reflection activities, which encourage metacognition, taking personal responsibility for one's learning, stamina, and persistence. In the interpersonal domain, deeper learning is fostered by ongoing collaboration, including the discussions about the readings, the small group collaborative investigations, the discourse circles, and even in the division of labor students work out for extended investigations or projects. Reflection activities encourage students to reflect not only on their learning but also on how well their group cooperated and how they could improve their discussions.

The approach was tested in 94 fourth-grade classrooms in one Southern state. Half of the teachers taught the integrated science-literacy curriculum, while the other half of the teachers taught the two topics separately, covering the same science content with materials provided by their school districts along with their regular literacy instruction. Students in the integrated lessons made significantly greater gains on measures of science understanding, science vocabulary, and science writing, and both groups made comparable gains in science reading comprehension. Examples like these demonstrate that cognitive outcomes, which are clearly emphasized in most educational testing and accountability schemes in our country, need not suffer—indeed can prosper—when they are taught and learned in a context in which inter- and intrapersonal skills and practices are equally emphasized. Such examples also demonstrate that at least some disciplines—in this case, English language arts—can benefit from being taught in another disciplinary context, like science. Research has demonstrated the effectiveness of similar curricula integrating English language arts in the disciplines of literature (Guthrie et al., 2004) and social studies (De La Paz, 2005).

SOURCE: Adapted from Cervetti et al. (2012).

reform efforts. In 1989, the National Council of Teachers of Mathematics (NCTM) published the *Curriculum and Evaluation Standards for School Mathematics* (*CESSM*), which was the first attempt to lay out comprehensive national goals for mathematics learning. The curriculum goals portion of the document was divided into three sections representing grade-level clusters: 1-4, 5-8, and 9-12. Each section contained goals for all students and additional goals for college-intending students. *CESSM* promoted a view of mathematics as accessible to all students if instruction were changed to place greater emphasis on understanding and applicable knowledge and less emphasis on the memorization of facts and procedures.

CESSM, serving as the first national model of content expectations in school mathematics, had substantial influence on the mathematics instructional goals and frameworks later developed by a number of individual states. Nevertheless, over time it became clear that *CESSM* lacked the specificity needed by state policy makers to set objectives at and across grade levels and by teachers to implement the report's pedagogical and curricular ideas in their classrooms. In response to these perceived limitations, in 2000 the NCTM developed and published a successor document, *Principles and Standards for School Mathematics* (*PSSM*) (National Council of Teachers of Mathematics, 2000).

While *PSSM* preserved the essential tenets of the earlier *CESSM*, especially its emphasis on the importance of learning mathematics with understanding, it also added several enhancements. To provide more grade-level-specific clarity and guidance, *PSSM* was divided into narrower grade-level bands: K-2, 3-5, 6-8, and 9-12. For each band, *PSSM* presented only one set of goals for all students. *PSSM* also had a common set of overarching curricular expectations across the K-12 spectrum, which was intended to help state officials develop logical progressions of instruction from grade to grade for inclusion in state curriculum guidelines. *PSSM* was much more specific than the *CESSM* about the research basis for its recommendations, and the NCTM published a companion document that reviewed research in a number of areas directly related to the content of *PSSM*.

PSSM was subjected to extensive field review prior to publication, and it was generally well received when published in 2000, but it arrived at the dawn of the No Child Left Behind (NCLB) era in American education. Because extant standardized tests of school mathematics were not well aligned with *PSSM*, and because NCLB regulations required that these tests be a regular feature of every school year in grades 3-8 in order to determine whether adequate yearly progress was being made, *PSSM* had far less impact on states, schools, teachers, and students than had been envisioned by the NCTM.

One decade later, the move toward national guidance regarding expectations for school mathematics learning took a giant leap forward with the publication of the *Common Core State Standards for Mathematics* (*CCSSM*; Common Core State Standards Initiative, 2010b). *CCSSM* presents grade-level-specific expectations that are intended to be the core expectations for mathematics learning in the United States. *CCSSM* diverges from *CESSM* and *PSSM* in certain ways, including how it names the strands of content to be taught and learned and how it distributes certain content across the grades, but it retains the same focus on the importance of teaching in ways that enable students to learn mathematics with understanding. The *CCSSM* states, "These Standards define what students should understand and be able to do in their study of mathematics" (Common Core State Standards Initiative, 2010b, p. 4). Not only is this a consistent theme across the reform documents, it is also a topic that has received considerable attention from the research community.

Research Perspectives on Teaching Mathematics for Understanding

Studies conducted over the past 60 years provide a solid body of evidence concerning the benefits of teaching mathematics for understanding. As summarized in Silver and Mesa (2011, p. 69), teaching mathematics for understanding is sometimes referred to as:

> authentic instruction, ambitious instruction, higher order instruction, problem-solving instruction, and sense-making instruction (e.g., Brownell and Moser, 1949; Brownell and Sims, 1946; Carpenter, Fennema, and Franke, 1996; Carpenter et al., 1989; Cohen, 1990; Cohen, McLaughlin, and Talbert, 1993; Fuson and Briars, 1990; Hiebert and Wearne, 1993; Hiebert et al., 1996; Newmann and Associates, 1996). Although there are many unanswered questions about precisely how teaching practices are linked to students' learning with understanding (see Hiebert and Grouws, 2007), the mathematics education community has begun to emphasize teaching that aims for this goal.

Among the hallmarks of this conceptually oriented version of instruction are (a) mathematical features, or tasks that are drawn from a broad array of content domains and are cognitively demanding, and (b) pedagogical features, or teaching practices that are suitable to support multiperson collaboration and mathematical discourse among students, as well as their engagement with mathematical reasoning and explanation, consideration of real-world applications, and use of technology or physical models (e.g., Hiebert and Carpenter, 1992; Fennema and Romberg, 1999).

Mathematical Features

The mathematics curriculum in the United States, especially in elementary and middle grades, has long been characterized as incoherent, cursory, and repetitive (e.g., Balfanz, Mac Ivar, and Byrnes, 2006). Many have argued that the excessive attention paid to numbers and operations has restricted students' opportunities to learn other interesting and important mathematics content. Reflecting this concern, the National Council of Teachers of Mathematics standards (1989, 2000) noted the importance of including topics in algebra, geometry, measurement, and data analysis in the middle grades. Broader coverage is expected not only to enrich mathematics learning by exposing students to more topics but also to make salient the connections that exist among different content domains and topics—connections that are viewed by psychologists as hallmarks of student understanding (National Research Council, 1999).

Reformers have also called for a new approach to the mathematics tasks that provide daily opportunities for student learning. For example, the *Professional Standards for Teaching Mathematics* (National Council of Teachers of Mathematics, 1991) claimed that student learning of mathematics with understanding depended to a great extent on the teacher using "mathematical tasks that engage students' interests and intellect" (p. 1). Although such tasks can help students develop understanding, establish and maintain curiosity, and communicate with others about mathematical ideas, mathematics teachers in grades K-8 usually present cognitively undemanding tasks, such as recalling facts and applying well-rehearsed procedures to answer simple questions (Stake and Easley, 1978; Stodolsky, 1988; Porter, 1989; Stigler and Hiebert, 1999). Research has shown that it is not easy for teachers to use cognitively demanding tasks well in mathematics classrooms (Stein, Grover, and Henningsen, 1996; Henningsen and Stein, 1997). However, the regular use of such tasks to maintain high levels of cognitive demand can lead to increased student understanding and the development of problem solving and reasoning (Stein and Lane, 1996) and greater overall student achievement (Hiebert et al., 2005).

Pedagogical Features

Reformers have also advocated a broader array of pedagogical strategies to increase students' understanding of mathematics, moving beyond the limited current practices described above. As noted earlier in this chapter, current practice is at odds with research findings about how people learn with understanding (National Research Council, 1999). Silver and Mesa (2011) describe the goals of the reformers as follows:

> Advocates for conceptually oriented teaching in school mathematics (e.g., National Council of Teachers of Mathematics, 1989, 2000) have suggested the potential value of fostering communication and interaction among students in mathematics classrooms through the use of complex tasks that are suitable for cooperative group work and that provide settings in which students need to explain and justify their solutions. Moreover, to increase students' engagement with mathematical tasks and their understanding of concepts, instructional reform efforts have also encouraged the use of hands-on learning activities and technological tools, as well as connecting work done in the mathematics classroom to other subjects and to the world outside school. Beyond exhortations, there is also some research evidence to support these hypotheses about pedagogy that might support students' development of mathematical understanding (e.g., Boaler, 1998; Fawcett, 1938; Fuson and Briars, 1990; Good, Grouws, and Ebmeier, 1983; Hiebert and Wearne, 1993; Stein and Lane, 1996). (Silver and Mesa, 2011, p. 69)

Two examples of instruction incorporating these types of pedagogical features are found in Box 5-3.

Deeper Learning Expectations in Mathematics

As noted earlier, the three major reform documents in school mathematics—*CESSM*, *PSSM*, and *CCSSM*—all emphasize deeper learning of mathematics, learning with understanding, and the development of usable, applicable, transferable knowledge and skills. These themes are in line with the broader statements we discussed earlier regarding the importance of 21st century learning skills. Generally speaking, the mathematics curriculum reform documents are much more explicit about expectations in the cognitive domain than they are about expectations in the intrapersonal and interpersonal domains. Yet, even in the domains less explicitly dealt with in the curriculum reform documents, one finds attention to some key 21st century goals, such as collaborative work, self-regulation, and the formation of positive attitudes and a mathematical identity. Moreover, there is a robust research literature on the matters of collaboration, metacognition, attitudes, motivation, and identity as they pertain to the teaching and learning of school mathematics. Chapter 3 of *Engaging Schools: Fostering High School Students' Motivation to Learn* (National Research Council and Institute of Medicine, 2004) provides an analysis of how many of these factors might interact with issues of race and culture to affect the learning of mathematics.

Again, the committee mapped the reform documents and the lists of 21st century learning skills to ascertain areas of overlap and emphasis. A

BOX 5-3
Examples of Deeper Learning in Mathematics

In Chapter 4, we provided an illustration of deeper learning of mathematics at the high school level (Boaler and Staples, 2008). Here, we focus on early mathematics learning. The weak performance of U.S. 15-year-olds on the mathematics component of the Programme for International Student Assessment (PISA) test (OECD, 2010) reflects the weakness of early math education in the United States. Deeper learning of mathematics in early childhood could potentially reverse the problem of persistent gaps in mathematics knowledge between children from low-income and middle-income backgrounds.

Example 1: Using Board Games for Early Mathematics Learning

One approach to helping preschoolers learn basic number concepts and strategies involves the use of board games. Playing board games with linearly arranged, consecutively numbered, equal-size spaces provides young children with multiple cues about the magnitude of the numbers. Ramani and Siegler (2011) compared the number knowledge of middle-income preschoolers who played a linear board game to the number knowledge of preschoolers from low-income backgrounds who also played this game. Among both groups of preschoolers, those with less initial knowledge of numbers gained more in understanding than those with greater initial knowledge. Significantly, the children from low-income backgrounds learned at least as much, and on several measures more, than preschoolers from middle-income backgrounds.

The study built on an earlier study of low-income preschoolers (Ramani and Siegler, 2008; Siegler and Ramani, 2009), which found that a brief game-playing intervention led to greater improvements in numeracy than alternative numerical activities lasting the same amount of time. The low-income preschoolers showed gains in their ability to estimate number lines, compare magnitudes, identify numerals, and in basic arithmetic, and these gains were stable over a 9-week period. Those who had earlier played the linear board game learned more from subsequent practice and feedback on addition problems than their peers who engaged in other numerical activities, suggesting that they were able to transfer the knowledge they had gained through game play.

A higher percentage of preschoolers from middle-income families than from low-income families report playing board games at home (Ramani and Siegler, 2011), and this difference may contribute to the gap in mathematics knowledge between young children from low-income and middle-income backgrounds. The authors suggest that parents and teachers more frequently engage young children in playing linear board games, which require minimal time to play and are extremely inexpensive.

Example 2: Restructuring the Elementary School Mathematics Classroom

Deeper learning as called for in the Common Core State Standards and other documents reviewed above remains rare in U.S. classrooms. In the 2005 NRC report *How Students Learn: History, Mathematics, and Science in the Classroom*, Griffin (2005) describes very different mathematics classroom activities that are part of the research-based program, *Number Worlds,* for prekindergarten through grade 2. The program is based on six guiding principles (National Research Council, 2005, p. 283), and we describe illustrative activities related to a few of these principles below:

1. Expose children to the major ways that numbers are represented and talked about.
2. Provide opportunities to link the "world of quantity" with the "world of counting numbers" and the "world of formal symbols."
3. Provide visual and spatial analogs of number representations that children can actively explore in hands-on fashion.
4. Engage children and capture their imagination so knowledge constructed is embedded not only in their minds but also in their hopes, fears, and passions.
5. Provide opportunities to acquire computational fluency as well as conceptual understanding.
6. Encourage the use of metacognitive processes (e.g., problem solving, communication, reasoning) that will facilitate knowledge construction.

To implement the first principle, children explore five different lands at each grade level. In each land, they learn about a particular form of number representation while simultaneously addressing specific knowledge goals (developmental milestones) for that grade level. They begin in Object Land, where they initially work with real objects and then move on to work with pictures of objects. Next, they visit Picture Land, where numbers are represented as semiabstract patterns of dots that are equivalent to mathematical sets. By playing various card and dice games, the students gradually come to think of these patterns in the same way that they think of the words they use to talk about numbers. Third, they explore Line Land, where numbers are represented as segments along a line, and they play linear games. Later, they visit Sky Land, where numbers are represented with vertical bar graphs and scales, and Circle Land, where numbers are represented by sundials and clocks, and they learn that numbers are used to measure time and the seasons of the year.

All of the activities are designed to help early elementary students mentally link physical quantities with counting numbers and formal symbols (design principle 2) as illustrated by the game "Plus Pup." To start, the teacher and children put a certain number of cookies into a lunch bag, and then the teacher or a child takes a walk with the bag. Along the way, the teacher or child picks up the Plus Pup card, and receives one more cookie. The teacher then invites the children to figure out how many cookies are in the bag. At first, the children open up the bag and count the cookies, but as they continue to replay the game, they gradually realize that they can use numbers to find the answer.

To support metacognitive processes (design principle 6), the program includes question cards that draw children's attention to the changes in quantities they enact during game play and prompt children to perform any calculations nec-

continued

BOX 5-3 Continued

essary to answer the questions. Additional follow-up questions encourage children to reflect on their own reasoning. The teacher usually uses the question cards at first, but over time, the children gradually begin to pose the questions themselves, assuming greater responsibility for their own learning. In a wrap-up period at the end of each lesson, a reporter from each small group first describes what the group did and learned and then takes questions from the rest of the class. This time for communication and reflection supports significant learning.

Evaluation studies indicate that the program is effective in helping diverse young children develop number knowledge that is deep, lasting, and transferable to further mathematics learning. A longitudinal 3-year study compared the performance of three groups of kindergarten through ninth grade students: (1) an urban, low-income group who participated in Number Worlds; (2) a low-income group who had been tested and identified as high achievers in mathematics; and (3) a largely middle-class group, also tested and designated as high achievers, who were enrolled in a magnet school with an enriched mathematics program. Over the course of the study period, from kindergarten entry to the end of second grade, the mathematics achievement of the Number Worlds group first caught up with, and then gradually exceeded, the achievement of the other two groups.

In addition to clearly enhancing mathematics achievement in the cognitive domain, the program generates positive dispositions toward mathematics among both students and teachers in the intrapersonal domain (Griffin, 2005) as well as enhances the interpersonal skills of communication, collaboration, and teamwork.

summary is provided in Figure 5-2, and outcomes of the mapping process are elaborated briefly below.

Cognitive Skills

In mathematics, as is the case with the other content areas treated in this chapter, the cognitive domain affords the strongest correspondence between 21st century skills and school learning goals for the subject. In particular, the *CCSSM*, *PSSM*, and *CESSM* documents all consider critical thinking, problem solving, constructing and evaluating evidence-based arguments, systems thinking, and complex communication to be important learning goals for mathematics, though there is some variation in how these skills are treated and the relative emphasis placed on each.

The two most prominent areas of overlap between 21st century skills and learning goals for school mathematics are found for the themes of argumentation/reasoning and problem solving. Problem solving and reasoning are central to mathematics and have long been viewed as key leverage

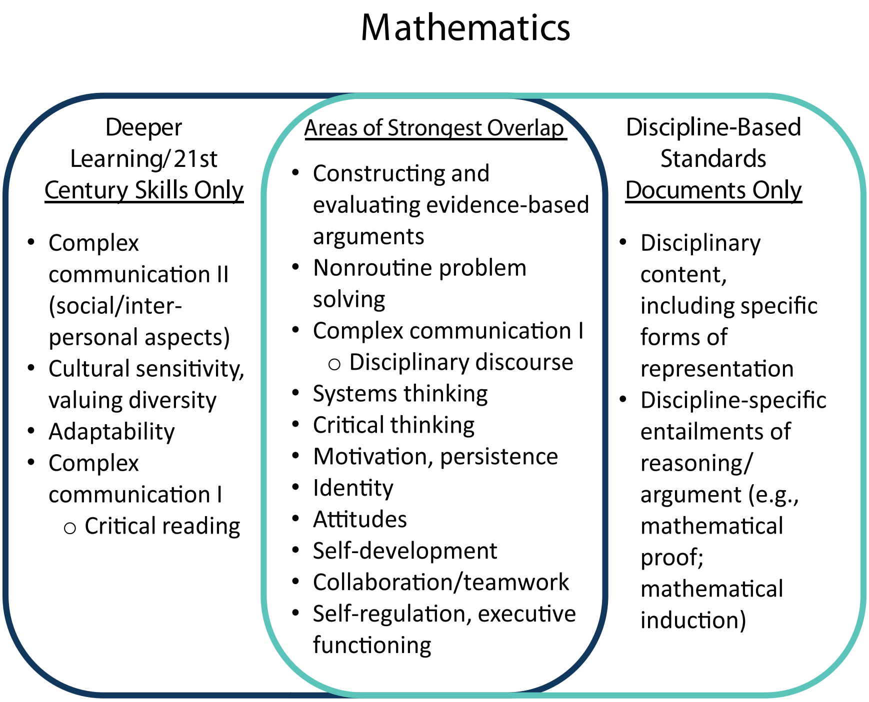

FIGURE 5-2 Overlap between CCSS mathematics standards and 21st century skills.
SOURCE: Created by the committee.

points in efforts to teach mathematics for understanding (Fawcett, 1938; Schoenfeld, 1985; Silver, 1985, 1994; Charles and Silver, 1988).

As the *PSSM* reasoning and proof standard states

> Being able to reason is essential to understanding mathematics. . . . [I]nstructional programs across PK-12 should enable students to . . . recognize reasoning and proof as fundamental aspects of mathematics; make and investigate mathematical conjectures; develop and evaluate mathematical arguments and claims; and select and use various types of reasoning and methods of proof. (National Council of Teachers of Mathematics, 2000, p. 56)

Students are expected to have opportunities to explore mathematical patterns in order to detect regularities, to formulate conjectures and hypotheses based on observed patterns and regularities, and to investigate and test the validity of these conjectures and hypotheses using mathematical reasoning. Students should learn to use varieties of mathematical reasoning and argumentation (e.g., probabilistic, geometric, algebraic, and proportional reasoning) and to generate mathematically valid proof arguments and counterarguments (e.g., develop validity justifications and produce a counterexample) (National Council of Teachers of Mathematics, 2000, pp. 56-59).

This theme of argumentation and reasoning is touched on explicitly in two of the *CCSSM* standards for mathematical practice: "Reason abstractly and quantitatively," and "Construct viable arguments and critique the reasoning of others." In discussing the latter standard, *CCSSM* states

> Mathematically proficient students understand and use stated assumptions, definitions, and previously established results in constructing arguments. They make conjectures and build a logical progression of statements to explore the truth of their conjectures. They are able to analyze situations by breaking them into cases, and can recognize and use counterexamples. They justify their conclusions, communicate them to others, and respond to the arguments of others. . . . Students at all grades can listen to or read the arguments of others, decide whether they make sense, and ask useful questions to clarify or improve the arguments. (Common Core State Standards Initiative, 2010b, p. 6)

The *CCSSM* also deals explicitly with problem solving. Its first standard in the category of mathematic practice is "Make sense of problems and persevere in solving them." In discussing this standard, *CCSSM* states

> Mathematically proficient students start by explaining to themselves the meaning of a problem and looking for entry points to its solution. They analyze givens, constraints, relationships, and goals. They make conjectures about the form and meaning of the solution and plan a solution pathway rather than simply jumping into a solution attempt. They consider analogous problems, and try special cases and simpler forms of the original problem in order to gain insight into its solution. They monitor and evaluate their progress and change course if necessary. . . . They can understand the approaches of others to solving complex problems and identify correspondences between different approaches. (Common Core State Standards Initiative, 2010b, p. 6)

This view that problem-solving processes play a central role in mathematical activity is resonant with the earlier characterization provided in *PSSM*'s problem-solving standard:

> Problem solving means engaging in a task for which the solution method is not known in advance. In order to find a solution, students must draw on their knowledge, and through this process, they will often develop new mathematical understandings. Solving problems is not only a goal of learning mathematics but also a major means of doing so . . . instructional programs across PK-12 should enable students to . . . build new

> mathematical knowledge through problem solving, solve problems that arise in mathematics and in other contexts, apply and adapt a variety of appropriate strategies to solve problems, and monitor and reflect on the process of mathematical problem solving. (National Council of Teachers of Mathematics, 2000, p. 52)

Students should learn to recognize classes of problems that can be solved using routine procedures and should also learn to use a wide range of problem-solving strategies (e.g., heuristic processes such as drawing a diagram, considering special cases, working backward, solving a simpler problem, and looking for patterns and regularities) that can be useful in solving nonroutine problems.

Intrapersonal and Interpersonal Skills

Unlike skills in the cognitive domain, those in the intrapersonal and interpersonal domains are not particularly prominent in the mathematics curriculum reform documents. Historically the interpersonal and intrapersonal domains have been represented in research conducted on mathematics teaching and learning (McLeod and Adams, 1989; McLeod, 1992; Schoenfeld, 1992), but they have tended to receive less attention as curricular or instructional outcomes. The two prominent areas of overlap between 21st century skills and learning goals for school mathematics in these domains are self-regulation and motivation/persistence.

The theme of self-regulation is evident in the *CCSSM* standard of mathematical practice, "Make sense of problems and persevere in solving them." The expectation is clear that students must learn to monitor and evaluate their progress when solving problems, and to change course if necessary. Within this *CCSSM* standard one also finds explicit attention to persistence, as the earlier quote illustrates. Students are expected to spend time examining a problem, considering pathways, reflecting on progress, and adjusting solution approaches rather than leaping immediately onto a solution path and then abandoning it at the first obstacle.

SCIENCE AND ENGINEERING

The Context: Evolution of National Standards in Science

National initiatives to outline disciplinary content standards for K-12 science education have undergone significant evolution over the past two decades. The American Association for the Advancement of Science's (AAAS's) reports *Science for All Americans* (American Association for the Advancement of Science, 1989) and *Benchmarks for Science Literacy* (American

Association for the Advancement of Science, 1993) and the National Research Council's *National Science Education Standards* (National Research Council, 1996) were ambitious efforts to lay out systematic guidelines and standards for science literacy for K-12 education based on reviews of research by national panels of experts. More recently, in July 2011, the National Research Council released the NRC science framework (National Research Council, 2012), and Achieve, Inc., has been commissioned by the Carnegie Corporation to develop a full set of standards based on this framework. These standards are intended to be the science education counterpart of the Common Core State Standards in English language arts and mathematics, and it is expected that they too will be adopted in many states.

The following analysis of the correspondence between disciplinary standards for science education and 21st century skills is based primarily on the NRC science framework as well as on several recent volumes published by the NRC that review and synthesize current research on students' learning and on curricular and pedagogical models in science. These reports include *How Students Learn: History, Mathematics, and Science in the Classroom* (National Research Council, 2005); *America's Lab Report: Investigations in High School Science* (National Research Council, 2006); *Taking Science to School: Learning and Teaching Science in Grades K-8* (National Research Council, 2007); and *Exploring the Intersection of Science Education and 21st Century Skills* (National Research Council, 2010).

Science Content and Process

One of the long-standing issues in science education has been the relative emphasis that should be placed on—and the nature of the relationship between—"content" (facts, formulas, concepts, and theories) and "process" (scientific method, inquiry, discourse). AAAS's Project 2061 aimed to transform science education in the United States by placing a heavy emphasis on inquiry, often interpreted primarily as hands-on investigation, as a corrective to the overemphasis on isolated factual content common in so many science classrooms (American Association for the Advancement of Science, 1989, 1993). The *National Science Education Standards*, too, called for engaging students in inquiry, both to motivate their interest in science and to help them learn about science content and the nature of science (National Research Council, 1996).

As these calls for more inquiry in science classrooms have been acted upon in recent decades, certain trends have emerged that indicate a need to further articulate what is meant by scientific inquiry. One trend was that inquiry in some circles came to be associated primarily with "hands-on" science, often reflecting a commitment by education practitioners to a change in the pedagogy from passive, teacher-led instruction to active, student-driven discovery. "Hands-on" laboratory activities can effectively support science learning if they are designed with clear learning goals in mind; are thoughtfully sequenced into the flow of science instruction; integrate learning of science content with learning about the processes of science; and incorporate time for student reflection and discussion (National Research Council, 2006). However, such approaches are not typical in American high schools. Instead, the calls for more inquiry sometimes resulted in a particular neglect of critical reasoning, analysis of evidence, development of models, and written and oral discourse associated with constructing and evaluating arguments and explanations—all aspects of inquiry that may be downplayed when "hands-on" activities are not carefully designed and scaffolded.

A second trend was the tendency to treat scientific methodology as divorced from content (National Research Council, 2007). Many students, for instance, are introduced to a generic "scientific method," which is presented as a fixed linear sequence of steps, emphasizing experimental investigations, which the students are often asked to apply in a superficial or scripted way. This approach to the scientific method often obscures or distorts the processes of inquiry as they are practiced by scientists. Practices, such as reasoning carefully about the implications of models and theories; framing questions and hypotheses so that they can be productively investigated; systematically analyzing and integrating data to serve as evidence to evaluate claims; and communicating and critiquing ideas in a scientific community are vital parts of inquiry. However, they tend to be missed when students are taught a scripted procedure designed to obtain a particular result in a decontextualized investigation. Furthermore, these higher-level reasoning and problem-solving practices require a reasonable depth of familiarity with the content of a given scientific topic if students are to engage in them in a meaningful way.

Debates over content versus process are not in step with the current views of the nature of science. Philosophers of science and scientists themselves now view science as both a body of established knowledge and an ongoing process of scientific discovery that can lead to revisions in that body of knowledge (National Research Council, 2005). Science is seen as a fundamentally social enterprise that is aimed at advancing knowledge through the development of theories and models that have explanatory and predictive power and that are grounded in evidence. In practice this means that the content and the process are deeply intertwined. Similarly, as highlighted in Chapters 4 and 6, strategies involving higher-order thinking and problem solving tend to be domain specific and are best developed and practiced in a suitably rich content domain (National Research Council, 2005).

Understanding the Structure of Scientific Knowledge

In recent decades, our understanding of what constitutes an appropriate foundation of factual and conceptual knowledge in science has been further developed. Research in cognitive science has emphasized that sophisticated scientific knowledge is characterized by a rich, conceptually organized, well-connected, and fluently integrated set of representations (National Research Council, 2005, 2007). An important hallmark of these integrated webs or networks of knowledge is that the facts, concepts, theories, and procedures that are organized in this way can be meaningfully understood, usefully applied, and productively added to or further developed on an ongoing basis. In this respect there is significant congruence among how scientific knowledge is construed within the discipline, how it is construed within the NRC science framework, and in the committee's definition of deeper learning as learning that can be successfully transferred and applied in new situations (see Chapter 4).

The development of sophisticated scientific knowledge involves simultaneous and mutually reinforcing learning of both content knowledge and process skills. For example, a review of science learning in grades K-8 proposed that students who are proficient in science (National Research Council, 2007, p. 2) have the following capabilities:

1. Know, use, and interpret scientific explanations of the natural world.
2. Generate and evaluate scientific evidence and explanations.
3. Understand the nature and development of scientific knowledge.
4. Participate productively in scientific practices and discourse.

Both of these reviews reflect a view of science as a body of knowledge as well as an ongoing process.

Current Science Instruction

Today's K-12 science classrooms generally reflect neither the calls for more fully developed inquiry experiences in national science standards nor the research evidence on how students learn science. As in mathematics, the curriculum has been criticized as being "a mile wide and an inch deep." The authors of *Taking Science to School* (National Research Council, 2007) offered this summary of K-8 science instruction: "Typical classroom activities convey either a passive and narrow view of science learning or an activity-oriented approach devoid of question-probing and only loosely related to conceptual learning goals" (p. 253). Large science textbooks cover many topics with little depth, providing little guidance on how to place science in the context of meaningful problems. As teachers try to cover the broad curriculum, they give insufficient attention to students' understanding and instead focus on superficial recall-level questions (Weiss et al., 2003; Weiss and Pasley, 2004). The patterns are similar to those observed in mathematics classrooms (Stigler and Hiebert, 1999).

Similarly, at the high school level, laboratory activities that typically take up about one science class period each are disconnected from the flow of science instruction. Instead of focusing on clear learning objectives, laboratory manuals and teachers often emphasize procedures, leaving students uncertain about what they are supposed to learn. Furthermore, these activities are rarely designed to integrate learning of science content and processes. During the rest of the week, students spend time listening to lectures, reading textbooks, and preparing for tests that emphasize many different topics (National Research Council, 2006).

Making matters worse, in the past decade time and resources for science education have often been cut back since science test scores have not counted in the formulations for whether schools are making adequate yearly progress under the NCLB legislation. This lack of emphasis has further limited the development of new capacity for high-level science instruction in K-12 schools and has thus also limited the potential impact of deeper learning goals within the state and national standards currently in use.

A limited number of small-scale studies (e.g., Herrenkohl et al., 1999; Kolodner et al., 2003; Klahr and Nigam, 2004; Krajcik et al., 2008; Cobern et al., 2010), reviews and syntheses (e.g., Linn, Davis, and Bell, 2004; Mayer, 2004; Kirschner, Sweller, and Clark, 2006), and meta-analyses (Minner, Levy, and Century, 2010) of thoughtfully implemented science instruction have shed some light on the current debates about the most appropriate pedagogical practices for science teaching and learning. The current synthesis based on available evidence does not dictate a particular pedagogical approach as uniformly superior. Scaffolding, modeling, guided inquiry, explicit instruction, individual study and practice, computer-mediated learning, and group problem solving and discussion have all been shown to be effective in various circumstances. The choice of instructional strategy often depends on the particular goals of a specific lesson or unit (National Research Council, 2000, 2007). As in other domains of learning, the research base indicates that one rarely gets something for nothing: If we want students to be skillful at reading and interpreting scientific materials, engaging in both written and oral scientific discourse, working fluently with quantitative data, constructing models, and problem solving effectively with peers, then we must give them the particular opportunities, models, and guidance needed to develop each of those sets of skills.

The Framework: Relating Scientific Practices and Concepts

The NRC science framework uses the term "practices" (in the plural) instead of process or skills to capture (1) the essential integration of knowledge and skills in action, and (2) the variety of activities, competencies, and dispositions involved in doing science productively, including habits of reasoning, discourse norms of communities and institutions, attitudes, values, epistemological understanding, and recognition of multiple methodologies (e.g., observation, field work, and modeling, in addition to laboratory experiments). The authors contrast this diversity with the thin procedural treatment of a single uniform "scientific method" that is commonly presented in science classrooms. They also note that modeling, communication, critique, and evaluation require particular attention and experiences to cultivate and that these experiences are often lacking in approaches that emphasize the hands-on aspects of inquiry as well as those that focus too narrowly on manipulating and controlling variables.

An overarching goal expressed in the NRC science framework is to ensure that all students—whether they pursue advanced education and careers in STEM fields or not—"possess sufficient knowledge of science and engineering to engage in public discussions on related issues; are careful consumers of scientific and technological information related to their everyday lives; [and] are able to continue to learn about science outside school" (National Research Council, 2012, p. 1). To these ends, they should have sufficiently deep understanding of core concepts in science, such as matter, energy, forces, earth and solar systems, organisms, and ecosystems, to think productively and to avoid common myths and misconceptions. They should also have sufficient experience with and understanding of a spectrum of scientific methods, including experimental, observational, and modeling approaches, to be able to evaluate and critique the quality and completeness of the available evidence and the relative degrees of certainty or uncertainty associated with it.

The NRC science framework is unequivocal in stating that the practices of science are inextricably tied to both *learning* and *doing* science. Science practices cannot and should not be taught in isolation, and, as new science standards based on the framework are developed, the practices should be infused throughout the standards for content knowledge. Participating in these practices is intended to simultaneously advance students' understanding of scientific methods, of the nature of science, of applications of science, and of particular foundational scientific concepts. In comparing the abilities described in the NRC science framework with 21st century skills, a key point to note is that the area of greatest overlap is found in the science and engineering practices. By considering how the framework connects disciplinary content to practices in this area of overlap, we can gain insight both into the meaning of "deep" in deeper learning and into certain clusters of 21st century skills.

The NRC science framework makes several important assertions about science and engineering education: (1) that disciplinary knowledge and skills (as exemplified in the "practices") are essentially intertwined and must be simultaneously coordinated in science and engineering education; (2) that engaging in the practices of science and engineering advances students' understanding of the nature of scientific knowledge, the variety of methodologies used in science and engineering, and areas of meaningful application; and (3) that participating in science or engineering practices also affects disciplinary learning by engaging students' interest and increasing their motivation.

This argument that engaging in science and engineering practices is necessary and beneficial for learning disciplinary content is noteworthy because such a connection is not made in a strong way within current frameworks of deeper learning and 21st century skills, such as the Hewlett Foundation's description of deeper learning[4] or the Partnership for 21st Century Skills framework.[5] These formulations generally note the importance of learning in core academic disciplines but give no guidance as to how or whether the learning of disciplinary content connects to the development of the other 21st century skills. The framework thus provides a rationale for connecting the "deep" learning of disciplinary content in science and engineering with at least some 21st century skills.

Organization of the NRC Science Framework

The NRC science framework includes engineering as well as science and notes that while the two disciplines have distinctly different goals, they share important features, such as reasoning and problem-solving processes, the testing and evaluation of outcomes and products, and the use of cognitive tools, such as analogical reasoning, systems thinking, and mental and physical models. In what follows the comments about science teaching and learning are generally intended to apply to engineering education as well. Where a distinction between science and engineering education seems important, it is noted.

The science framework is laid out in three dimensions, which are conceptually distinct but integrated in practice in the teaching, learning, and doing of science and engineering. The three dimensions are

[4]See http://www.hewlett.org/programs/education-program/deeper-learning for description [April 2012].

[5]See http://www.p21.org/overview/skills-framework/57 for description [April 2012].

- core disciplinary ideas,
- crosscutting concepts, and
- scientific and engineering practices

Core Disciplinary Ideas

One goal of the revision to the *National Science Education Standards* was to reduce the long catalog of factual knowledge students are expected to master in order to place a deeper and more sustained focus on a much smaller set of core ideas that have broad importance across scientific disciplines and that are key for developing more complex ideas. Drawing on recent research on cognition, development, and learning in science,[6] the new framework adopts a "learning progressions" approach to the core disciplinary ideas. In this approach, the learning standards are organized as integrated, continuous progressions of ideas that increase in sophistication over multiple years, from the early elementary grades through high school. The core ideas are grouped according to life sciences, earth and space sciences, physical sciences, and engineering and technology.

Crosscutting Concepts

The NRC science framework identifies seven crosscutting concepts, which are important scientific concepts that bridge across multiple disciplines. They include patterns; cause and effect; scale, proportion, and quantity; systems and system models; energy and matter; structure and function; and stability and change.

Scientific and Engineering Practices

The NRC science framework conceptualizes practices as occurring in and connecting across three "spaces":

1. **Investigation and empirical inquiry**, in which the dominant practices are observing phenomena, planning experiments and data collection, deciding what and how to measure, and identifying sources of uncertainty. This space involves interaction with the natural or physical world.
2. **Construction of explanations or designs**, a conceptual theory-building space, focused on developing hypotheses, models, and solutions.

[6] A comprehensive list of research references is included in an appendix that accompanies the NRC science framework.

3. **Evaluation space**, focused on analysis, argument, and evaluation, in which the dominant practices are the analysis and construction of arguments and the critique of fit of evidence in relation to predictions (science) or of design outcomes to constraints and goals (engineering).

Eight key practices, which collectively span these spaces, are highlighted in the framework. Each is fairly richly described, so they are perhaps best thought of as complex activities rather than discrete skills. The key practices are as follows (National Research Council, 2012, p. 42):

1. Asking questions (for science) and defining problems (for engineering)
2. Developing and using models
3. Planning and carrying out investigations
4. Analyzing and interpreting data
5. Using mathematics, information and computer technology, and computational thinking
6. Constructing explanations (for science) and designing solutions (for engineering)
7. Engaging in argument from evidence
8. Obtaining, evaluating, and communicating information

While the three dimensions of the NRC science framework (i.e., core disciplinary ideas, crosscutting concepts, and science and engineering practices) and the way in which they are conceptually organized do not map in a tidy way to 21st century skills, there is significant overlap. Furthermore, the framework allows (indeed, forces) distinct discipline-based interpretations of what some of these skills mean in the context of science education.

In the *Taking Science to School* report (National Research Council, 2007), an expert committee identified four strands of science proficiency: knowing, using, and interpreting scientific explanations of the natural world; generating and evaluating scientific evidence and explanations; understanding the nature and development of scientific knowledge; and participating productively in scientific practices and discourse. There are significant similarities between these strands for scientific proficiency and the framework's three-dimensional organization, and the framework authors explicitly cite many of the findings summarized in *Taking Science to School* as the basis for similar recommendations. The framework is more detailed and specific than the *Taking Science to School* report in addressing the knowledge and practices students need to develop over the K-12 span.

The framework also makes important connections to other disciplines—most notably English language arts and mathematics. The crosscutting concepts include a special focus on the mathematical concepts of scale, quantity, and proportion, with the observation that scientific systems and processes span remarkable ranges of magnitudes on dimensions of time (e.g., nanoscale to geologic time) and space (e.g., atoms to galaxies). Students need to be fluent with systems of measurement for different types of quantities, with ratio relationships among different quantities, and with the relative magnitudes associated with various scientific concepts and phenomena. They also need to be able to create, interpret, and manipulate a variety of representations for quantitative data.

Similarly, the framework emphasizes the importance of reading, writing, and speaking skills in science and engineering. It notes that scientists and engineers typically spend half of their working time reading, interpreting,

BOX 5-4
An Example of Deeper Learning in Science

Many of the elements of the vision for science education outlined in *A Framework for K-12 Science Education* are currently uncommon in science instruction in U.S. classrooms. These include the sustained development of a smaller set of core disciplinary ideas over longer periods of time, the cultivation of reasoning and problem-solving skills even in earlier grades, attention to scientific communication (both written and oral) that explicitly involves developing explanatory theories and models and using data as evidence to construct and evaluate explanations and arguments, and development of an understanding of the nature of scientific knowledge. What might this look like as realized in the classroom?

One particularly rich illustration comes from the work of Herrenkohl et al. (1999) who conducted a study of an extended unit of science instruction with third through fifth graders investigating sinking and floating. Over a period of 10 weeks, students worked in small groups to carry out a series of investigations based on cognitive research on the conceptual pathway that students follow in coming to understand when and why various objects will sink or float (Smith, Snir, and Grosslight, 1992; Smith et al., 1994). Conceptual development in this domain involves understanding and relating concepts of mass, volume, density, and relative density and is known to be conceptually challenging for many students. Students' investigations were carefully scaffolded to support reasoning practices in science and were also interspersed with teacher-guided whole-class discussions in which students gained experience communicating, monitoring, and critiquing their own thinking and the thinking of their peers as they developed, tested, and evaluated theoretical explanations for the phenomena they were observing.

The team of researchers, along with the classroom teachers, incorporated a number of instructional tools and practices. As students conducted their investigations, they were introduced to explicit strategies in science, including predicting and producing text. As noted above, the integration of literacy activities in disciplinary contexts provides students with opportunities to master the particular challenges posed by disciplinary materials. In science, for example, texts often include unfamiliar vocabulary and complex sentence structures and are also often multimodal, incorporating diagrams, tables, graphs, images, and mathematical expressions. Students must also learn discourse norms for discussion and critique in science—discerning, for instance, that a scientific "argument" is not the same thing as an interpersonal disagreement (see Box 5-4). Varying interpretations are adjudicated through reasoning with evidence, and changing one's mind because of convincing evidence presented by a peer does not mean that one "lost the fight."

and theorizing, summarizing results, and relating predictions and theories to the results obtained. Through classroom discussions and repeated opportunities to practice these science strategies, students came to be able to distinguish between predictions and theories, to develop theory-based explanations of their observations, and to use evidence to evaluate their theories, rejecting some and refining others. During whole-class discussion, as small groups reported on their work, students also became experienced at taking on several "audience roles," taking responsibility for checking their peers' predictions and theories; summarizing results; and assessing the relation between the reporters' predictions, theories, and results. Public documents in the classroom, such as a theory chart used to help students track the development of their thinking over time, and a questions chart, which they used to catalog good questions for the audience to ask reporters, were used to scaffold students' awareness of how scientific thinking and knowledge develop and change over time and of the kinds of strategies that lead to progress.

The researchers described their approach as "sociocognitive," and we note that it requires students to develop and practice strategies from the cognitive, interpersonal, and intrapersonal domains. Students learned to apply explicit reasoning and planning strategies for designing, conducting, and interpreting their investigations. They also became better able to monitor their thinking and to recognize when their ideas were or were not well developed or justified. They also became more comfortable with scientific discourse, learning not to become defensive when questioned by peers and learning the norms and expectations for scientific reasoning and discussion. Results from coded videotapes of classroom activities and discussions and from pretests and posttests indicated that students' notions of scientific theorizing and their ability to engage in it evolved significantly, as did their conceptual understanding of the phenomena of floating and sinking.

SOURCE: Created by the committee, based on Herrenkohl et al. (1999).

Relating the NRC Science Framework to Deeper Learning and 21st Century Skills

We asked how, from the point of view of the framework, a proposed 21st century skill might be characterized within science and engineering and what degree of support the framework would provide for incorporating such a skill as part of teaching and learning in the discipline. Our findings are shown in Figure 5-3 and discussed below.

Cognitive Competencies

Drawing on the framework (as well as other sources mentioned above), we found the strongest correspondence—and hence the strongest support—in the cluster of 21st century skills categorized as "cognitive." In particular, critical thinking, nonroutine problem solving, constructing and evaluating evidence-based arguments, systems thinking, and complex communication

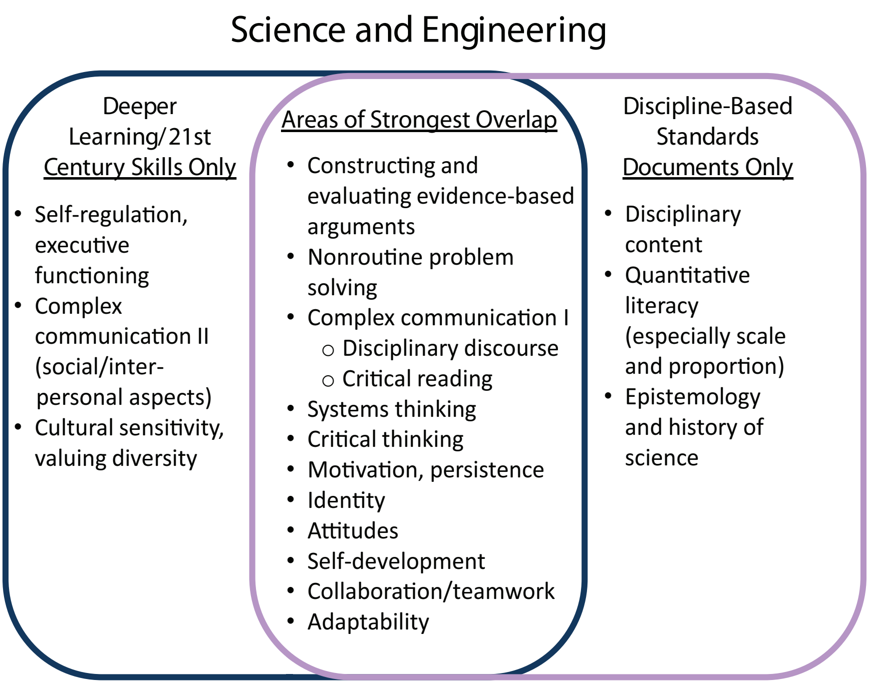

FIGURE 5-3 Overlap between science standards framework and 21st century skills.
SOURCE: Created by the committee.

were all strongly supported in the framework and were construed as being central and indispensible to the disciplines of science and engineering.

However, each of these abilities tends to be embodied in particular ways in the science and engineering standards. For example, "complex communication" entails mastering the discourse norms for framing and communicating scientific questions and hypotheses or engineering problems and design proposals. The framework emphasizes communicating findings and interpretations clearly and participating constructively in peer critiques and reviews as well as the capacity to engage in critical reading (including quantitative comprehension) of discipline-based texts, data archives, and other scientific information sources.

Similarly, "constructing and evaluating evidence-based arguments" is framed in terms of generating, evaluating, and testing scientific hypotheses or engineering designs. In particular, the framework highlights the importance of distinguishing scientific from nonscientific questions; distinguishing evidence from claims; and evaluating the reliability, completeness, and degree of uncertainty associated with evidence and interpretations.

Intrapersonal Competencies

In some respects, the intrapersonal category is the most difficult domain of skills to evaluate. Metacognitive reasoning about one's own thinking and working processes and the capacity to engage in self-directed learning throughout one's lifetime receive explicit support in the framework. However, the degree of support for such factors as motivation and persistence, attitudes, identity and value issues, and self-regulation (if construed as a person being punctual, organized, taking on responsibility, and so forth) is weaker or more indirect. At the same time, though, there is no obvious conflict or lack of compatibility between the vision of science education presented by the framework and these 21st century skills. The NRC science framework is not mute on such topics as valuing diversity, being a conscientious and self-motivated learner, or appreciating the intellectual values of science and engineering. Rather, it seems to situate the issues as something other than disciplinary learning goals for individual students. Issues of diversity and equity, for instance, are treated as goals that are important for the communal enterprise of science and its relation to societal needs and values. Personal qualities, such as engagement and persistence, seem to be viewed as means that can help support successful science learning for more students, rather than as stand-alone end goals or outcomes of science education.

To some degree, the difficulties encountered in aligning intrapersonal and interpersonal skills with disciplinary standards may be ontological in nature: The science and engineering standards are intended to characterize a set of knowledge and skills that students are expected to master during the K-12 years, while at least some of the deeper learning and 21st century skills are intended to characterize desired qualities of a person as a lifelong learner, as a citizen, and as a member of the workforce (Conley, 2011). In this respect, some of these skills would be expected to be complementary to, rather than overlapping with, disciplinary standards—a view that is compatible with the vision presented in the NRC science framework.

Interpersonal Competencies

Within the domain of interpersonal skills, the framework provides strong support for collaboration and teamwork. A pervasive theme in the framework is the importance of understanding science and engineering as norm-governed enterprises conducted within a community, requiring well-developed skills for collaborating and communicating. In addition, the framework supports adaptability, construed as the ability and inclination to revise one's thinking or strategy in response to evidence or peer review.

There is less attention paid to interpersonal social skills and values, such as cultural sensitivity or valuing diversity. While these are not seen as being in conflict with learning about and practicing science and engineering, they are not strongly supported as explicit learning goals for students in the disciplines. Indeed, these almost seem to be emphasized more as important skills for teachers to use in engaging diverse students in science learning than as disciplinary learning goals for the students themselves.

Findings

Several important observations emerge from our mapping of science and engineering standards with 21st century skills. First, some of these skills correspond with the disciplinary standards, and standards documents value these skills highly as important for learning and practicing science and engineering. However, the standards documents value specific interpretations of these skills from a disciplinary perspective, and there may be other interpretations of these skills that differ substantially from these disciplinary interpretations. For example, there is very strong support in the framework for "complex communication" when viewed as sophisticated discourse within the discipline or as critical reading and quantitative literacy skills; however, there is considerably less support for complex communication skills if they are construed as involving interpersonal sensitivity, cultural awareness, or negotiation and persuasion skills.

Another key observation is that, aside from the possible divergence of interpretations just mentioned, there is little in statements of 21st century skills that would be viewed as directly in competition with or incompatible with standards for teaching and learning science and engineering. Of course, there is always room for conflict over relative emphasis and the competition for ever-scarce classroom time, and there would also likely be some potential for conflict depending on certain choices of pedagogical strategies, which are not strictly dictated by the framework. We note, however, that one theme of a recent National Research Council workshop (National Research Council, 2010) was that those science education initiatives that aligned particularly well with 21st century skills tended to emphasize project-based and problem-solving approaches to curriculum and learning. The emphasis on the eight key practices in the Framework would converge in this direction as well.

CONCLUSIONS AND RECOMMENDATIONS

While we found substantial support for deeper learning and 21st century skills in the various standards documents and supporting research literature, we also found a certain degree of unevenness in their prominence and coverage. A cluster of skills, primarily from the cognitive domain, appeared as central in each of the three disciplines, although the particular interpretations of them varied from discipline to discipline. This set included critical reasoning, the ability to construct and evaluate arguments in relation to evidence, nonroutine problem solving, and complex communication (both written and oral) involving the discourse standards of the various disciplinary communities. However, the definitions of argumentation and standards of evidence differed across the three disciplines.

- **Conclusion: Some 21st century competencies are found in standards documents, indicating that disciplinary goals have expanded beyond their traditional focus on basic academic content. A cluster of cognitive competencies—including critical thinking, nonroutine problem solving, and constructing and evaluating evidence-based arguments—is strongly supported in standards documents across all three disciplines.**

Intrapersonal skills and characteristics, such as persistence, self-efficacy, self-regulation, and one's identity as a capable learner, were treated more variably across the standards documents, although the research literature on teaching and learning in the disciplines provides some support for their importance. We note that the smaller degree of attention paid to noncognitive dimensions in the standards documents stands in contrast to the evidence discussed in Chapter 3, which indicates that they are important for larger educational and workforce goals, such as staying in school, completing degrees, and attaining higher levels of education. However, we also observe that they may be less likely to be emphasized in disciplinary standards because they may be crosscutting competencies and thus not unique to or distinctively expressed within a given discipline.

- **Conclusion: Coverage of other 21st century competencies—particularly those in the intrapersonal and interpersonal domains—is uneven. For example, standards documents across all three disciplines include cognitive and interpersonal competencies related to discourse structures and argumentation, but the disciplines differ in their view of what counts as evidence and what the rules of argumentation are. This uneven coverage could potentially lead to learning environments for different subjects that do not equally support the development of 21st century competencies.**

Our review of the research on how the disciplines have characterized "deeper learning" and sought to foster it indicates that instruction for deeper learning is rare in current English language arts, mathematics, and science classrooms.

- **Conclusion: Development of higher-order 21st century competencies within the disciplines will require systematic instruction and sustained practice. It will be necessary to devote additional instructional time and resources to advance these sophisticated disciplinary learning goals over what is common in current practice.**

The committee's review of research on learning goals in the three disciplines indicates that people in each of the disciplines desire to develop skills and knowledge that will transfer beyond the classroom. However, the goals for transfer are specific to each discipline. For example, the NRC science framework envisions that, by the end of twelfth grade, students will be prepared "to engage in public discussions on science-related issues, to be critical consumers of scientific information related to their everyday lives, and to continue to learn about science throughout their lives" (National Research Council, 2012, pp. 1-2). As we discuss further in Chapter 6, attempts to cultivate general problem-solving skills in the absence of substantive disciplinary or topical knowledge have not typically been effective. We speculate that there may be a mismatch between the expectations of employers in this regard and what is known about learning and transfer. It is an open question as to whether a student who becomes an adept problem solver across a variety of academic disciplines would be better able to transfer problem-solving abilities to new areas than a student who was strong in just one discipline, or whether particular kinds of instructional practices and experiences in the K-12 setting would increase the likelihood of transfer of advanced skills across domains. More research is needed to address these questions.

- **Conclusion: Teaching for transfer within each discipline aims to increase transfer within that discipline. Research to date provides little guidance about how to help learners aggregate transferable knowledge and skills across disciplines. This may be a shortcoming in the research or a reflection of the domain-specific nature of transfer.**

- **Recommendation 2: Foundations and federal agencies should support programs of research designed to illuminate whether, and to what extent, teaching for transfer within an academic discipline can facilitate transfer across disciplines.**

6

Teaching and Assessing for Transfer

The prior chapters have established transfer as the defining characteristic of deeper learning; discussed the importance of cognitive, intrapersonal, and interpersonal skills for adult success; and expanded our description of deeper learning, including both the process of deeper learning and its manifestation in the disciplines of English language arts, mathematics, and science. This chapter takes the argument one step further by reviewing research on teaching for transfer. The first section discusses the importance of specifying clear definitions of the intended learning goals and the need for accompanying valid outcome measures if we are to teach and assess for transfer. Accepting that there are limitations in the research, the next section describes emerging evidence indicating that it is possible to support deeper learning and development of transferable knowledge and skills in all three domains. The third section then summarizes what is known about how to support deeper learning and the development of transferable cognitive competencies, identifying features that may serve as indicators that an intervention is likely to develop these competencies in a substantial and meaningful way. The fourth section then discusses what is known about how to support deeper learning in the intrapersonal and interpersonal domains. The fifth section returns to issues of assessment and discusses the role of assessment in support of deeper learning. The final section offers conclusions and recommendations.

THE NEED FOR CLEAR LEARNING GOALS AND VALID MEASURES

Educational interventions may reflect different theoretical perspectives on learning and may target different skills or domains of competence. In all cases, however, the design of instruction for transfer should start with a clear delineation of the learning goals and a well-defined model of how learning is expected to develop (National Research Council, 2001). The model—which may be hypothesized or established by research—provides a solid foundation for the coordinated design of instruction and assessment aimed at supporting students' acquisition and transfer of targeted competencies.

Designing measures to evaluate student accomplishment of the particular learning goals can be an important starting point for the development process because outcome measures can provide a concrete representation of the ultimate student learning performances that are expected and of the key junctures along the way, which in turn can enable the close coordination of intended goals, learning environment characteristics, programmatic strategies, and performance outcomes. Such assessments also communicate to educators and learners—as well as designers—what knowledge, skills, and capabilities are valued (Resnick and Resnick, 1992; Herman, 2008).

An evidence-based approach to assessment rests on three pillars that need to be closely synchronized (National Research Council, 2001, p. 44):

- A *model* of how students represent knowledge and develop competence in a domain
- Tasks or situations that allow one to *observe* student performance relative to the model
- An *interpretation* framework for drawing inferences from student performance

Developing that first pillar—a model of the learning outcomes to be assessed—offers a first challenge in the assessment of cognitive, intrapersonal, and interpersonal competencies. Within each of these three broad domains, theorists have defined and conducted research on a wealth of individual constructs. In the previous chapters, we noted that the research literature on cognitive and noncognitive competencies has used a wide variety of definitions, particularly in the intrapersonal and interpersonal domains. In Chapter 2, we suggested certain clusters of competencies within each domain as the targets of assessment and instruction and offered preliminary definitions. Questions remain, however, about the implications of these definitions. For example, the range of contexts and situations across which the learning of these competencies should transfer remains unclear.

A second challenge arises from the existing assessment models and methodologies used to observe and interpret students' responses relative to these constructs. It is widely acknowledged that most current large-scale measures of educational achievement do not do a good job of reflecting deeper learning goals in part because of constraints on testing formats and testing time (Webb, 1999; also see Chapter 7). While a variety of well-developed exemplars exist for constructs in the cognitive domain, those for intrapersonal and interpersonal competencies are less well developed. Below, we briefly discuss examples of measures for each domain of competence. (For a fuller discussion of this topic, see National Research Council, 2011a.)

Measures of Cognitive Competence

Promising examples of measures focused on important cognitive competencies can be found in national and international assessments, in training and licensing tests, and in initiatives currently under way in K-12. One example is the computerized problem-solving component of the Programme for International Student Assessment (PISA), which is scheduled for operational administration in 2012 (National Research Council, 2011b). In this 40-minute test, items are grouped in units around a common problem, which keeps reading and numeracy demands to a minimum. The problems are presented within realistic, everyday contexts, such as refueling a moped, playing on a handball team, mixing elements in a chemistry lab, and taking care of a pet. The difficulty of the items is manipulated by increasing the number of variables or the number of relationships that the test taker has to deal with.

Scoring of the items reflects the PISA 2012 framework, which defines four processes that are components of problem solving: (1) information retrieval, (2) model building, (3) forecasting, and (4) monitoring and reflecting. Points are awarded for information retrieval, based on whether the test taker recognizes the need to collect baseline data and uses the method of manipulating one variable at a time. Scoring for the process of model building reflects whether the test taker generates a correct model of the problem. Scoring of forecasting is based on the extent to which responses to the items indicate that the test taker has set and achieved target goals. Finally, points are awarded for monitoring and reflecting, which includes checking the goal at each stage, detecting unexpected events, and taking remedial action if necessary.

Another promising example of assessment of complex cognitive competencies, created by the National Council of Bar Examiners, consists of three multistate examinations that jurisdictions may use as one step in the process of licensing lawyers.[1] The three examinations are the Multistate Bar Examination (MBE), the Multistate Essay Examination (MEE), and the Multistate Performance Test (MPT). All are paper-and-pencil tests that are designed to measure the knowledge and skills necessary to be licensed in the profession and to ensure that the newly licensed professional knows what he or she needs to know in order to practice. These overarching goals—as well as the goals of the individual components summarized briefly below—reflect an assumption that law students need to have developed transferable knowledge that they will be able to apply when they become lawyers.

The purpose of the MBE is to assess the extent to which an examinee can apply fundamental legal principles and legal reasoning to analyze a given pattern of facts. The questions focus on the understanding of legal principles rather than on memorization of local case or statutory law. The MBE consists of 60 multiple-choice questions and is administered over an entire day.

The purpose of the MEE is to assess the examinee's ability to (1) identify legal issues raised by a hypothetical factual situation; (2) separate material that is relevant from that which is not; (3) present a reasoned analysis of the relevant issues in a clear, concise, and well-organized composition; and (4) demonstrate an understanding of the fundamental legal principles relevant to the probable resolution of the issues raised by the factual situation. This test lasts for 6 hours and consists of nine 30-minute questions.

The goal of the MPT is to assess the fundamental skills of lawyers in realistic situations by asking the candidate to complete a task that a beginning lawyer should be able to accomplish. It requires applicants to sort detailed factual materials; separate relevant from irrelevant facts; analyze statutory, case, and administrative materials for relevant principles of law; apply relevant law to the facts in a manner likely to resolve a client's problem; identify and resolve ethical dilemmas; communicate effectively in writing; and complete a task within time constraints. Examinees are given 90 minutes to complete each task.

These and other promising examples each start with a strong model of the competencies to be assessed; use simulated cases and scenarios to pose problems that require extended analysis, evaluation, and problem solving; and apply sophisticated scoring models to support inferences about student learning. The PISA example, in addition, demonstrates the dynamic and interactive potential of technology to simulate authentic problem-solving situations.

The PISA problem-solving test is one of a growing set of examples that use technology to simultaneously engage students in problem solving and assess their problem-solving skills. Another example is SimScientists, a

[1]The following description of the three examinations relies heavily on Case (2001).

simulation-based curriculum unit that includes a sequence of assessments designed to measure student understanding of ecosystems (Quellmalz, Timms, and Buckley, 2010). The SimScientists summative assessment is designed to measure middle school students' understanding of ecosystems and scientific inquiry. Students are presented with the overarching task of describing an Australian grassland ecosystem for an interpretive center and respond by drawing food webs and conducting investigations with the simulation. Finally, they are asked to present their findings about the grasslands ecosystem.

SimScientists also includes elements focusing on transfer of learning, as described in a previous NRC report (National Research Council, 2011b, p. 94):

> To assess transfer of learning, the curriculum unit engages students with a companion simulation focusing on a different ecosystem (a mountain lake). Formative assessment tasks embedded in both simulations identify the types of errors individual students make, and the system follows up with graduated feedback and coaching. The levels of feedback and coaching progress from notifying the student that an error has occurred and asking him or her to try again, to showing the results of investigations that met the specifications.

Students use this targeted, individual feedback to engage with the tasks in ways that improve their performance. As noted in Chapter 4, practice is essential for deeper learning, but knowledge is acquired much more rapidly if learners receive information about the correctness of their results and the nature of their mistakes.

Combining expertise in content, measurement, learning, and technology, these assessment examples employ evidence-centered design and are developing full validity arguments. They reflect the emerging consensus that problem solving must be assessed as well as developed within specific content domains (as discussed in the previous chapter; also see National Research Council, 2011a). In contrast to these examples, many other current technology-based projects designed to impact student learning lack a firm assessment or measurement basis (National Research Council, 2011b).

Project- and problem-based learning and performance assessments that require students to engage with novel, authentic problems and to create complex, extended responses in a variety of media would seem to be prime vehicles for measuring important cognitive competencies that may transfer. What remains to be seen, however, is whether the assessments are valid for their intended use and if the reliability of scoring and the generalizability of results can achieve acceptable levels of rigor, thereby avoiding validity and reliability problems of complex performance assessments developed in the past (e.g., Shavelson, Baxter, and Gao, 1993; Linn et al., 1995).

Measures of Intrapersonal and Interpersonal Competence

As is the case with interpersonal skills, many of the existing instruments for the measurement of intrapersonal skills have been designed for research and theory development purposes and thus have the same limitations for large-scale educational uses as the instruments for measuring interpersonal skills. These instruments include surveys (self-reports and informant reports), situational judgment tests, and behavioral observations. As with the assessment of interpersonal competencies, it is possible that evidence of intrapersonal competencies could be elicited from the process and products of student work on suitably designed complex tasks. For example, project- or problem-based performance assessments theoretically could be designed to include opportunities for students to demonstrate metacognitive strategies or persistence in the face of obstacles. Student products could be systematically observed or scored for evidence of the targeted competencies, and then these scores could be counted in student grades or scores on end-of-year accountability assessment. To date, however, strong design methodologies, interpretive frameworks and approaches to assuring the score reliability, validity, and fairness have not been developed for such project- or problem-based performance assessments.

There are few well-established practical assessments for interpersonal competencies that are suitable for use in schools, with the exception of tests designed to measure those skills related to formal written and oral communication. Some large-scale measures of collaboration were developed as part of performance assessments during the 1990s, but the technical quality of such measures was never firmly established. The development of those assessments revealed an essential tension between the nature of group work and the need to assign valid scores to individual students. Today there are examples of teacher-developed assessments of teamwork and collaboration being used in classrooms, but technical details are sketchy.

Most well-established instruments for measuring interpersonal competencies have been developed for research and theory-building or for employee selection purposes, rather than for use in schools. These instruments tend to be one of four types: surveys (self-reports and informant reports), social network analysis, situational judgment tests, or behavioral observations (Bedwell, Salas, and Fiore, 2011). Potential problems arise when applying any of these methods for large-scale educational assessment, to which stakes are often attached. Stakes are high when significant positive or negative consequences are applied to individuals or organizations based on their test performance, consequences such as high school graduation, grade-to-grade promotion, specific rewards or penalties, or placement into special programs.

Stakes attached to large-scale assessment results heighten the need for the reliability and validity of scores, particularly in terms of being resistant to fakeability. Cost and feasibility also are dominant issues for large-scale assessments. Each of the instrument types has limitations relative to these criteria. Self-report, social network analysis, and situational judgment tests, which can provide relatively efficient, reliable, and cost-effective measures, are all subject to social desirability bias—the tendency to give socially desirable and socially rewarded rather than honest responses to assessment items or tasks. While careful design can help to minimize or correct for social desirability bias, if any of these three types of assessment instruments were used for high-stakes educational testing, social desirability bias would likely be heightened.

Behavioral ratings, in contrast, present challenges in assuring reliability and cost feasibility. For example, if students' interpersonal skills are assessed based on self, peer, or teacher ratings of student presentations of portfolios of their past work (including work as part of a team), a number of factors may limit the reliability and validity of the scores. These include differences in the nature of the interactions reflected in the portfolios for different students or at different times; differences in raters' application of the scoring rubric; and differences in the groups with whom individual students have interacted. This lack of uniformity in the sample of interpersonal skills included in the portfolio poses a threat to both validity and reliability (National Research Council, 2011a). Dealing with these threats to reliability takes additional time and money beyond that required for simply presenting and scoring student presentations.

Collaborative problem-solving tasks currently under development by PISA offer one of the few examples today of a direct, large-scale assessment targeting social and collaboration competencies; other prototypes are under development by the ATC21S project and by the military. The quality and practical feasibility of any of these measures are not yet fully documented. However, like many of the promising cognitive measures, these rely on the abilities of technology to engage students in interaction, to simulate others with whom students can interact, to track students' ongoing responses, and to draw inferences from those responses.

Summary

In summary, there are a variety of constructs and definitions of cognitive, intrapersonal, and interpersonal competencies and a paucity of high-quality measures for assessing them. All of the examples discussed above are measures of maximum performance rather than of typical performance (see Cronbach, 1970). They measure what students *can do* rather than what they *are likely to do* in a given situation or class of situations. While measures of maximum performance are usually the focus in the cognitive domain, typical performance may be the primary focus of measures for some intrapersonal and interpersonal competencies. For example, measures of dispositions and attitudes related to conscientiousness, multicultural sensitivity, and persistence could be designed to assess what students are likely to do (typical performance). In comparison to measures of maximum performance, measures of typical performance require more complex designs and tend to be less stable and reliable (Patry, 2011).

Both the variety of definitions of constructs across the three domains and the lack of high-quality measures pose challenges for teaching, assessment, and learning of 21st century competencies. They also pose challenges to research on interventions designed to impact student learning and performance, as we discuss below.

EMERGING EVIDENCE OF INSTRUCTION THAT PROMOTES DEEPER LEARNING

Despite the challenges posed by a lack of uniform definitions and high-quality measures of the intended performance outcomes, there is emerging evidence that cognitive, intrapersonal, and interpersonal competencies can be developed in ways that promote transfer. The most extensive and strongest evidence comes from studies of interventions targeting cognitive competencies, but there is also evidence of development of intrapersonal and interpersonal competencies. The research includes studies encompassing how people learn in formal, informal, and workplace learning environments, as discussed further below.

Evidence from Interventions in Formal Learning Environments

As illustrated by the examples in the previous chapter, some classroom-based interventions targeting specific cognitive competencies have also, through changes in teaching practices, fostered development of intrapersonal and interpersonal competencies. The students learn through discourse, reflection, and shared experience in a learning community. For example, Boaler and Staples (2008) note the following:

> The discussions at Railside were often abstract mathematical discussions and the students did not learn mathematics through special materials that were sensitive to issues of gender, culture, or class. But through their mathematical work, the Railside students learned to appreciate the different ways that students saw mathematics problems and learned to value the contribution of different methods, perspectives, representations, partial ideas and even incorrect ideas as they worked to solve problems. (p. 640)

Both the mathematics knowledge and skills and the positive dispositions toward mathematics and feelings of self-efficacy in mathematics developed by these students appear to be durable and transferable, as nearly half of the students enrolled later in calculus classes and all indicated plans to continue study of mathematics.

In the domain of English language arts, Guthrie, Wigfield, and their colleagues developed an instructional system designed to improve young students' reading by improving their motivation and self-regulation as well as their use of cognitive and metacognitive strategies (Guthrie et al., 1996, 2004; Guthrie, McRae, and Klauda, 2007; Wigfield et al., 2008; Taboada et al., 2009). Several empirical studies found this intervention to be successful in improving the performance of young readers, reflecting gains in the cognitive knowledge and skills that were the primary targets of the intervention (Guthrie et al., 2004). The young students involved in the intervention showed greater engagement in reading both in school and outside of school (Wigfield et al., 2008). These findings suggest that the students not only developed the intrapersonal competencies of motivation and self-regulation but also transferred these competencies to their reading in the contexts of both school and home.

There is also some evidence that intrapersonal and interpersonal competencies can be effectively taught and learned in the classroom. In the past, interventions often focused on reducing or preventing undesirable behaviors, such as antisocial behavior, drug use, and criminal activities. Increasingly, however, intervention programs are designed instead to build positive capacities, including resilience, interpersonal skills, and intrapersonal skills, in both children and families. In a recent review of the research on these new skill-building approaches—including meta-analyses and numerous randomized trials—a National Research Council committee (2009b) concluded that effectiveness has been demonstrated for interventions that focus on strengthening families, strengthening individuals, and promoting mental health in schools and in healthcare and community programs.

Durlak et al. (2011) recently conducted a meta-analysis of school-based instructional programs designed to foster social and emotional learning. They located 213 studies that targeted students aged 5 to 18 without any identified adjustment or learning problems, that included a control group, and that reported sufficient data to allow calculation of effect sizes. Almost half of the studies employed randomized designs. More than half (56 percent) were implemented in elementary school, 31 percent in middle school, and the remainder in high school. The majority were classroom based, delivered either by teachers (53 percent) or by personnel from outside the school (21 percent). Most of the programs (77 percent) lasted less than a year, 11 percent lasted 1 to 2 years, and 12 percent lasted more than 2 years.

The authors analyzed the effectiveness of these school-based programs in terms of six student outcomes in the cognitive, intrapersonal, and interpersonal domains: social and emotional skills, attitudes toward self and others, positive social behaviors, conduct problems, emotional distress, and academic performance. Measures of these outcomes included student self-reports; reports and ratings from a teacher, parent, or independent rater; and school records (including suspensions, grades, and achievement test scores). Overall, the meta-analysis showed statistically significant, positive effect sizes for each of the six outcomes, with the strongest effects ($d = 0.57$) in social and emotional skills.[2] These positive effects across the different outcomes suggest that students transferred what they learned about positive social and emotional skills in the instructional programs, displaying improved behavior throughout the school day.

Among the smaller group of 33 interventions that included follow-up data (with an average follow-up period of 92 weeks), the effects at the time of follow up remained statistically significant, although the effect sizes were smaller. These findings suggest that the learning of social and emotional skills was at least somewhat durable.

An even smaller subset of the reviewed studies included measures of academic performance. Among these studies the mean effect size was 0.27, reinforcing the interconnectedness of learning across the cognitive, intrapersonal, and interpersonal domains.

One promising example showing that interventions can develop transferable intrapersonal competencies is Tools of the Mind, a curriculum used in preschool and early primary school to develop self-regulation, improve working memory, and increase adaptability (Diamond et al., 2007). It includes activities such as telling oneself aloud what one should do, dramatic play, and aids to facilitate memory and attention (such as an activity in which a preschooler is asked to hold a picture of an ear as a reminder to listen when another preschooler is speaking). A randomized controlled trial in 18 classrooms in a low-income urban school district indicated that the curriculum was effective in improving self-regulation, classroom behavior, and attention. The documented improvement in classroom behavior suggests that the young children transferred the self-regulation competencies they learned through the activities to their daily routines. The intervention also improved working memory and cognitive flexibility, further illustrating

[2]In research on educational interventions, the standardized effect size, symbolized by *d,* is calculated as the difference in means between treatment and control groups, divided by the pooled standard deviation of the two groups. Following rules of thumb suggested by Cohen (1988), an effect size of approximately 0.20 is considered "small," approximately 0.50 is considered "medium," and approximately 0.80 is considered "large." Thus, the effect size of 0.57 on social and emotional skills is considered "large" or "strong."

the links across the cognitive, intrapersonal, and interpersonal domains (Barnett et al., 2008).

Because of the closely intertwined nature of cognitive, intrapersonal, and interpersonal competencies an intervention targeting learning and skill development in one domain can influence other domains, as illustrated by a study included in the Durlak et al. (2011) meta-analysis. Flay et al. (2006) conducted a randomized controlled trial of the Positive Action Program—a drug education and conflict resolution curriculum with parent and community outreach—in 20 elementary schools in Hawaii. Although the intervention was focused on social and emotional competencies, it had large, statistically significant effects on mathematics (an effect size of 0.34) and reading achievement (0.74).

Evidence from Interventions in Informal Learning Environments

Studies of informal learning environments provide more limited evidence that cognitive, intrapersonal, and interpersonal competencies can be taught in ways that promote deeper learning and transfer. Informal learning takes place in a variety of settings, including after-school clubs, museums, science centers, and homes, and it includes a variety of experiences, from completely unstructured to highly structured workshops and educational programs. Informal learning activities may target a range of different learning goals, including goals determined by the interests of individual learners (National Research Council, 2011b). These characteristics of informal learning pose challenges both to clearly identifying the goals of a particular informal learning activity and to a careful assessment of learners' progress toward those goals—essential components of any rigorous evaluation (National Research Council, 2009a). Despite these challenges, research and evaluation studies have shown, for example, that visitors to museums and science centers can develop a deeper understanding of a targeted scientific concept through the direct sensory or immersive experience provided by the exhibits (National Research Council, 2009a).

Somewhat stronger evidence that informal learning environments can develop important competencies emerges from evaluations of structured after-school programs with clearly defined learning goals. Durlak, Weissberg, and Pachan (2010) conducted a meta-analysis of after-school programs designed to promote social and emotional learning among children and youth. They located 68 studies of social and emotional learning programs that included both a control group and measures of postintervention competencies, and they analyzed data on three categories of outcomes:

1. feelings and attitudes (child self-perception and school bonding);
2. indicators of behavioral adjustment (positive social behaviors, problem behaviors, and drug use); and
3. school performance (achievement test scores, school grades, and school attendance).

Overall, the programs had a positive and statistically significant impact on participants' competencies, with the largest mean effects in self-confidence and self-esteem, increases in positive social behaviors and decreases in problem behaviors, and increases in achievement test scores. The only outcomes for which effects were not statistically significant were school attendance and drug use.

In structured after-school settings, as in the in-school environment, a few examples illustrate the potential of technology- and game-based approaches to develop transferable knowledge and skills. For example, an evaluation of the Fifth Dimension—an informal after-school computer club that incorporates games—showed positive effects on students' computer literacy, comprehension, problem solving, and strategic efficiency (Mayer et al., 1999). However, the use of technology must be carefully structured to support transferable learning, as we discuss further below.

Parenting Interventions

Because informal learning and skill development begins at birth, and because parents strongly influence this process, some interventions target parents' cognitive, intrapersonal, and interpersonal competencies as a route to helping children develop these competencies. Parenting interventions are a route to boosting the competencies and improving the behavior of struggling children (Magnuson and Duncan, 2004). When considering interventions to develop parenting competencies:

> It is useful to distinguish between parenting education and parenting management training. Parenting education programs seek to boost parents' general knowledge about parenting and child development. Information is provided in conjunction with instrumental and emotional support. Home visitation programs for new mothers and parent-teacher programs are perhaps the most familiar examples. Management training programs are designed for parents of children with diagnosed problem behavior, usually conduct disorders. Clinical therapists teach parents concrete behavioral strategies designed to improve their children's behavior. Typically, parents are taught how to reinforce their child's positive behavior and punish negative behavior appropriately. Evaluation evidence on parenting management programs is much more positive than the evidence on parent education programs. (Magnuson and Duncan, 2004, p. 206)

There is a substantial experimental literature on the efficacy of home visitation programs. The most successful (and expensive) of these programs is the nurse/family partnership model developed by David Olds (Olds, Sadler, and Kitzman, 2007). Meta-analyses of its evaluations show some positive effects on certain parent and child outcomes, such as reductions in child maltreatment and visits to emergency rooms, but it is less clear whether such programs affect school readiness skills (Sweet and Appelbaum, 2004). The long-term impacts on school readiness are inconsistent, but the evidence suggests that there could be very modest effects on children's social adjustment and cognitive competencies.

Evidence from Workplace Learning Environments

Another area yielding emerging evidence that interventions can develop transferable competencies is the body of literature in industrial and organizational psychology that focuses on the transfer of learning from organizational training programs to the workplace. This research has been summarized in a number of recent reviews and meta-analyses (e.g., Ford and Weissbein, 1997; Burke and Hutchins, 2008; Cheng and Hampson, 2008; Baldwin, Ford, and Blume, 2009; Blume et al., 2010; Grossman and Salas, 2011).

U.S. employers invest heavily in employee training, spending an estimated $46 billion to $54 billion per year when employee salaries during training time are included (Mikelson and Nightingale, 2004).[3] This investment reflects a belief that training will transfer to improvements in job performance. Although Georgenson (1982) is often cited as estimating that only 10 percent of training experiences transfer from the training classroom to the work site, he did not, in fact, make such an estimate (Fitzpatrick, 2001). In recent years, a number of researchers have sought to measure the actual extent of transfer from training to on-the-job performance, to characterize what is transferred, and to identify the conditions promoting transfer. To measure the extent of transfer, researchers often turn to the Kirkpatrick model for evaluating the effectiveness of training (Kirkpatrick and Kirkpatrick, 2006). This model includes four levels of effectiveness: (1) trainees' immediate reactions after a training session, (2) learning, (3) changes in on-the-job behavior, and (4) results (return on training investment).

[3]It is difficult to estimate total employer training investments, partly because most employers do not carefully account for training costs (Mikelson and Nightingale, 2004). In addition, there have been no systematic national surveys since those conducted by the U.S. Census Bureau in 1994 and 1997. More recent surveys, such as those conducted by the American Society for Training and Development (2009), include the most training-intensive firms, causing an upward bias in the results.

In a meta-analysis of the effects of organizational training, Arthur et al. (2003) proposed that transfer takes place if the training is found to be effective at any or all of the levels from (2) through (4) of the framework, such that:

(a) learning is demonstrated through pretraining and posttraining tests of trainees' knowledge and skills (which may include cognitive, intrapersonal, and interpersonal competencies);
(b) improvements in on-the-job behavior are demonstrated through changes in pre- and post-training performance measures; or
(c) results are demonstrated through calculations of organizational return on investment.

The authors found that the training had significant, positive effects for each of these three levels of the evaluation framework: d = .63, .62, and .62 for learning, behavior, and results, respectively. They concluded that training does indeed transfer.

Attention has shifted recently from whether training transfers to which conditions specifically enhance the transfer of training. A convenient framework for characterizing those conditions is Baldwin and Ford's model of transfer (Baldwin and Ford, 1988; Ford and Weissbein, 1997; Baldwin, Ford, and Blume, 2009). The model proposes that three categories of factors influence transfer: trainee characteristics, training design, and work environment. Baldwin and Ford (1988) proposed that the key trainee characteristics promoting transfer are cognitive ability, personality, and motivation, while the key training design features include following the principles of learning, correctly sequencing the training, and providing appropriate training content. The key work environment features that promote transfer include supervisor and peer support for the training and opportunities to use the training on the job (see Figure 6-1).

A meta-analysis of 89 studies conducted by Blume et al. (2010) examined these various factors and found positive relationships between transfer and several of them, including the trainee characteristics of cognitive ability and motivation (as well as conscientiousness) and support within the work environment. The authors also examined moderators of these relationships and found that the above factors predicted transfer more strongly when the training content focused on "open" skills, such as leadership development, rather than on "closed" skills, such as how to use a particular type of computer software. Transfer was also promoted to the extent that the training environment and the transfer environment (the job) were similar. This latter finding reflects the research from learning sciences discussed in Chapter 4, which found that transfer is enhanced when the original learning

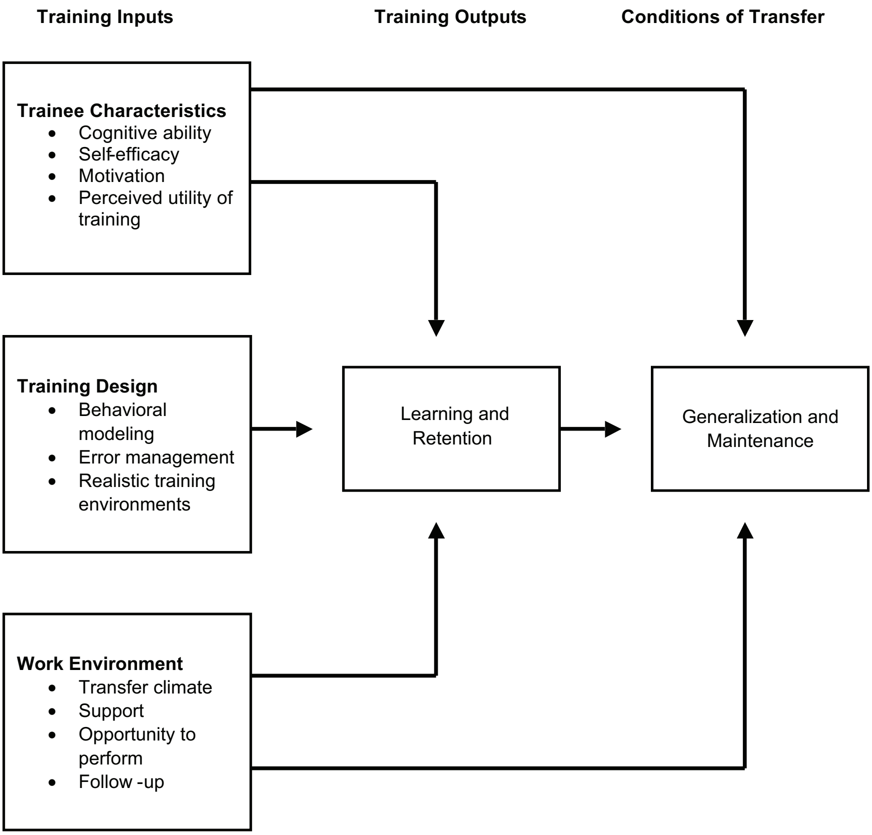

FIGURE 6-1 A model of the transfer process.
SOURCE: Grossman and Salas (2011). Reprinted with permission from John Wiley and Sons.

situation and the new learning situation have similar underlying principles (e.g., Singley and Anderson, 1989).

Because the Blume et al. (2010) meta-analysis included studies that varied in terms of the content of the training being evaluated, the research design, and the evaluation methods, it is informative to supplement that report's findings with information obtained using other methodologies. Burke and Hutchins (2008) surveyed training professionals about best practices and identified several factors thought to contribute to effective transfer. The most important were supervisory support, coaching, opportunities to perform what was learned in training, interactive training, measurement of transfer, and job-relevant training. These survey findings are consistent with the empirical studies of the predictors of transfer.

Grossman and Salas (2011) conducted a comprehensive review of the meta-analyses and other research reviews with the purpose of extracting

> the strongest, most consistent findings from the literature in order to help organizations, and even researchers, identify the "bottom line" . . . [and to] serve as a valuable complement to Burke and Hutchins's (2008) practice-based paper. (p. 117)

Within the category of trainee characteristics, Grossman and Salas confirmed the importance of cognitive ability, self-efficacy, and motivation for facilitating transfer of training to the job. They suggested that goal-setting was well established as a means to increase motivation and that transfer was facilitated when learners understood the relevance of the training to the job. These findings reinforce the findings from cognitive research and the studies of educational interventions showing that intrapersonal competencies, including motivation, enhance learning and transfer.

Grossman and Salas also discussed training design and concluded that the elements that most strongly facilitate transfer include behavior modeling, error management (an increasingly popular training strategy of allowing trainees to make errors and providing error management instructions), and realistic training environments (e.g., on-the-job training and the use of low- and high-fidelity simulations).

Concerning the work environment, the authors found that the transfer climate was the most important factor influencing transfer (Grossman and Salas, 2011). This finding is supported by the meta-analyses from Colquitt, LePine, and Noe (2000) and Blume et al. (2010). Specifically, Grossman and Salas found that transfer is facilitated when the trainee's workplace prompts the use of the new competencies learned in training and when trainees are given goals, incentives, feedback, and the opportunity to practice the competencies. Two other features of the work environment shown to play an important role in facilitating transfer were supervisor support (which included such things as recognition, encouragement, rewards, and modeling) and peer support. These findings were similar to those of Blume et al. (2010). Still other features of the work environment that were found to play a role in facilitating transfer were the opportunity to perform the learned competencies with minimal delay, posttraining follow-up, and feedback. Figure 6-1 presents a summary of the factors affecting transfer that was originally developed by Baldwin and Ford (1988) and later modified by Grossman and Salas to reflect their findings.

Research on Team Training. Evidence that cognitive, intrapersonal, and interpersonal skills can be taught and learned also emerges from research on team training in organizations, although this research does not focus specifically on questions of transfer. In a recent meta-analysis of the research on team training, Salas et al. (2008) analyzed data from 45 studies of team training, focusing on four types of outcomes that cut across the three domains: (1) cognitive outcomes, such as declarative and procedural knowledge of work tasks; (2) affective outcomes, such as feelings of trust and confidence in team members' ability; (3) team processes, such as communication, coordination, strategy development, self-correction, and assertiveness; and (4) team performance, such as quantity, quality, accuracy, and efficiency. This variety of outcome measures reflects the variety of goals of team training interventions, which often target multiple cognitive, intrapersonal, and interpersonal competencies. These goals are based on the assumption that team training transfers within and across domains so that knowledge of work tasks, for example, is applied in ways that improve task (and team) performance. Salas and his colleagues found statistically significant, positive correlations between the training interventions and each of the four outcomes, with the highest correlation being for team processes (i.e., training targeting development of intrapersonal and interpersonal competencies).

INSTRUCTIONAL DESIGN PRINCIPLES FOR TRANSFER—COGNITIVE DOMAIN

While the evidence discussed above and in Chapters 4 and 5 indicates that various cognitive competencies are teachable and learnable in ways that promote transfer, we noted in Chapter 5 that such instruction remains rare in U.S. classrooms; few effective strategies and programs to foster deeper learning exist. Research and theory suggest a set of principles that can guide the development of such strategies and programs, as discussed below. It is important to note that the principles are derived from research that has focused primarily on transfer of knowledge and skills within a single topic area or domain of knowledge (see Box 6-1).

How can instructors teach in ways that promote transfer? Addressing this seemingly simple question has been a central task of researchers in learning and instruction for more than a century, and within the past several decades, a number of useful advances have been made toward providing evidence-based answers (Mayer, 2008; Mayer and Alexander, 2011). Evidence-based guidelines for promoting deeper learning (i.e., learning of transferable knowledge) have been offered by a recent task force report from the Association for Psychological Science (Graesser, Hakel, and Halpern, 2007), a guidebook published by the Institute of Education

BOX 6-1
Deeper Learning Across Topics or Disciplines

Most of the research to date on deeper learning has focused on learning within a single discipline, often investigating how children learn a specific topic, procedure, or strategy. This focus reflects the limited success of earlier efforts to develop generic knowledge or skills that could be widely transferred or applied across disciplines, topics, or knowledge domains. In science, for example, early research sought to clarify children's understanding of scientific experimentation by presenting them with "knowledge-lean" tasks about causes and effects that required no prior knowledge of relevant science concepts. However, such methods were criticized, and further research clearly demonstrated that children's prior knowledge plays an important role in their ability to formulate a scientific question about a topic and design an experiment to test the question (National Research Council, 2007). Current research presents children with "knowledge-rich" tasks, recognizing that their causal reasoning is closely related to their prior knowledge of the question or concept to be investigated.

Only a few studies have examined transfer across disciplines, topics, or contexts. For example, Bassok and Holyoak (1989) studied transfer of learning in algebra and physics, focusing on problems with identical underlying structures but different surface features—arithmetic-progression problems in algebra and constant-acceleration problems in physics. High school and college students were first trained to solve such problems, either in algebra or physics, and then were presented with word problems that used either content from the domain in which they were trained or content based on an unfamiliar domain. The algebra students, whose training included the information that the problems were broadly applicable, were very likely to spontaneously recognize that physics problems involving velocity and distance could be addressed using the same equations. These students recognized the applicability to physics, regardless of whether they had learned arithmetic-progression problems using word problems focusing on several different types of content (e.g., growth of savings accounts, height of a human pyramid) or had learned using word problems focusing on a single type of content—i.e., money problems. In contrast, students who had learned to solve constant-acceleration problems in physics almost never recognized or transferred this approach to solve the algebra problems. The authors note that the algebra-focused students were able to "screen out" the domain-specific content of the word problems, while the physics-focused students had been taught that the physical concepts involved in word problems were critical to the applicability of the equations. Bassok and Holyoak concluded that although expertise is generally based on content-specific knowledge, it may be possible to teach some mathematical procedures in a way that enables students to transfer these procedures across content domains; they called for further research to explore such possibilities.

Studies such as these provide some clues about how to support transfer of learning across specific knowledge domains, but much further research is needed to clarify whether, and to what extent, it may be possible to teach students in ways that promote deeper learning and transfer across disciplines or broad content domains.

SOURCE: Created by the committee.

Sciences (Pashler et al., 2007), and a review of problem-solving transfer in the *Handbook of Educational Psychology* (Mayer and Wittrock, 2006).

Before describing various research-based principles for instructional design, it is worth noting that recent research on teaching and learning reveals that young children are capable of surprisingly sophisticated thinking and reasoning in science, mathematics, and other domains (National Research Council and Institute of Medicine, 2009; National Research Council, 2012). With carefully designed guidance and instruction, they can begin the process of deeper learning and development of transferable knowledge as early as preschool. As noted in Chapters 4 and 5, this process takes time and extensive practice over many years, suggesting that instruction for transfer should be introduced in the earliest grades and should be sustained throughout the K-12 years as well as in postsecondary education. Thus, the principles discussed below should be seen as broadly applicable to the design of instruction across a wide array of subject matter areas and across grade levels spanning K-16 and beyond.

Research-Based Methods for Developing Transferable Knowledge

Using Multiple and Varied Representations of Concepts and Tasks

Mayer (2009, 2011b) has shown, based on 11 experimental comparisons, that adding diagrams to a text (or adding animation to a narration) that describes how a mechanical or biological system works can increase student performance on a subsequent problem-solving transfer test by an average of more than one standard deviation. Allowing students to use concrete manipulatives to represent arithmetic procedures has been shown to increase transfer test performance both in classic studies in which bundles of sticks are used to represent two-column subtraction (Brownell and Moser, 1949) and in an interactive, computer-based lesson in which students move a bunny along a number line to represent addition and subtraction of signed numbers (Moreno and Mayer, 1999).

Research suggests that the use of multiple and varied representations is also effective in informal learning environments. For example, a recent National Research Council (2009a) study found that visitors to museums and science centers commonly report developing a deeper understanding of a concept through the concrete, sensory, or immersive experiences provided by the exhibits. One investigation reported in this study found that children who interacted purposefully with exhibits about magnetism gained conceptual understanding of the concept of magnetism (Rennie and McClafferty, 2002).

While adding diagrams or animations to text can enhance learning and transfer, researchers have found that how multimedia learning environments are designed strongly influences their effectiveness. Based on dozens of experiments leading to his theory of multimedia learning, Mayer (2009) has identified 12 principles of multimedia design that can enhance transfer (see Box 6-2).

Encouraging Elaboration, Questioning, and Self-Explanation

Chi and colleagues have shown that, in both book-based and computer-based learning environments, students learn more deeply from reading a science text if they are prompted to explain the material to themselves aloud as they read (Roy and Chi, 2005; Fonseca and Chi, 2011). Research has investigated how different types of questioning techniques promote deeper learning (Graesser and Person, 1984; Graesser, D'Mello, and Cade, 2011), indicating that some successful tutoring techniques include asking why, how, what if, what if not, and so what. As noted in the previous chapter, carefully designed questions posed by teachers and fellow students, such as asking students to justify their answers, have been shown to support deeper learning in mathematics (Griffin, 2005; Boaler and Staples, 2008) and science (Herrenkohl et al., 1999). Asking the learner to summarize the material in a text can also lead to deeper learning (Pressley and Woloshyn, 1995; Mayer and Wittrock, 1996). Finally, research on the testing effect shows that students learn better when they test themselves (without feedback) on material that they have just read than when they study it again; this is true both with paper-based materials (Roediger and Karpicke, 2006) and with online multimedia lessons (Johnson and Mayer, 2009).

There is evidence that this method also supports learning for transfer in designed informal science learning centers (e.g., zoos, museums, and aquariums). Exhibits can be designed to encourage learners to pose questions to themselves and others, helping them think abstractly about scientific phenomena (National Research Council, 2009a). When parents provide explanations of science exhibits to their children, they may help them link the new information to their previous knowledge. How exhibits are designed appears to influence the number and kinds of questions visitors ask.

Engaging Learners in Challenging Tasks, with Supportive Guidance and Feedback

For more than 40 years, research has repeatedly shown that asking students to solve challenging problems in science and other disciplines without appropriate guidance and support (i.e., pure discovery) is ineffective in promoting deep learning (Shulman and Keislar, 1966; Mayer, 2004; de Jong, 2005; Kirchner, Sweller, and Clark, 2006). In contrast, asking students to solve challenging problems while providing appropriate and specific cognitive guidance along the way (i.e., guided discovery) can be a useful

BOX 6-2
Principles of Multimedia Design for Deeper Learning

Principles for Reducing Extraneous Processing (thinking unrelated to the learning goal)

- *Coherence principle:* Exclude extraneous words, pictures, and sounds.
- *Signaling principle:* Add cues to highlight the organization of essential material.
- *Redundancy principle:* Graphics with narration are more effective than graphics with narration and on-screen text.
- *Spatial contiguity principle:* Place corresponding words and pictures close together on the page or screen.
- *Temporal contiguity principle:* Present corresponding words and pictures simultaneously rather than successively.

Principles for Managing Essential Processing (thinking related to the learning goal)

- *Segmenting principle:* Present lesson in user-paced segments.
- *Pretraining principle:* Present names and characteristics of key concepts in advance of the main lesson.
- *Modality principle:* Use graphics and narration, rather than animation and on-screen text.

Principles for Managing Generative Processing (thinking that enables deeper learning)

- *Multimedia principle:* Use words and pictures, rather than words alone.
- *Personalization principle:* Use words in a conversational style.
- *Voice principle:* Narration should be spoken with a friendly human voice rather than a voice produced by a machine.
- *Image principle:* Adding a speaker's image does not necessarily enhance learning.

Boundary Conditions

The series of experiments also indicated that the effectiveness of these design principles for supporting deeper learning are limited by two boundary conditions. First, some design effects are stronger for low-experience learners than for high-experience learners, which Mayer (2009) refers to as the individual-differences condition. Second, the effects of applying the principles are stronger for multimedia lessons with highly complex content than for those with less complex content and are also stronger for fast-paced presentations than for slow-paced presentations.

SOURCE: Adapted from Mayer (2009).

technique for promoting deep learning (de Jong, 2005; Tobias and Duffy, 2009). For example, there is no compelling evidence that beginners deeply learn science concepts or processes by freely exploring a science simulation or game (National Research Council, 2011b), but including guidance in the form of advice, feedback, prompts, and scaffolding (i.e., completing part of the task for the learner) can promote deeper learning in beginners (de Jong, 2005; Azevedo and Aleven, 2010).

Providing guided exploration and metacognitive support also enhances learning for transfer in informal settings. Based on its review of the research on informal science learning, a National Research Council committee (2009a) recommended that science exhibits and programs be designed with specific learning goals in mind and that they provide support to sustain learners' engagement and learning. For example, exhibits and programs should "prompt and support participants to interpret their learning experiences in light of relevant prior knowledge, experiences, and interests" (p. 307). There is emerging evidence that designing simulations to enable guided exploration, with support, enhances deeper learning of science (National Research Council, 2011b).

Teaching with Examples and Cases

A worked-out example is a step-by-step modeling and explanation of how to carry out a procedure, such as how to solve probability problems (Renkl, 2005, 2011). Under appropriate conditions, students gain deep understanding when they receive worked-out examples as they begin to learn a new procedural skill, both in paper-based and computer-based venues (Sweller and Cooper, 1985; Renkl, 2005, 2011). In particular, deep learning is facilitated when the problem is broken into conceptually meaningful steps which are clearly explained and when the explanations are gradually taken away with increasing practice (Renkl, 2005, 2011).

Priming Student Motivation

Deep learning occurs when students are motivated to exert the effort to learn, so another way to promote deep learning is to prime student motivation (Schunk, Pintrich, and Meece, 2008; Summers, 2008; Wentzel and Wigfield, 2009). Research on academic motivation shows that students learn more deeply when they attribute their performance to effort rather than to ability (Graham and Williams, 2009), when they have the goal of mastering the material rather than the goal of performing well or not performing poorly (Anderman and Wolters, 2006; Maehr and Zusho, 2009), when they expect to succeed on a learning task and value the learning task (Wigfield, Tonks, and Klauda, 2009), when they have the belief that they are capable of achieving the task at hand (Schunk and Zimmerman, 2006; Schunk and Pajares, 2009), when they believe that intelligence is changeable rather than fixed (Dweck and Master, 2009), and when they are interested in the learning task (Schiefele, 2009). There is promising evidence that these kinds of beliefs, expectancies, goals, and interests can be fostered in learners by, for example, peer modeling techniques (Schunk, Pintrich, and Meece, 2008) and through the interventions described in Chapter 4 (Yaeger and Walton, 2011). Elementary school students showed increased self-efficacy for solving subtraction problems and increased test performance after watching a peer demonstrate how to solve subtraction problems while exhibiting high self-efficacy (such as saying, "I can do that one" or "I like doing these") versus control conditions (Schunk and Hanson, 1985). As discussed in Chapter 4, research has shown that, in a responsive social setting, learners can adopt the criteria for competence they see in others and then use this information to judge and perfect the adequacy of their own performance (National Research Council, 2001).

Although informal learning environments are often designed to tap into learners' own, intrinsic motivations for learning, they can also prime and extend this motivation. For example, to prime motivation and support deeper learning in structured informal science learning environments (e.g., zoos, aquariums, museums, and science centers), research suggests that science programs and exhibits should

- be interactive;
- provide multiple ways for learners to engage with concepts, practices, and phenomena within a particular setting; and
- prompt and support participants to interpret their learning experiences in light of relevant prior knowledge, experiences, and interests (National Research Council, 2009a, p. 307).

Similarly, research suggests that to prime learners' motivation for the difficult task of learning science through inquiry, simulations and games should provide explanatory guidance, feedback, and scaffolding; incorporate an element of narrative or fantasy; and allow a degree of user control without allowing pure, open-ended discovery (National Research Council, 2011b).

Using Formative Assessment

The formative assessment concept (discussed further below) emphasizes the dynamic process of *using* assessment evidence to continually improve student learning; this is in contrast to the concept of summative assessment, which focuses on development and implementation of an instrument to measure what a student has learned up to a particular point in time (National Research Council, 2001; Shepard, 2005; Heritage, 2010). Deeper learning is enhanced when formative assessment is used to: (1) make learning goals clear to students; (2) continuously monitor, provide feedback, and respond to students' learning progress; and (3) involve students in self- and peer assessment. These uses of formative assessment are grounded in research showing that practice is essential for deeper learning and skill development but that practice without feedback yields little learning (Thorndike, 1927; see also Chapter 4).

Research on each of the six major instructional approaches to teaching for transfer discussed above helps to pinpoint the boundary conditions for each instructional method, including for whom, for which learning contexts, and for which instructional objectives.

Promoting Deeper Learning Through Problem-Based Learning: An Example

One curriculum model that incorporates several of the methods described above is problem-based learning (PBL). PBL approaches represent learning tasks in the form of rich extended problems that, if carefully designed and implemented, can engage learners in challenging tasks (problems) while providing guidance and feedback. They can encourage elaboration, questioning, and self-explanation and can prime motivation by presenting problems that are relevant and interesting to the learners. While a variety of different approaches to PBL have been developed, such instruction often follows six key principles (Barrows, 1996):

1. Student-centered learning
2. Small groups
3. Tutor as a facilitator or guide
4. Problems first
5. The problem is the tool to achieve knowledge and problem-solving skills
6. Self-directed learning

Two recent meta-analyses of the research on interventions following these principles suggest that PBL approaches can support deeper learning and transfer. Gijbels et al. (2005) focused on empirical studies that compared PBL with lecture-based instruction in higher education in Europe (with most of the studies coming from medical education). The meta-analysis identified no significant difference in the understanding of concepts between students engaged in PBL and those receiving lecture-based instruction. However, students in the PBL environments demonstrated deeper understanding of the underlying principles that linked the concepts together. In addition, students in the PBL environments demonstrated a slightly better ability to apply their knowledge than students in the lecture-based classes. As noted in the previous chapter, two hallmarks of deeper learning are that it develops understanding of underlying principles and that it supports the application of knowledge—i.e., transfer.

More recently, Strobel and van Barneveld (2009) conducted a meta-synthesis of eight previous meta-analyses and research reviews that had compared PBL approaches with traditional lecture-based instruction. They found that how learning goals were defined and assessed in the various individual studies affected the findings about the comparative effectiveness of the two different approaches. When the learning goal was knowledge, and assessments were focused on short-term retention, traditional approaches were more effective than PBL, but when knowledge assessments focused on longer-term retention (12 weeks to 2 years following the initial instruction), PBL approaches were more effective. Furthermore, when learning goals were related to transfer or application of knowledge, PBL approaches were more effective. Two particular learning goals were identified by the authors as showing such advantages: performance, as measured by supervisor ratings of medical students' clinical practice, and mixed knowledge and skill (including application of knowledge). Although PBL appears promising, more extensive and rigorous research is needed to determine its effectiveness in supporting deeper learning.

Design Principles for Teaching Problem-Solving and Metacognitive Strategies

Problem solving and metacognition are important competencies that are often included in lists of 21st century skills. Problem-solving and metacognitive strategies differ in several respects. Problem solving typically involves applying sets of procedures organized as strategies that allow persons to tackle a range of new tasks and situations within some performance domain such as how to simplify an algebraic equation or summarize a text, and they represent one of the five types of transferable knowledge discussed in Chapter 4 (see Table 4-3). Metacognition refers to a person's ability to select, monitor, manage, and evaluate cognitive processing during the learning or performance of a cognitive task. Metacognitive strategies are higher-level methods for managing one's thinking and reasoning while learning or performing a task. Metacognitive strategies may play a central role in people's ability to transfer—that is, in people's ability to solve new problems and learn new things. The ability to apply metacognitive strategies when learning is a key dimension of self-regulated learning, as discussed in Chapter 4. Recent research advances have specified metacognitive strategies, determined their role in solving problems in mathematics (e.g., Griffin, 2005) and other disciplines, and illuminated how to teach them. These advances reflect the central role of metacognition in the development of transferable 21st century competencies.

There are five main issues to consider in developing transferable strategies for effective problem solving and metacognition: determining what to teach, how to teach, where to teach, when to teach, and how long to teach (Mayer, 2008).

What to Teach

In determining what to teach, the first question one must answer is whether competency in problem solving or metacognition is based on improving the mind in general as a single monolithic ability or on acquiring a collection of smaller component skills. Early in the history of psychology and education the varying beliefs about the nature of cognitive ability were epitomized by the opposing approaches of Galton (1883) and Binet (1962). Galton proposed that cognitive ability was a unitary construct best measured by reaction time tasks and perceptual discrimination tasks. Later research showed that Galton's battery of cognitive measures did not correlate strongly with such measures of intellectual ability as school grades (Sternberg, 1990). In contrast, when Binet was charged with developing a test to predict academic success in the Paris school system, he conceptualized cognitive ability as a collection of small component skills and pieces of knowledge that could be learned, and his test was successful in predicting school success.

Similarly, modern psychometric approaches to human cognitive ability that are based on factor analyses of large batteries of cognitive tests reveal that there are many small component factors to cognitive ability rather than a single general ability factor (Carroll, 1993; Willis, Dumont, and Kaufman, 2011). And research-based cognitive theories of intelligence are based on the idea that cognitive performance on academic tasks depends on a collection of smaller cognitive and metacognitive processes rather than on a single mental ability (Mayer, 2010; Hunt, 2011). Although conventional wisdom among laypeople may hold that intellectual ability is a single monolithic ability, research on testing and individual differences in information processing suggests that intellectual ability is best seen as a collection of smaller component skills. It follows that cognitive strategy instruction should focus on helping students develop a collection of clearly defined component skills and learning how to assemble and integrate them rather than on improving their minds in general.

How to Teach

On the issue of how to teach, a key question is whether instruction should focus on the product of problem solving (i.e., getting the right answer) or on the process of problem solving (i.e., the thinking that goes into getting the right answer). Three research-based instructional techniques for the teaching of problem-solving and metacognitive strategies are modeling, prompting, and apprenticeship. In modeling the learner observes an expert perform the task, usually with commentary so that the learner receives a step-by-step explanation for why each step is taken. Modeling generally takes the form of worked-out examples that can be printed in books, presented on computer screens, or presented live by an expert. In prompting, the learner is given a problem to solve along with questions and hints about the reasons for carrying out various actions. For example, in self-explanation methods, the learner is asked to explain aspects of his or her cognitive processing while solving a problem. Because such explanations require reflection on one's own thinking and learning, these methods help learners develop metacognitive strategies.

In a classic study, Bloom and Broder (1950) taught college students how to solve problems on exams in college subjects such as economics by asking them to think aloud as they solved a problem, watch a model think aloud as he solved the problem, and then compare their thought processes with that of the model problem solver. Several hours of training based on this modeling of effective problem-solving processes resulted in significant improvements in exam scores as compared to a control group that did not receive this training. Modeling of the cognitive processes of successful problem solvers has been a component in the development of several successful problem-solving programs, as indicated in assessments of the Productive Thinking Program (Olton and Crutchfield, 1969; Mansfield, Busse, and Krepelka, 1978), Instrumental Enrichment (Feuerstein, 1980), and Project Intelligence (Hernstein et al., 1986; Nickerson, 2011).

Apprenticeship teaching and learning methods can help learners understand and apply the process of problem solving. In apprenticeship, a mentor or teacher models problem solving by describing how he or she approaches the process, coaches by providing guidance and tips to the learner who is carrying out a task, and scaffolds by directly performing or eliminating difficult parts of the task that the learner is unable to perform (Mayer and Wittrock, 2006). One example of apprenticeship methods is reciprocal teaching, as when students and a teacher took turns discussing strategies for increasing reading comprehension (Palincsar and Brown, 1984; Brown and Palincsar, 1989). Students who engaged in reciprocal teaching demonstrated a much larger gain in reading comprehension scores than students who learned reading with conventional methods, as the reciprocal teaching method helped them to solve problems they encountered while reading text.

Azevedo and Cromley (2004) identified several metacognitive strategies that are commonly used in the learning of new material, including planning, monitoring, using strategies, managing, and enjoying. Planning refers to the development of a plan for learning, and it includes activating relevant prior knowledge. Monitoring refers to recognizing when one does or does not comprehend something and figuring out what needs to be clarified. Using strategies involves determining when to use various learning strategies, such as taking notes, writing summaries, and generating drawings. Managing involves using time wisely, such as seeking help when needed. Enjoying involves expressing interest in the material. In short, a reasonable conclusion is that instructional methods should focus on the processes of problem solving and metacognition rather than solely on the final products of those processes.

Where to Teach

On the issue of where to teach, the key issue is whether problem-solving and metacognitive strategies should be learned in a specific domain or in a general way. Early in the history of educational psychology Thorndike sought to test the conventional wisdom of the day, which held that certain school subjects such as Latin and geometry helped to develop proper habits of mind—general ways of thinking that applied across disciplines (Thorndike and Woodworth, 1901; Thorndike, 1932). For example, in a classic study, Thorndike (1923) found that students who had learned Latin and students who had not learned Latin showed no differences in their ability to learn a new school subject: English. Combined with numerous other studies showing a lack of general transfer, these results led Thorndike to conclude that transfer is always specific—that is, the elements and relations in the learned material must be the same as the elements and relations in the to-be-learned material. Research on problem-solving and metacognitive expertise supports the idea that competency tends to be domain specific, as discussed in Chapter 4. People who are experts in solving problems in one domain are not able to transfer their problem-solving skill to other domains (de Groot, 1965; Ericsson et al., 2006). As noted above, research has shown that children's ability to solve problems in science is dependent on their prior knowledge of the topic or concept under study (National Research Council, 2007). These findings suggest that strategy instruction should be conducted within the specific context in which the problems will be solved (i.e., embedded within specific disciplines) rather than as a general stand-alone course.

When to Teach

On the subject of when to teach, the key question is whether problem-solving strategies should be taught before or after lower-level skills are mastered. Although the research base is less developed on this question, there is converging evidence that novices can benefit from training in high-level strategies. For example, in writing instruction students can be taught how to communicate with words—by dictating to an adult, for example, or by giving an oral presentation or being allowed to write with misspelled words and improper grammar—before they have mastered lower-level skills such as spelling and punctuation (Bereiter and Scardamalia, 1987; De La Paz and Graham, 1995). In observational studies of cognitive apprenticeship, beginners successfully learn high-level skills through a process of *assisted performance* (Tharp and Gallimore, 1988) in which they are allowed to attempt parts of complex tasks before than have mastered basic skills. These findings suggest that higher-order thinking skills can be learned along with lower-order ones early in the instructional process.

How Long to Teach

On the fifth issue, how long to teach, the main question is what the role should be of prolonged, deliberate practice in learning problem-solving strategies. Research on the development of expertise indicates that "high degrees of competence only come through extensive practice" (Anderson and Schunn, 2000, p. 17) and that learners need feedback that explains how to improve (Shute, 2008; Hattie and Gin, 2011). For example, students were found to develop expert-like performance in troubleshooting electronic and mechanical equipment if they spent 20-25 hours with a computer simulation in which they received immediate and focused feedback (Lesgold, 2001). In case studies, Ericsson and colleagues have found a close relationship between the development of professional expertise and the amount of *deliberate practice*—intensive practice at increasingly more challenging levels—even among learners with equivalent talent (see, e.g., Ericsson, 2003). Although programs that require only a few hours of work can produce improvements in problem-solving skill, the development of expert problem-solving skill requires years of deliberate practice.

Research indicates that extended time and practice also enhances learning in informal settings. For example, the National Research Council (2009a) recommends that designers of science exhibits and programs support and encourage learners to extend their learning over time, noting that "learning experiences in informal settings can be sporadic and . . . without support, learners may not find ways to sustain their engagement with science or a given topic."

BOX 6-3
Issues in Teaching Cognitive and Metacognitive Skills

1. What to teach: Focus on a collection of small component skills rather than trying to improve the mind as a single monolithic ability.
2. How to teach: Focus on the learning process (through modeling, prompting, or apprenticeship) rather than on the product.
3. Where to teach: Focus on learning to use the skill in a specific domain rather than in general.
4. When to teach: Focus on teaching higher skills even before lower skills are mastered.
5. How long to teach: Focus on deliberate practice to develop expertise.

SOURCE: Adapted from Mayer (2008).

Summary

Research and theory to date suggest answers to each of the five questions posed above (see Box 6-3). They suggest that instructors should teach component skills and their integration rather trying to improve the mind in general; should focus on the processes of problem solving and metacognition (through modeling or prompting) rather than solely on product; should focus on using the strategies in a specific context rather than in general; should focus on learning problem-solving and metacognitive strategies before or while lower-level skills are mastered; and should focus on prolonged, deliberate practice and application rather than one-shot deals.

Summary: Developing Transferable Cognitive Competencies

A persistent theme in research on learning and teaching for transfer concerns the situated nature of learning. That is, it is not fruitful to try to teach high-level thinking skills in general; rather, transferable knowledge is best learned within the disciplinary situations or sets of topics within which the knowledge will be used. In the previous chapter, we explored learning and teaching for transfer within three disciplines—English language arts, mathematics, and science. Within each discipline, the kinds of teaching techniques for transferable knowledge are adapted to the particular subject matter by such means as using multiple representations, encouraging questioning and self-explanation, providing guidance and support during exploration, teaching with examples, and priming motivation. The examples included in that chapter (Herrenkohl et al., 1999; Griffin, 2005) provide straightforward evidence that pure discovery (or unassisted inquiry) is not a particularly effective instructional method and that a more effective approach involves a combination of explicit instruction and guided exploration with metacognitive support.

Similarly, the disciplinary goals discussed in the previous chapter vary in how they approach the teaching of cognitive competencies. On the topic of what to teach, each discipline focuses on competencies that are important for the particular subject matter—such as discourse structures for argumentation and the interpretation of evidence in science, problem solving in mathematics, and comprehension of text in English language arts. On the issue of how to teach, each discipline adapts various techniques, including the modeling of thinking processes within discipline-specific tasks. On the subject of where to teach, high-level strategies are taught within discipline-specific situations rather than as general strategies. On the question of when to teach, each discipline teaches high-level content along with more basic, foundational content rather than waiting for basic skills to be mastered first. Finally, on the subject of how long to teach, each discipline views disciplinary learning as a long-term learning progression in which major competencies are learned at increasingly more sophisticated levels over the course of schooling—such as the way in which learning to read or write becomes more sophisticated and adapted for specific purposes.

INSTRUCTIONAL DESIGN PRINCIPLES—INTRAPERSONAL AND INTERPERSONAL DOMAINS

The research on instruction that directly targets intrapersonal and interpersonal learning goals is less extensive and rigorous than the research on instruction targeting cognitive learning goals. Although the limited evidence base poses a challenge to identifying specific principles of instructional design to advance intrapersonal and interpersonal knowledge and skills, there is suggestive evidence that some of the principles for instruction in the cognitive domain may be applicable to instruction in these two other domains.

In their meta-analysis of studies of after-school social and emotional learning programs described above, Durlak, Weissberg, and Pachan (2010) analyzed the studies' findings related to eight outcomes clustered into three categories, as follows:

- Feelings and attitudes (child self-perceptions, bonding to school)
- Behavioral adjustment (positive social behaviors, problem behaviors, drug use)
- School performance (achievement test scores, grades, attendance)

Based on prior research, the authors identified four practices thought to work together in combination to enhance the effectiveness of such programs:

- A sequenced, step-by-step training approach
- Emphasizing active forms of learning, so that youth can practice new skills
- Focusing specific time and attention on skill training
- Clearly defining goals, so that youth know what they are expected to learn

Among the programs evaluated in the studies, 41 followed all four of the research-based practices listed above, while 27 did not follow all four. The group of programs that followed the four practices showed statistically significant mean effects for all outcomes (including drug use and school attendance), while the group of programs that did not follow all four practices did not yield significant mean effects for any of the outcomes. These findings support the authors' hypothesis that the four research-based practices work best in combination to support the development of intrapersonal and interpersonal skills.

In a more recent meta-analysis of school-based social and emotional learning programs, Durlak et al. (2011) reviewed 213 studies, examining findings of effectiveness in terms of six outcomes:

- Social and emotional skills
- Attitudes toward self and others
- Positive social behaviors
- Conduct problems
- Emotional distress
- Academic performance

When the authors considered the findings in terms of the four research-based practices identified in their earlier study (Durlak, Weissberg, and Pachan, 2010), they found that the group of programs that followed all four of these recommended practices showed significant effects for all six outcomes, whereas programs that did not follow all four practices showed significant effects for only three outcomes (attitudes, conduct problems, and academic performance). The authors also found that the quality of implementation mattered. When programs were well conducted and proceeded according to plan, gains across the six outcomes were more likely.

These four practices are similar to some of the research-based methods and design principles described above for supporting deeper learning in the cognitive domain. For example, the earlier discussion identified the method of encouraging elaboration, questioning, and self-explanation as an effective way to support deeper learning of cognitive skills and knowledge. Similarly, the research on teaching social and emotional skills suggests that active forms of learning that include elaboration and questioning—such as role playing and behavioral rehearsal strategies—support deeper learning of intrapersonal and interpersonal skills and knowledge. These active forms of social and emotional learning provide opportunities for learners to practice new strategies and receive feedback.

The research on social and emotional skills indicates that it is important for teachers and school leaders to give sufficient attention to skill development, with a sequential and integrated curriculum providing opportunities for extensive practice. This echoes two findings about teaching cognitive skills: (1) teaching should be conducted within the specific context in which problems will be solved—in this case, social and emotional problems; and (2) the development of expert problem-solving skill requires years of deliberate practice. Providing adequate time and attention for skill development in the school curriculum appears to enhance the learning of intrapersonal and interpersonal skills. Finally, the research on social and emotional learning—like the research on cognitive learning—indicates that establishing explicit learning goals enhances effectiveness (Durlak et al., 2011). Just as the research on instruction for cognitive outcomes has demonstrated that learners need support and guidance to progress toward clearly defined goals (and that pure "discovery" does not lead to deep learning), so, too, has the research on instruction for social and emotional outcomes.

Research on team training also provides suggestive evidence that certain instructional design principles are important for the deeper learning of intrapersonal and interpersonal skills. In their meta-analysis, Salas et al. (2008) analyzed the potential moderating influence that the content of the team-training interventions had on outcomes. They identified three types of content: primarily task work; primarily teamwork (i.e., communication and other interpersonal skills); and both task work and teamwork. Their results suggest that when the goal is performance improvement the content makes little difference. However, for process outcomes (i.e., the development of intrapersonal and interpersonal skills that facilitate effective teamwork) and affective outcomes, teamwork and mixed-content training are associated with larger effect sizes than training focused on task work. The finding that, in situations when the goal is to improve team processes, focusing training content on teamwork skills improves effectiveness provides further support for the design principle that instruction should focus on clearly defined learning goals. The authors caution, however, that this conclusion is based on only a small number of studies.

ASSESSMENT *OF* AND *FOR* DEEPER LEARNING

Earlier in this chapter we discussed the need for clear learning goals and valid measures of important student outcomes, be they cognitive, intrapersonal, or interpersonal. Thus any discussion of issues related to the use of assessment to promote deeper learning presupposes that concerns about what to assess, how to assess, and how to draw valid inferences from the evidence have been addressed. These concerns must be addressed if assessment is to be useful in supporting the processes of teaching and learning. In this section we focus on issues related to how assessment can function in educational settings to accomplish the goal of supporting and promoting deeper learning.

Since its beginning, educational testing has been viewed as a tool for improving teaching and learning (see, for example, Thorndike, 1918), but perspectives on the ways that it can best support such improvement have expanded in recent years. Historically the focus has been on assessments *of* learning—the so-called *summative assessments*—and on the data they can provide to support instructional planning and decision making. More recently, assessment *for* learning—the so-called *formative assessment*—has been the subject of an explosion of interest, spurred largely by Black and Wiliam's 1998 landmark review showing impressive effects of formative assessment on student learning, particularly for low-ability students. A more recent meta-analysis of studies of formative assessment showed more modest, but still significant, effects on learning (Kingston and Nash, 2011).

The formative assessment concept emphasizes the dynamic process of *using* assessment evidence to continually improve student learning, while summative assessment focuses on development and implementation of an assessment instrument to measure what a student has learned up to a particular point in time (National Research Council, 2001; Shepard, 2005; Heritage, 2010).

Both types of assessment have a role in classroom instruction and in the assessment of deeper learning and 21st century skills, as described below. (The role of accountability testing in the development of these skills is treated in Chapter 7.)

Assessments *of* Learning

Assessments of learning look back over a period of time (a unit, a semester, a year, multiple years) in order to measure and make judgments about what students have learned and about how well programs and strategies are working—as well as how they can be improved. Assessments of learning often serve as the starting point for the design of instruction and teaching because they make explicit for both teachers and students what is expected and they provide benchmarks against which success or progress can be judged. For the purpose of instruction aimed at deeper learning and development of 21st century skills, it is essential that such measures (1) fully represent the targeted skills and knowledge and a model of their development; (2) be fair in enabling students to show what they know; and (3) provide reliable, unbiased, and generalizable inferences about student competence (Linn, Baker, and Dunbar, 1991; American Educational Research Association, American Psychological Association, and the National Council for Measurement in Education, 1999). In other words, the intended learning goals, along with their development, the assessment observations, and the interpretative framework (National Research Council, 2001) must be justified and fully synchronized.

When this is the case, the results for individual students can be useful for grading and placing students, for initial diagnoses of learning needs, and, in the case of students who are academically oriented, for motivating performance. Aggregated at the class, school, or higher levels, results may help in the identification of new curriculum and promising practices as well as in the assessment of teaching strategies and the evaluation of personnel and institutions.

Assessment *for* Learning: Formative Assessment

In contrast to assessments *of* learning that look backward over what has been learned, assessments *for* learning—formative assessments—chart the road forward by diagnosing where students are relative to learning goals and by making it possible to take immediate action to close any gaps (see Sadler, 1989). As defined by Black and Wiliam (1998), formative assessment involves both understanding and immediately responding to students' learning status. In other words, it involves both diagnosis and actions to accelerate student progress toward identified goals.

Such actions may be teacher directed and coordinated with a hypothesized model of learning. Actions could include: teachers asking questions to probe, diagnose, and respond to student understanding; teachers asking students to explain and elaborate their thinking; teachers providing feedback to help students transform their misconceptions and transition to more sophisticated understanding; and teachers analyzing student work and using results to plan and deliver appropriate next steps, for example, an alternate learning activity for students who evidence particular difficulties or misconceptions. But the actions are also student centered and student directed. A hallmark of formative assessment is its emphasis on student efficacy, as students are encouraged to be responsible for their learning, and the classroom is turned into a learning community (Gardner, 2006; Harlen, 2006). To assume that responsibility, students must clearly understand what learning is expected of them, including its nature and quality. Students receive feedback that helps them to understand and master performance gaps, and they are involved in assessing and responding to their own work and that of their peers (see also Heritage, 2010).

The importance of the teacher's role in formative assessment was demonstrated by the recent meta-analysis by Kingston and Nash (2011). The authors estimated a weighted mean effect size of 0.20 across the selected studies. However, in those studies investigating the use of formative assessment based on professional development that supported teachers in implementing the strategy, the weighted mean effect size was 0.30. Formative assessment occurs hand in hand with the classroom teaching and learning process and is an integral component of teaching and learning for transfer. It embodies many of the principles of designing instruction for transfer that were discussed in the previous section of this chapter. For example, formative assessment includes questioning, elaboration, and self-explanation, all of which have been shown to improve transfer. Formative assessment can provide the feedback and guidance that learners need when engaged in challenging tasks. Furthermore, by making learning goals explicit, by engaging students in self- and peer assessment, by involving students in a learning community, and by demonstrating student efficacy, formative assessment can promote students as agents in their own learning, which can increase student motivation, autonomy, and metacognition as well as collaboration and academic learning (Gardner, 2006; Shepard, 2006). Thus, formative assessment is conducive to—and may provide direct support for—the development of transferable cognitive, intrapersonal, and interpersonal skills.

A few examples suggest that teachers and students can enhance deeper learning by drawing on the evidence of their learning progress and needs provided by the formative assessment embedded within simulations and games. One such example, SimScientists, was described above. Another example, called Packet Tracer, was developed for use in the Cisco Networking Academy, which helps prepare networking professionals by providing online curricula and assessments to public and private education and training institutions throughout the world. In the early years of the networking academy, assessments were conducted by instructors and consisted of either hands-on exams with real networking equipment or else multiple-choice exams. Now Packet Tracer has been integrated into the online curricula, allowing instructors and students to construct their own activities and students to explore problems on their own. Student-initiated assessments are embedded in the curriculum and include quizzes, interactive activities, and "challenge labs"—structured activities focusing on specific curriculum goals, such as integration of routers within a computer network. Students use the results of these assessments to guide their online learning activities and to improve their performance. A student may, with instructor authorization, access and re-access an assessment repeatedly.

Formative and Summative Assessment: Classroom Systems of Assessment

Assessments of learning and for learning (summative and formative assessments) can work together in a coherent system to support the development of cognitive, intrapersonal, and interpersonal skills. If they are to do so, however, the assessments must be in sync with each other and with the model of how learning develops. Figure 6-2 shows the interrelationships among components of such a model. The model features explicit learning goals for targeted cognitive, intrapersonal, and interpersonal competencies and poses a sequential and integrated approach to their development, as supported by the literature (see, for example, Durlak and Weissburg, 2011).

In Figure 6-2, the benchmarks represent critical juncture points in progress toward the ultimate goals, while the formative assessment represents the interactive process between the teachers and students and continuous data that facilitate student progress toward the junctures and ultimate goals.

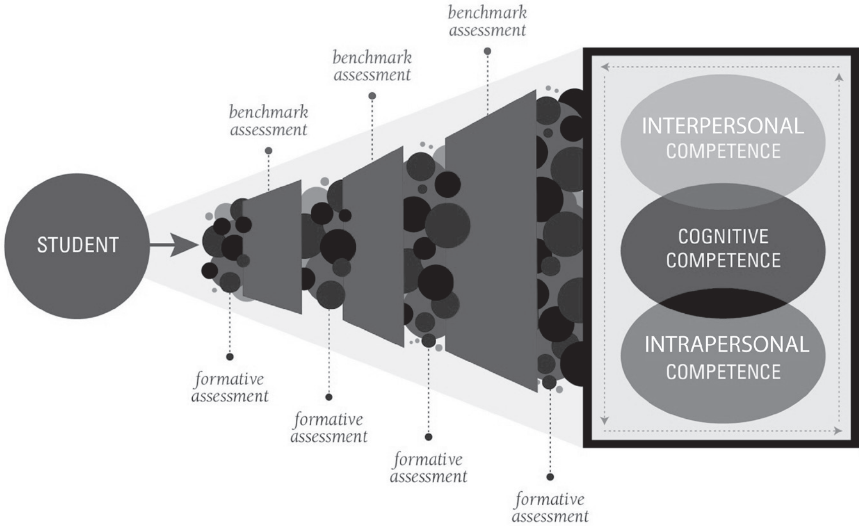

FIGURE 6-2 A coherent assessment system.
SOURCE: Adapted from Herman (2010a).

Formative Assessment: Teacher Roles and Practices

The coherent assessment system depicted in Figure 6-2 depends on formative assessment to facilitate student progress. Herman has described formative assessment as follows (2010b, p. 74):

> Rather than imparting knowledge in a transmission-oriented process, in formative assessment teachers guide students toward significant learning goals and actively engage students as assessors of themselves and their peers. Formative assessment occurs when teachers make their learning goals and success criteria explicit for students, gather evidence of how student learning is progressing, partner with students in a process of reciprocal feedback, and engage the classroom as a community to improve students' learning. The social context of learning is fundamental to the process as is the need for classroom culture and norms that support active learning communities—for example, shared language and understanding of expected performance; relationships of trust and respect; shared responsibility for and power in the learning process. Theorists (Munns and Woodward, 2006) observe that enacting a meaningful process of formative assessment influences what students perceive as valued knowledge, who can learn, who controls and is valued in the learning process.

Yet formative assessment itself involves a change in instructional practice: It is not a regular part of most teachers' practice, and teachers' pedagogical content knowledge may be an impediment to its realization (Heritage et al., 2009; Herman, Osmundson, and Silver, 2010). These and other challenges related to teaching and assessing 21st century competencies are discussed in Chapter 7. In that chapter, we reach conclusions about the challenges and offer recommendations to overcome them.

CONCLUSIONS AND RECOMMENDATIONS

The research literature on teaching and assessment of 21st century competencies has examined a plethora of variously defined cognitive, interpersonal, and interpersonal competencies, Although the lack of uniform definitions makes it difficult to identify and delineate the desired learning outcomes of an educational intervention—an essential first step toward measuring effectiveness—emerging evidence demonstrates that it is possible to develop transferable competencies.

- **Conclusion: Although the absence of common definitions and quality measures poses a challenge to research, emerging evidence indicates that cognitive, intrapersonal, and interpersonal competencies can be taught and learned in ways that promote transfer.**

The emerging evidence on teaching and learning of cognitive, intrapersonal, and interpersonal competencies builds on a larger body of evidence related to teaching for transfer. Researchers have examined the question of how to design instruction for transfer for more than a century. In recent decades, advances in the research have begun to provide evidence-based answers to this question. Although this research has focused on acquisition of cognitive competencies, it indicates that the process of learning for transfer involves the interplay of cognitive, intrapersonal, and interpersonal competencies, as reflected in our recommendations for design of instruction and teaching methods:

- **Recommendation 3: Designers and developers of instruction targeted at deeper learning and development of transferable 21st century competencies should begin with clearly delineated learning goals and a model of how learning is expected to develop, along with assessments to measure student progress toward and attainment of the goals. Such instruction can and should begin with the earliest grades and be sustained throughout students' K-12 careers.**

- **Recommendation 4: Funding agencies should support the development of curriculum and instructional programs that include research-based teaching methods, such as:**

    - **Using multiple and varied representations of concepts and tasks,** such as diagrams, numerical and mathematical representations, and simulations, combined with activities and guidance that support mapping across the varied representations.
    - **Encouraging elaboration, questioning, and explanation—**for example, prompting students who are reading a history text to think about the author's intent and/or to explain specific information and arguments as they read—either silently to themselves or to others.
    - **Engaging learners in challenging tasks,** while also supporting them with guidance, feedback, and encouragement to reflect on their own learning processes and the status of their understanding.
    - **Teaching with examples and cases,** such as modeling step-by-step how students can carry out a procedure to solve a problem and using sets of worked examples.
    - **Priming student motivation** by connecting topics to students' personal lives and interests, engaging students in collaborative problem solving, and drawing attention to the knowledge and skills students are developing, rather than grades or scores.

- o **Using formative assessment** to: (a) make learning goals clear to students; (b) continuously monitor, provide feedback, and respond to students' learning progress; and (c) involve students in self- and peer assessment.

The ability to solve complex problems and metacognition are important cognitive and intrapersonal competencies that are often included in lists of 21st century skills. For instruction aimed at development of problem-solving and metacognitive competencies, we recommend:

- **Recommendation 5: Designers and developers of curriculum, instruction, and assessment in problem solving and metacognition should use modeling and feedback techniques that highlight the processes of thinking rather than focusing exclusively on the products of thinking. Problem-solving and metacognitive competencies should be taught and assessed within a specific discipline or topic area rather than as a stand-alone course. Teaching and learning of problem-solving and metacognitive competencies need not wait until all of the related component competencies have achieved fluency. Finally, sustained instruction and effort are necessary to develop expertise in problem solving and metacognition; there is simply no way to achieve competence without time, effort, motivation, and informative feedback.**

Most of the available research on design and implementation of instruction for transfer has focused on the cognitive domain. We compared the instructional design principles and research-based teaching methods emerging from this research with the instructional design principles and research-based teaching methods that are beginning to emerge from the smaller body of research focusing on development of intrapersonal and interpersonal skills, identifying some areas of overlap and similarities.

- **Conclusion: The instructional features listed above, shown by research to support the acquisition of cognitive competencies that transfer, could plausibly be applied to the design and implementation of instruction that would support the acquisition of transferable intrapersonal and interpersonal competencies.**

The many gaps and weaknesses in the research reviewed here, particularly the lack of common definitions and measures, and the limited research in the intrapersonal and interpersonal domains limit our understanding of how to teach for transfer across the three domains.

- **Recommendation 6: Foundations and federal agencies should support research programs designed to fill gaps in the evidence base on teaching and assessment for deeper learning and transfer. One important target for future research is how to design instruction and assessment for transfer in the intrapersonal and interpersonal domains. Investigators should examine whether, and to what extent, instructional design principles and methods shown to increase transfer in the cognitive domain are applicable to instruction targeted to the development of intrapersonal and interpersonal competencies. Such programs of research would benefit from efforts to specify more uniform, clearly defined constructs and to produce associated measures of cognitive, intrapersonal, and interpersonal competencies.**

7

Systems to Support Deeper Learning

This chapter discusses elements of the U.S. education system that present both opportunities to advance the process of deeper learning and challenges that may slow such advance. The first section focuses on the role of the larger educational system in hindering or supporting educational interventions that foster deeper learning and development of 21st century competencies, with attention to two critical system elements (1) teacher preparation and professional development, and (2) assessment. The second section briefly summarizes the opportunities that could potentially emerge from wide implementation of educational interventions that foster deeper learning, as well as the challenges to such wide implementation. The chapter ends with conclusions and recommendations.

DESIGNING COHERENT EDUCATIONAL SYSTEMS FOR TRANSFER

The previous chapters presented a vision of the cognitive, intrapersonal, and interpersonal competencies that are valuable for functioning effectively at home, work, and in the community. The vision is one in which students and other learners develop a suite of enduring, transferable competencies in the cognitive, intrapersonal, and interpersonal domains. In Chapter 6, the committee recommended that formal and informal learning environments should include a set of coherent, interrelated features if they are to support development of such competencies. However, unless there is coherence in the larger educational environment, it will be difficult to widely implement instruction that incorporates such features.

In formal education, realizing the vision of deeper, transferable knowledge for all students will require complementary changes across the many elements that make up the public education system. These elements include curriculum, instruction, assessment, and teacher preparation and professional development.

While this report provides preliminary definitions of the kinds of transferable competencies that are valuable and offers general guidelines for use in designing instruction to develop these competencies, further research and development are needed to create more specific instructional materials and strategies—the curriculum. Future curricula inspired by our vision of deeper learning should integrate learning across the cognitive, intrapersonal, and interpersonal domains in whatever ways are appropriate for the targeted learning goals. For example, when targeting cognitive knowledge and thinking strategies, curricula should integrate development of the intrapersonal skills of metacognition, self-efficacy, and positive attitudes toward learning that have been shown to enhance deeper learning in the cognitive domain.

Reflecting our findings about the development of competencies across different ages and stages of development, curricula designed to support the process of deeper learning should incorporate a developmental perspective. They should be offered beginning in preschool and provide repeated opportunities across grade levels and domains (cognitive, intrapersonal, interpersonal) for students to develop and practice transferable competencies.

Teacher Preparation and Professional Development

Current systems of teacher preparation and professional development will require major changes if they are to support teaching that encourages deeper learning and the development of transferable competencies. Changes will need to be made not only in conceptions of what constitutes effective professional practice but also in the purposes, structure, and organization of preservice and professional learning opportunities (Garrick and Rhodes, 2000; Darling-Hammond, 2006; Webster-Wright, 2009; Lampert, 2010).

Ball and Cohen (1999) have called for such major changes, proposing a practice-based theory of professional education that would enable teachers to "support much deeper and more complex learning for their students" (p. 7). The authors identified several types of knowledge and skills teachers would require for such instruction, including:

- understanding of subject matter;
- knowledge of both students' common ideas and misconceptions related to the subject matter and also the thinking of individual students;

- understanding of, and sensitivity to, cultural, ethnic, and gender differences;
- knowledge of how children learn; and
- a repertoire of flexible, adaptable teaching strategies to engage learners.

The authors proposed that teachers could develop these capacities by learning in and from practice. Teachers would learn how to elicit students' thinking on an ongoing basis and use what they find out to improve their teaching practice, framing, guiding, and revising tasks and questions. They would approach teaching from a stance of inquiry. Finally, the authors sketched the outlines of professional education that would develop the knowledge and skills teachers require. Such education would focus on learning professional performance, would cultivate the knowledge and skills outlined above, and would be centered in teachers' professional practice. Teachers' learning would be supported by colleagues in communities of practice, as they reflected together on samples of student work or videotaped lessons.

Building on this theory of practice-based professional education, Windschitl (2009), Wilson (2011), and others have recommended replacing current disjointed teacher learning opportunities with more integrated continuums of teacher preparation, induction, support, and ongoing professional development. Windschitl (2009) proposed that teacher preparation programs within such a continuum should center on a common core curriculum grounded in a substantial knowledge of child or adolescent development, learning, and subject-specific pedagogy; those programs also should provide future teachers with extended opportunities to practice under the guidance of mentors (student teaching), lasting at least 30 weeks, that reflect the program's vision of good teaching and that are interwoven with coursework.

Research to date has identified other characteristics of effective teacher preparation programs, including extensive use of case study methods, teacher research, performance assessments, and portfolio examinations that are used to relate teachers' learning to classroom practice (Darling-Hammond, 1999). Deeper learning and the acquisition of 21st century competencies—for both teachers and their students—might also be supported through induction programs that help new teachers make effective use of study groups, peer learning, managed classroom discussions, and disciplined discourse routines (Monk and King, 1994; Ghousseini, 2009). Wilson (2011) and others have noted that one of the most promising practices for both induction and professional development involves bringing teachers together to analyze samples of student work, such as drawings, explanations, or essays, or to observe videotaped classroom dialogues. Working from principled analyses of how the students are responding to the instruction, the teachers can then change their instructional practices accordingly.

Windschitl (2009) identified a number of features of professional development that could help science teachers implement new teaching approaches to cultivate students' 21st century competencies in the context of science. These features are as follows:

- Active learning opportunities focusing on science content, scientific practice, and evidence of student learning (Desimone et al., 2002).
- Coherence of the professional development with teachers' existing knowledge, with other development activities, with existing curriculum, and with standards in local contexts (Garet et al., 2001; Desimone et al., 2002).
- The collective development of an evidence-based "inquiry stance" by participants toward their practice (Blumenfeld et al., 1991; Kubitskey and Fishman, 2006).
- The collective participation by teachers from same school, grade, or subject area (Desimone et al., 2002).
- Adequate time both for planning and for enacting new teaching practices.

More broadly across the disciplines, preservice teachers and inservice teachers will need opportunities to engage in the kinds of teaching and learning environments envisioned in this report. Experiencing instruction designed to support transfer will help them to design and implement such instruction in their own classrooms. Teachers will also need opportunities to learn about different approaches to assessment and the purposes of these different approaches. For example, as noted in the previous chapter, formative assessment can play a key role in fostering deeper learning and the development of 21st century competencies. However, most teachers are not familiar with formative assessment and do not regularly incorporate it in their teaching practice (Heritage et al., 2009; Herman, Osmundson, and Silver, 2010).

Assessment

Research has shown that assessment and feedback play an essential role in the deeper learning of cognitive competencies. In particular, as noted in Chapter 6, ongoing formative assessment by teachers can provide guidance to students which supports and extends their learning, encouraging deeper learning and development of transferable competencies. Current educational policies, however, focus on summative assessments that measure mastery of content and often hold schools and districts accountable for improving student scores on such assessments. Although this focus on summative assessment poses a challenge to the wider teaching and learning of 21st century competencies, recent policy developments do appear to open the window for a wider diffusion of interventions to develop these competencies. For example, the previous chapter noted that the new Common Core State Standards and *A Framework for K-12 Science Education: Practices, Crosscutting Concepts, and Core Ideas* (hereafter referred to as the NRC science framework) include facets of 21st century competencies.

While the new English language arts and mathematics standards and the science framework articulate goals for deeper learning and the development of facets of 21st century competencies, the extent to which these goals are realized in schools will be strongly influenced by their inclusion in district, state, and national assessments. Because educational policy remains focused on outcomes from summative assessments that are part of accountability systems, teachers and administrators will focus instruction on whatever is included in state assessments. Thus, as new assessment systems are developed to reflect the new standards in English language arts, mathematics, and science, significant attention will need to be given to the design of tasks and situations that call upon a range of important 21st century competencies as applied in each of the major content areas.

Although improved assessments would facilitate a wider focus on teaching approaches that support the development of 21st century competencies, there are a number of challenges to developing such assessments. First, research to date has focused on a wide variety of different constructs in the cognitive, intrapersonal, and interpersonal domains. Although our taxonomy offers a useful starting point, further research is needed to more carefully organize, align, and define these constructs. There are also psychometric challenges. Progress has been made in assessing cognitive competencies, but much further research is needed to develop assessments of intrapersonal and interpersonal competencies that are suitable for both formative and summative assessment uses in educational settings. Experiences during the 1980s and 1990s in the development and implementation of performance assessments, including assessments with open-ended tasks, can offer valuable insights, but assessments must be reliable, valid, and fair if they are to be widely used in formal and informal learning environments.

A third challenge involves political and economic forces influencing assessment development and use. Traditionally, policy makers have favored the use of standardized, on-demand, end-of-year tests for purposes of accountability. Composed largely of selected response items, these tests are relatively cheap to develop, administer, and score; have sound psychometric properties; and provide easily quantifiable and comparable scores for assessing individuals and institutions. Yet, as discussed in Chapter 6, such standardized tests have not been conducive to measuring or supporting the process of deeper learning nor to the development of 21st century competencies. In the face of current fiscal constraints at the federal and state levels, policy makers may seek to minimize assessment costs by maintaining lower cost, traditional test formats, rather than incorporating into their systems relatively more expensive, richer performance- and curriculum-based assessments that may better measure 21st century competencies.

The fourth challenge involves teacher and administrator capacity to understand and interpret the new assessments. The features of instruction and assessment discussed in Chapter 6 are not well known to teachers, students, or school administrators.

With support from the U.S. Department of Education, two large consortia of states are currently developing new assessment frameworks and methods aligned with the Common Core State Standards in English language arts and mathematics. If these assessment and frameworks include the facets of 21st century competencies included in the Common Core State Standards, this will provide a strong incentive for states, districts, schools, and teachers to emphasize those facets of 21st century competencies in English language arts and science instruction. Next Generation Science Standards based on the NRC science framework are under development, and the NRC has begun a study to develop an assessment framework based on the NRC science framework. When new science assessments are created, the inclusion of facets of 21st century competencies will, as is the case with English language arts and mathematics, provide a strong incentive for states, districts, schools, and teachers to emphasize those facets in the context of science lessons.

OPPORTUNITIES AND CHALLENGES

The development of 21st century competencies in K-12 education and informal learning environments opens up many new opportunities. Because these competencies support the learning of school subjects, more attention to them in school programs and also in informal learning environments could potentially reduce disparities in educational attainment. Reducing these disparities would prepare a broader swathe of young people to enjoy the positive outcomes of increased educational attainment, including greater success in the workplace, improved health, and greater civic participation relative to people with fewer years of schooling. At the same time, developing these competencies in K-12 education could also lead to positive adult outcomes for more young people, independent of any increases in their years of schooling.

Important challenges do remain, however. For educational interventions capable of developing transferable knowledge and skills to move beyond isolated promising examples and flourish more widely in the educational system, larger systemic issues involving curriculum, instruction, assessment, and professional development will need to be addressed. In particular, as noted above, new types of assessment systems are needed that are capable of accurately measuring and supporting the acquisition of these skills. A sustained program of research and development will be required to create assessments that are capable of measuring cognitive, intrapersonal, and interpersonal competencies. As noted in Chapter 3, such assessments are needed first for research purposes, to increase our understanding of the extent to which these competencies affect later life outcomes. In addition, improved assessments of the competencies would be valuable for formative assessment purposes and might ultimately be used for summative purposes.

It will be important for researchers and publishers to develop new curricula that incorporate the research-based design principles and instructional methods described in Chapter 6. Finally, as noted briefly above, new approaches to teacher preparation and professional development will be needed to help current and prospective teachers understand the instructional principles for the teaching and assessment of 21st century competencies and the role of these competencies in the learning of core academic content. If teachers are not only to understand these ideas but also to translate them into their daily instructional practice, they will need support from school and district administrators, including time for learning, shared lesson planning and review, and reflection.

CONCLUSIONS AND RECOMMENDATIONS

While new national goals that encompass 21st century competencies have been articulated in the Common Core State Standards for English language arts and mathematics and in the NRC science education framework, the extent to which these goals are realized in educational settings will be strongly influenced by the nature of their inclusion in district, state, and national assessments. Because educational policy remains focused on outcomes from summative assessments that are part of accountability systems, teachers and administrators will focus instruction on whatever is included in state assessments. Thus as new assessment systems are developed to reflect the new standards in English language arts, mathematics, and science, it will be necessary to give significant attention to the design of tasks and situations that call upon a range of important 21st century competencies as applied in each of the major content areas. A sustained program of research and development will be required to create assessments that are capable of measuring cognitive, intrapersonal, and interpersonal skills.

- **Recommendation 7: Foundations and federal agencies should support research to more clearly define and develop assessments of 21st century competencies. In particular, they should provide sustained support for the development of valid, reliable, and fair assessments of intrapersonal and interpersonal competencies, initially for research purposes and, later, for formative assessment. Pending the results of these efforts, foundations and agencies should consider support for development of summative assessments of these competencies.**

Two large consortia of states, with support from the U.S. Department of Education, are currently developing new assessment frameworks and methods aligned with the Common Core State Standards in English language arts and mathematics. If these assessment frameworks include the facets of 21st century competencies represented in the Common Core State Standards, they will provide a strong incentive for states, districts, schools, and teachers to emphasize these critical facets of 21st century competencies as part of disciplinary instruction.

- **Recommendation 8: As the state consortia develop new assessment systems to reflect the Common Core State Standards in English language arts and mathematics, they should devote significant attention to the design of tasks and situations that call upon a range of important 21st century competencies as applied in each of the major content areas.**

Next Generation Science Standards are at an early stage of development, and assessments aligned with these standards have not yet been created. When new science assessments are developed, the inclusion of facets of 21st century competencies will provide a similarly strong incentive for states, districts, schools, and teachers to emphasize those facets in classroom science instruction.

- **Recommendation 9: As states and test developers begin to create new assessment systems aligned with new science standards, they should devote significant attention to designing measures of 21st century competencies properly reflecting a blend of science practices, crosscutting concepts, and core ideas.**

Because 21st century competencies support learning of school subjects in particular and educational attainment more generally, more attention to the development of these skills in the K-12 curriculum could potentially reduce disparities in educational attainment and allow a broader swathe of young people to enjoy the fruits of workplace success, improved health, and greater civic participation. However, important challenges to achieving this outcome remain. For educational interventions focused on developing transferable competencies to move beyond isolated promising examples and flourish more widely in formal educational settings, larger systemic issues and policies involving curriculum, instruction, assessment and professional development will need to be addressed. Addressing these systemic issues will require supportive state and federal policies and programs, to facilitate the development of new types of assessment systems, new curricula that incorporate the instructional design guidelines and research-based features described above, and new approaches to teacher preparation and professional development.

- **Recommendation 10: The states and the federal government should establish policies and programs—in the areas of assessment, accountability, curriculum and materials, and teacher education—to support students' acquisition of transferable 21st century competencies. For example, when reauthorizing the Elementary and Secondary Education Act, the Congress should facilitate the systemic development, implementation, and evaluation of educational interventions targeting deeper learning processes and the development of transferable competencies.**

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Appendix A

21st Century Skills and Competencies Included in the OECD Survey

1. Creativity/innovation
2. Critical thinking
3. Problem solving
4. Decision making
5. Communication
6. Collaboration
7. Information literacy
8. Research and inquiry
9. Media literacy
10. Digital citizenship
11. Information and communications technology operations and concepts
12. Flexibility and adaptability
13. Initiative and self-direction
14. Productivity
15. Leadership and responsibility
16. Other (please specify)

SOURCE: Adapted from Ananiadou and Claro (2009).

Appendix B

Reports on 21st Century Skills Used in Aligning and Clustering Competencies

Report	Skills
Association for Career and Technical Education. (2010). *What Is Career Ready?* Alexandria, VA: Author. Available: http://dpi.wi.gove/oea/pdf/crpaper.pdf [October 2011].	• Critical thinking • Problem solving • Oral/written communication • Creativity • Adaptability • Diversity • Continuous learning • Collaboration • Teamwork • Responsibility • Professionalism/ethics
Bedwell, W.L., Salas, E., and Fiore, S.M. (2011). *Developing the 21st Century (and Beyond) Workforce: A Review of Interpersonal Skills and Measurement Strategies*. Paper prepared for the NRC Workshop on Assessing 21st Century Skills. Available: http://www7.nationalacademies.org/bota/21st_Century_Workshop_Salas_Fiore_Paper.pdf [October 2011].	• Active listening • Oral communication • Written communication • Cooperation • Coordination • Trust • Service orientation • Conflict resolution • Negotiation • Assertive communication • Self-presentation • Social influence

Report	Skills
Binkley, M., Erstad, O., Herman, J., Raizen, S., Ripley, M., and Rumble, M. (2010). *Defining 21st Century Skills*. White Paper commissioned for the Assessment and Teaching of 21st Century Skills Project (ATC21S). Available on request from ATC21S: http://atc21s.org/index.php/resources/white-papers/#item1.	• Critical thinking • Problem solving • Decision making • Information literacy (including research on sources, evidence, biases) • Information and communications technology literacy • Creativity/innovation • Personal and social responsibility (including cultural awareness and competence) • Communication • Collaboration
Conley, D.T. (2007). *Redefining College Readiness*. Eugene, OR: Educational Policy Improvement Center. Available: https://www.epiconline.org/files/pdf/RedefiningCollegeReadiness.pdf [October 2011].	• Problem solving • Analysis • Reasoning/argumentation • Interpretation
Finegold, D., and Notabartolo, A.S. (2010). *21st Century Competencies and Their Impact: An Interdisciplinary Literature Review*. Paper commissioned for the NRC Project on Research on 21st Century Competencies: A Planning Process on Behalf of the Hewlett Foundation. Available: http://www7.nationalacademies.org/bota/Finegold_Notabartolo_Impact_Paper.pdf [October 2011].	• Critical thinking • Problem solving • Decision making • Information literacy • Information and communication technology literacy • Creativity/innovation • Flexibility • Communication • Collaboration • Leadership • Responsibility • Initiative • Self-direction • Productivity
Hoyle, R.H., and Davisson, E.K. (2011). *Assessment of Self-Regulation and Related Constructs: Prospects and Challenges*. Paper prepared for the NRC Workshop on Assessment of 21st Century Skills. Available: http://www7.nationalacademies.org/bota/21st_Century_Workshop_Hoyle_Paper.pdf [October 2011].	• Executive function (inhibition, working memory, shifting) • Leadership • Type 1 processes (forethought, performance, self-reflection) • Type 2 processes (self-monitoring, self-evaluation, self-reinforcement)

Report	Skills
Voogt, J., and Pareja Roblin, N. (2010). *21st Century Skills Discussion Paper.* Report prepared for Kennisnet, University of Twente, The Netherlands. Available: http://www.internationalsymposiumoneducationalreform.com/storage/21st%20Century%20Skills.pdf [October 2011].	• Problem solving • ICT literacy • Creativity • Communication • Collaboration

Appendix C

Biographical Sketches of Committee Members

JAMES W. PELLEGRINO (*Chair*) is a liberal arts and sciences distinguished professor and distinguished professor of education at the University of Illinois at Chicago (UIC). He is co-director of UIC's interdisciplinary Learning Sciences Research Institute. Dr. Pellegrino's current work is focused on analyses of complex learning and instructional environments, including those incorporating powerful information technology tools, with the goal of better understanding. A special concern of his research is the incorporation of effective formative assessment practices, assisted by technology, to maximize student learning and understanding. Dr. Pellegrino has served on numerous National Research Council (NRC) boards and committees, including the Board on Testing and Assessment. He co-chaired the NRC committee that authored the report *Knowing What Students Know: The Science and Design of Educational Assessment*. He recently helped the College Board build new frameworks for curriculum, instruction, assessment, and professional development in AP biology, chemistry, physics, and environmental science. Dr. Pellegrino earned his B.A. in psychology from Colgate University in Hamilton, New York, and both his M.A. and Ph.D. from the University of Colorado.

GREG J. DUNCAN is a distinguished professor of education at the University of California, Irvine. He has published extensively on issues of income distribution, child poverty, and welfare dependence. He is co-author with Aletha Huston and Tom Weisner of *Higher Ground: New Hope for the Working Poor and Their Children* (2007) and co-editor with Lindsay Chase Lansdale of *For Better and for Worse: Welfare Reform and the Well-Being* *of Children and Families* (2001). With Jeanne Brooks-Gunn, he co-edited two books on neighborhood poverty and child development. He continues to study neighborhood effects on the development of children and adolescents and other issues involving welfare reform, income distribution, and its consequences for children and adults. Duncan is a member of the interdisciplinary MacArthur Network on the Family and the Economy. He was elected president of the Society for Research in Child Development for 2009-2011. A member of the National Academy of Sciences, Dr. Duncan currently serves on the steering committee for the Board on Testing and Assessment's Workshop on Assessment of 21st Century Skills. He previously served as a member of the Panel to Review the National Children's Study Research Plan, and as co-chair of the Committee on Evaluation of Children's Health. He received his Ph.D. in economics from the University of Michigan.

JOAN L. HERMAN is director of the National Center for Research on Evaluation, Standards, and Student Testing (CRESST) at the University of California, Los Angeles. Her research has explored the effects of testing on schools and the design of assessment systems to support school planning and instructional improvement. Her recent work has focused on the validity and utility of teachers' formative assessment practices in mathematics and science. She also has wide experience as an evaluator of school reform and is noted in bridging research and practice. A former teacher and school board member, Herman also has published extensively in research journals and is a frequent speaker to policy audiences on evaluation and assessment topics. She is past president of the California Educational Research Association, has held a variety of leadership positions in the American Educational Research Association and Knowledge Alliance, is a member of the Joint Committee for the Revision of the Standards for Educational and Psychological Measurement, co-chairs the Board of Education for Para Los Niños, and is current editor of *Educational Assessment*. She served as a member of the National Research Council's Committee on Test Design for K-12 Science Achievement as well as the Roundtable on Education Systems and Accountability and the Committee on Best Practices for State Assessment Systems and is chairing the Board on Testing and Assessment's Workshop on 21st Century Skills. Ms. Herman received her doctorate of education in learning and instruction from the University of California, Los Angeles.

MARGARET A. HONEY joined the New York Hall of Science as president and chief executive officer in November 2008. She is widely recognized for her work using digital technologies to support children's learning across the disciplines of science, mathematics, engineering, and technology. Prior to joining the New York Hall of Science, she was vice president of Wireless

Generation, an education technology company. Earlier, she spent 15 years as vice president of the Education Development Center (EDC) and director of EDC's Center for Children and Technology. There she directed numerous large-scale research projects funded by the National Science Foundation, the Institute for Education Sciences, the Carnegie Corporation, and other organizations. As a member of the Educational Advisory Board of the Partnership for 21st Century Skills, she worked closely with business representatives to define 21st century skills and consider how to teach and assess them. Her activities have included collaborations with public television, investigations of data-driven decision-making tools and practices, and creation of one of the first Internet-based professional development programs in the country. She currently serves on the National Research Council's Board on Science Education and recently chaired the Committee on Learning Science: Computer Games, Simulations, and Education. Earlier, she chaired the steering committee for the workshop on IT Fluency and High School Graduation Outcomes. She received her Ph.D. in developmental psychology from Columbia University.

PATRICK C. KYLLONEN is the director of the Center for New Constructs at Educational Testing Service (ETS), Princeton, New Jersey. Before joining ETS, he was a faculty member at the University of Georgia and director of the Cognitive Performance Division of the Air Force Research Laboratory. He is the recipient of numerous awards, including one from the technical cooperation program for the design, development, and evaluation of the trait-self-description (personality) inventory for use in five countries; has served on the board of several journals; has been a regular reviewer for the National Science Foundation, the Institute of Education Sciences, and other agencies; and is a fellow of Division 15 of the American Psychological Association. Dr. Kyllonen is known for his work on the measurement of human abilities, working memory, learning and skill acquisition, psychomotor abilities, personality assessment, computer-based testing, and psychometrics. Most recently his focus has been on noncognitive assessment. He currently oversees a wide array of research and development projects on measurement of noncognitive abilities at all levels of education, from kindergarten through graduate school. He participated in an expert planning meeting as part of the National Research Council project, Research on 21st Century Competencies: A Planning Process on Behalf of the Hewlett Foundation, and currently serves as a member of the steering committee for the Workshop on Assessment of 21st Century Skills. Dr. Kyllonen received his Ph.D. in educational psychology from Stanford University and his B.A. in experimental psychology from St. John's University.

HENRY M. LEVIN is the William Heard Kilpatrick professor of economics and education at Teachers College, Columbia University, and director of the National Center for the Study of Privatization in Education, a nonprofit, nonpartisan research organization. He is a specialist in the economics of education and human resources, cost-effectiveness analysis, school reform, and educational vouchers. Among his 21 published books are *Readings in the Economics of Education* with C. Belfield (2003) and *Privatizing Educational Choice* with C. Belfield (2005). He has served on several National Research Council committees, including the recent Committee on Strengthening Benefit-Cost Methodology for the Evaluation of Early Childhood Interventions, the Committee on Educational Excellence and Testing Equity (2000-2002), and the Panel on Secondary School Education for the Changing Workplace (early 1980s). He received his bachelor's degree in marketing and economics from New York University and his Ph.D. in economics from Rutgers University.

CHRISTINE MASSEY is the director of research and education at the Institute for Research in Cognitive Science at the University of Pennsylvania. She is also director of PENNlincs, which serves as an outreach arm of the Institute, linking recent theory and research in cognitive science to education efforts in public schools and cultural institutions. She has directed major projects that combine research investigating students' learning and conceptual development in science and math with the development and evaluation of new curriculum materials, learning technology, and educational programs for students and teachers. These projects include development of mathematics learning software that incorporates principles of perceptual learning, creation of the Science for Developing Minds curriculum series, development of a robotics curriculum for the middle grades, and kits and exhibit enhancements to support family learning in zoos and museums. She is an Eisenhower fellow and has also been a fellow in the Spencer Foundation/National Academy of Education's postdoctoral fellowship program. Dr. Massey served as a member of the National Research Council's steering committee for the Workshop on the Intersection of Science Education and 21st Century Skills. She earned her Ph.D. in psychology with a specialization in cognitive development at the University of Pennsylvania.

RICHARD E. MAYER is professor of psychology at the University of California, Santa Barbara, where he has served since 1975. His research interests are in educational and cognitive psychology. His current research involves cognition, instruction, and technology with a special focus on multimedia learning and computer-supported learning. He is past president of Division 15 (Educational Psychology) of the American Psychological Association, past vice president of Division C (Learning and Instruction) of the American

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LITERATURE REVIEW JUNE 2012

Teaching Adolescents To Become Learners

The Role of Noncognitive Factors in Shaping School Performance: A Critical Literature Review

Camille A. Farrington, Melissa Roderick, Elaine Allensworth, Jenny Nagaoka, Tasha Seneca Keyes, David W. Johnson, and Nicole O. Beechum

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ACKNOWLEDGEMENTS We would like to recognize the many people who contributed to this review. Our research colleagues at the University of Chicago Consortium on Chicago School Research and our practitioner colleagues at the Network for College Success gave critical feedback and helped us think through the implications of the existing literature for both research and practice. We would particularly like to thank Eliza Moeller, Faye Kroshinksy, Kersti Azar, Kafi Moragne, Thomas Kelley-Kemple, Mary Ann Pitcher, Sarah Howard, Rito Martinez, Jackie Lemon, Catherine Whitfield, LaKisha Pittman, Cecily Langford, Michael Kristovic, Sue Sporte, W. David Stevens, Marisa de la Torre, Julia Gwynne, Bronwyn McDaniel, and Penny Bender Sebring for their feedback on our model of noncognitive factors and their critical comments on and contributions to the report. We are indebted to members of the CCSR Steering Committee who provided substantive feedback on our research, particularly Lila Leff and Kim Zalent. Angela Duckworth and David Yeager gave us very helpful critical commentary that strengthened our final product. CCSR Associate Director for Communications, Emily Krone and Communications and Research Manager, Bronwyn McDaniel were instrumental in shepherding this through the production process. Welcome to baby Caroline Mary Phillips, whose conception and birth coincided very closely with the conception and delivery of this project.

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RAIKES FOUNDATION

Raikes Foundation provides opportunities and support during adolescence to help young people become healthy, contributing adults with a special interest in improving outcomes for early adolescents (ages 10 to 14). As early adolescents transition into middle school, they enter a challenging developmental period, the stakes for academic performance are higher, and their choices can have lifelong impact. This is also a critical stage for identity development; young people establish beliefs about their capabilities and potential, develop patterns of behavior around learning, and cultivate the relationships with peers and adults that impact their sense of belonging. Raikes Foundation's early adolescent grantmaking aims to develop each young person's agency by building the mindsets and learning strategies that support youth in productively persisting through middle grades and on to college, career, and life success. Raikes Foundation primarily invests in the development of programs and practices, inside and outside the classroom, to intentionally build critical mindsets and learning strategies among low-income early adolescents. Raikes Foundation also supports research and efforts to raise awareness of the importance of mindsets and learning strategies to youth success.

LUMINA FOUNDATION

Lumina Foundation is committed to enrolling and graduating more students from college. It is the nation's largest foundation dedicated exclusively to increasing students' access to and success in postsecondary education. Lumina's mission is defined by Goal 2025—to increase the percentage of Americans who hold high-quality degrees and credentials to 60 percent by 2025. Lumina pursues this goal in three ways: by identifying and supporting effective practice, by encouraging effective public policy, and by using communications and convening capacity to build public will for change. Lumina has worked with and made grants to many colleges, universities, peer foundations, associations, and other organizations that work to improve student access and outcomes across the nation.

THE UNIVERSITY OF CHICAGO CONSORTIUM ON CHICAGO SCHOOL RESEARCH

The University of Chicago Consortium on Chicago School Research (CCSR) conducts research of high technical quality that can inform and assess policy and practice in the Chicago Public Schools. CCSR seeks to expand communication among researchers, policymakers, and practitioners as it supports the search for solutions to the problems of school reform. CCSR encourages the use of research in policy action and improvement of practice, but does not argue for particular policies or programs. Rather, CCSR researchers help to build capacity for school reform by identifying what matters for student success and school improvement, creating critical indicators to chart progress, and conducting theory-driven evaluation to identify how programs and policies are working. A number of features distinguish CCSR from more typical research organizations: a comprehensive data archive, a focus on one place—Chicago, engagement with a diverse group of stakeholders, a wide range of methods and multiple investigators, and a commitment to sharing research findings with diverse publics.

BACKGROUND OF THIS REPORT

Early in 2011, Program Officers from Lumina Foundation and Raikes Foundation approached researchers at CCSR about undertaking a joint project, focused on the role of noncognitive skills in students' school performance and educational attainment. In addition to their financial support, Lumina and Raikes brought their respective interests and expertise in postsecondary attainment and middle grades education. CCSR brought its trademark approach to school reform: using research and data to identify what matters for student success and school improvement, creating theory-driven frameworks for organizing the research evidence, and asking critical questions about the applicability of research to practice.

A NOTE ON TERMINOLOGY

Noncognitive Factors

School performance is a complex phenomenon, shaped by a wide variety of factors intrinsic to students and in their external environment. In addition to content knowledge and academic skills, students must develop sets of behaviors, skills, attitudes, and strategies that are crucial to academic performance in their classes, but that may not be reflected in their scores on cognitive tests. Other researchers have described these factors as *noncognitive skills*; we broaden the term to *noncognitive factors* to go beyond a narrow reference to skills and include strategies, attitudes, and behaviors. This change in terminology suggests a more expansive understanding of noncognitive factors, requiring that we look beyond individual-level skills to consider the ways students interact with the educational context within which they are situated and the effects of these interactions on students' attitudes, motivation, and performance.

While we are strongly persuaded by the evidence of the importance of these factors for students' course performance, we find "noncognitive" to be an unfortunate word. It reinforces a false dichotomy between what comes to be perceived as weightier, more academic "cognitive" factors and what by comparison becomes perceived as a separate category of fluffier "noncognitive" or "soft" skills. As others have pointed out, contrasting cognitive and noncognitive factors can be confusing because "few aspects of human behavior are devoid of cognition" (Borghans, Duckworth, Heckman, & Weel, 2008, p. 974). In reality, these so-called cognitive and noncognitive factors continually interact in essential ways to create learning, such that changes in cognition are unlikely to happen in the absence of this interaction (Bransford, Brown, & Cocking, 2000). How could one's study skills, for example, not be part of a cognitive process? How could one's intelligence not come into play in the exercise of one's social skills? Alas, the word *noncognitive* is already deeply embedded in educational policy circles, in the economics literature, and in broader discussions of student achievement. Though we agree with others' objections to this terminology, we feel compelled to use it. To try to substitute in another word now would likely confuse rather than illuminate our collective understanding of this important area of research.

One further clarification is in order. Throughout this review, we use the term *cognitive factors* to refer generally to the "substance" of what is learned in school, namely a student's grasp of content knowledge and academic skills such as writing and problem-solving. This is distinct from a student's *capacity* to learn. Advances in cognitive science over the last 30 years have highlighted the limitations of the concept of an individual's intelligence "quotient" (IQ) as a fixed and quantifiable amount of intellectual capacity. Research in human cognition has moved away from the idea of cognition as being isolated within an individual brain to depending on the contexts in which it exists, "including the environment, perception, action, affect, and sociocultural systems" (Barsalou, 2010, p. 325). Barsalou summarizes 30 years of research in cognitive science by saying that "continuing to study cognition as an independent isolated module is on the fast track to obsolescence." In our review, then, we work from the idea that learning is an interplay between cognitive and noncognitive factors and that intelligence is embedded in both the environment and in socio-cultural processes.

CHAPTER 1

The Promise of Noncognitive Factors

Over the past 20 years, changes in the U.S. economy have raised the stakes for educational attainment, resulting in dire economic consequences for workers without a high school diploma and some college education. American adolescents have responded by dramatically increasing their educational aspirations; almost all high school students in the U.S. now say they expect to go to college (Engel, 2007). Education policymakers have attempted to ensure students' qualifications for college by ratcheting up academic demands through more rigorous high school graduation requirements, increasing participation in advanced coursework, and raising standards within courses. Test-based accountability measures have been enacted with the intention of holding schools accountable for reaching these higher standards.

Currently, there is considerable optimism around the new Common Core State Standards, with expectations that this articulated framework of content knowledge and core academic skills will lead to more high school graduates who are ready for college and the workforce. There is also growing consensus that schools need to "ramp up" expectations in the middle grades, resulting in policies to start the study of algebra in eighth grade, for example. Many states and districts are simultaneously developing measures of high school and college readiness that rely on specific patterns of coursework (e.g., AP courses) and standardized test scores as readiness benchmarks. These efforts suggest that students' readiness for high school or college depends almost entirely on their mastery of content knowledge and academic skills as developed through the courses they take.

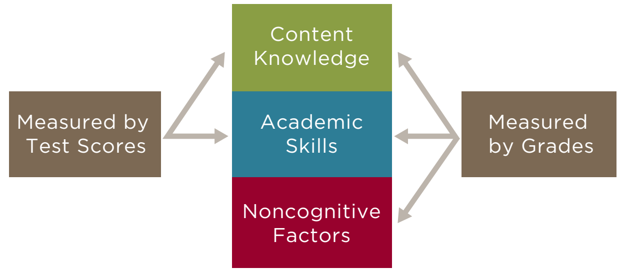
Unfortunately, there is little to no rigorous evidence that efforts to increase standards and require higher-level coursework—*in and of themselves*—are likely to lead many more students to complete high school and attain college degrees. Current policy efforts rest on the assumption that a more rigorous high school curriculum will improve student performance on standardized tests, which will reflect that students are better prepared for college. But what matters most for college graduation is not which courses students take, or what their test scores are, but how well students perform in those courses, as measured by their high school course grades.[1] Students' course grades, grade point average (GPA), or class rank are vastly better predictors of high school and college performance and graduation, as well as a host of longer-term life outcomes, than their standardized test scores or the coursework students take in school (Allensworth & Easton, 2005, 2007; Camara & Echternacht, 2000; Geiser & Santelices, 2007; Hauser & Palloni, 2011; Hoffman, 2002; Hoffman & Lowitzki, 2005; Moffat, 1993; Munro, 1981; Tross et al., 2000; Zheng et al., 2002). GPA is not only important in predicting whether a student will complete high school or college; it is also the primary driver of differences by race/ethnicity and gender in educational attainment (Allensworth & Easton, 2007; Jacob, 2002; Roderick, Nagaoka, & Allensworth, 2006). **Box 1.1 and Appendix** further illustrate this point.

The findings on the critical importance of GPA for students' future outcomes suggest that we need to better understand why they are so predictive of later success. Grades must capture some other important student attributes—over and above the content that test scores measure—but what? The prevailing interpretation is that, in addition to measuring students' content knowledge and core academic skills, grades also reflect the degree to which students have demonstrated a range of academic behaviors, attitudes, and strategies that are critical for success in school and in later life, including study skills, attendance, work habits, time management, help-seeking behaviors, metacognitive strategies, and social and academic problem-solving skills that allow students to successfully manage new environments and meet new academic and social demands (Conley, 2007; Farkas, 2003; Paris & Winograd, 1990) (see **Figure 1.1**). To this list of critical success factors, others have added students' attitudes about learning, their beliefs about their own intelligence, their self-control and persistence, and the quality of their relationships with peers and adults (Ames & Archer, 1988; Bandura, 1997; Bandura & Schunk, 1981; Keith, Keith, Troutman, Bickley, Trivette, & Singh, 1993; Pintrich, 2000; Schunk & Hanson, 1985; Wentzel, 1991; Zimmerman, 1990). There is a long list of factors—beyond content knowledge and academic skills—shown to have an impact on student performance.

Economists refer to these factors as "noncognitive" because they are not measured by commonly administered cognitive tests such as IQ tests or academic examinations. In a wide range of studies, many of these noncognitive attributes are shown to have a direct positive relationship to students' concurrent school performance as well as future academic outcomes. Economist and Nobel laureate James Heckman (2008) argues that noncognitive factors such as motivation, time management, and self-regulation are critical

FIGURE 1.1

Factors Measured by Test Scores versus Grades



BOX 1.1

Measuring Academic Performance: The Case for Focusing on Grades

Despite all the attention to standardized tests, a growing body of research shows that achievement test scores are not strong predictors of whether students will graduate from high school or college. Research on early indicators of high school performance finds that passing courses and GPA in the middle grades and even earlier in elementary school are among the strongest predictors of high school outcomes (Kurlaender, Reardon, & Jackson, 2008; Neild & Balfanz, 2001; Zau & Betts, 2008). Likewise, high school grades are stronger and more consistent predictors of college persistence and graduation than college entrance examination scores or high school coursetaking (Geiser & Santelices, 2007; Roderick, Nagaoka, & Allensworth, 2006). In a study using data from the University of California, Geiser and Santelices (2007) found that high school grades were a stronger predictor of both college GPA and likelihood of college graduation than students' SAT scores, class rank, and family background.[2]

In *Crossing the Finish Line*, Bowen, Chingos, & McPherson (2009) also found that high school grades were much better predictors of college graduation than ACT or SAT scores. Like others with similar findings, Bowen and colleagues speculate that, beyond measuring content mastery, grades "reveal qualities of motivation and perseverance—as well as the presence of good study habits and time management skills" and "often reflect the ability to accept criticism and benefit from it and the capacity to take a reasonably good piece of one's work and reject it as not good enough" (p. 124). Ultimately it is these qualities, more so than content knowledge, that signal which students are likely to excel in their studies and persevere in their schooling.

Furthermore, it is not just course grades and educational attainment that are better predicted by grades than by tested performance. Miller (1998) found that high school grades had strong, significant relationships with earnings nine years after high school, for both men and women, even after controlling for educational attainment and school effects. Earnings were higher by about 20 percent for each GPA point earned in high school (As versus Bs; Bs versus Cs; Cs versus Ds). Hauser and Palloni (2011) found that students' class rank (as determined by their grades) accounted for all of the relationship between IQ and length of life, and suggested this was due to having established responsible patterns of behavior during adolescence.

These findings make sense. Students who come to class and complete their work are likely to have developed the kind of work habits they will need in college as well as in the workforce. Students who struggle with self-discipline or productivity in high school will likely find the challenges of college overwhelming, regardless of their intellectual ability or content knowledge. The finding that course grades matter over and above achievement test scores suggests that grades do indeed capture something important about students that test scores do not.

for later life outcomes, including success in the labor market. Recent research on noncognitive factors has not only suggested their importance for student academic performance but has also been used to argue that social investments in the development of these noncognitive factors would yield high payoffs in improved educational outcomes as well as reduced racial/ethnic and gender disparities in school performance and educational attainment.

Interest in noncognitive factors has been propelled in recent years, in part, by some compelling results from a number of psychological studies. This body of work has shown some short-term interventions that target students' psycho-social beliefs—such as interventions that work to change students' beliefs about their intelligence, that promote social belonging, or that connect performance to future goals—as having substantial effects on school performance that are sustained over time (e.g., Blackwell et al., 2007; Good, Aronson, & Inzlicht, 2003; Oyserman, Terry, & Bybee, 2002; Walton & Cohen, 2007). Two widely cited psychologists, Duckworth and Seligman (2005), suggest that academic performance depends in large part on students' self-control or Conscientiousness, concluding that "a major reason for students falling short of their intellectual potential [is] their failure to exercise self-discipline" (p. 939). They claim that measures of self-discipline are far more predictive of positive academic outcomes than are measures of IQ. Carol Dweck and her colleagues (2011) conclude in a review of the evidence on academic mindsets and what they term "academic tenacity" that "educational interventions and initiatives that target these psychological factors can have transformative effects on students' experience and achievement in school, improving core academic outcomes such as GPA and test scores months and even years later" (p. 3).

Just as importantly, researchers are increasingly turning to noncognitive factors to explain differences in school performance by race/ethnicity and gender. Brian Jacob (2002) notes that academic difficulties are often attributed to poor "noncognitive skills" among boys, including "the inability to pay attention in class, to work with others, to organize and keep track of homework or class materials and to seek help from others" (p. 590). Interventions that focus on developing academic mindsets, moreover, are being designed and evaluated as a method to reduce stereotype threat and improve the academic performance and educational attainment of racial/ethnic minority students (Aronson, Cohen, & McColskey, 2009). As we review later, much of this work shows promising results. Thus, a collection of research suggests not only that noncognitive factors contribute to students' academic performance but also that racial/ethnic and gender differences in school performance can be reduced by focusing on students' attitudes and behaviors.

Unfortunately, knowing that noncognitive factors matter is not the same as knowing how to develop them in students. And what exactly is the nature of these noncognitive factors? Are they inherent student characteristics that some students have and others do not? Are they fixed traits, or do they change in response to context or environment? Can they be taught and learned in a school setting? Are noncognitive factors more important—or more problematic—for one race/ethnicity or gender over another? Many of the big claims about noncognitive factors have little clear evidence about their implications for educational practice. The suggestion that educators would see big returns from developing academic mindsets, self-discipline, and other noncognitive factors rests on the assumption that these factors are malleable and that educators or researchers have practical knowledge of how to change them. It also requires that educators understand the potential payoffs of different approaches to developing student noncognitive factors, that they have concrete strategies to address their development, and that tools exist to reliably measure changes in these factors.

If indeed noncognitive factors are malleable and are critical to academic performance, a key task for educators becomes the intentional development of these skills, traits, strategies, and attitudes in conjunction with the development of content knowledge and academic skills. In essence, teachers would play a vital role in helping students move from being passive recipients of academic content to active learners who can manage their workload, assess their progress and status, persist in difficult tasks, and develop a reliable set of strategies to master increasingly complex academic content as they proceed through school.

While evidence increasingly suggests that college and career readiness is driven by more than just content knowledge and core academic skills—that noncognitive factors play a key role in student success—it is unclear how all the different types of noncognitive factors interact to shape academic performance or what their implications are for educational practice. Studies of noncognitive factors often examine one particular skill, mindset, or behavior in isolation, making it unclear how all of these factors work together to affect student outcomes. There is, as yet, little coherence to the broad array of research findings and claims around the role of noncognitive factors in students' performance in school. In this report, we seek to bring this much-needed coherence as we review the research on noncognitive factors with a focus on students in the middle grades, in high school, and in the transition to college. We are particularly interested in identifying which noncognitive factors matter for students' long-term success, clarifying why and how these factors matter, determining if these factors are malleable and responsive to context, determining if they play a role in persistent racial/ethnic or gender gaps in academic achievement, and illuminating how educators might best support the development of important noncognitive factors within their schools and classrooms. In reviewing the literature, we use students' course grades as the outcome of interest. For each noncognitive factor, then, we examine the research evidence on the relationship between that factor and students' course grades or GPA, which we refer to broadly in this report as "academic performance."

In Chapter 2, we bring together the existing literature into a conceptual framework that organizes the broad body of research on noncognitive factors. In this framework, we identify five general categories of noncognitive factors related to academic performance: 1) academic behaviors, 2) academic perseverance, 3) academic mindsets, 4) learning strategies, and 5) social skills. We evaluate the research evidence behind each of the five categories in Chapters 3 through 7 in order to identify gaps in the knowledge base and help policymakers and practitioners judge potential high-leverage points for improving student achievement. For each category, we review the research evidence, asking:

- How is this factor related to academic performance?
- Is this factor malleable?
- What is the role of classroom context in shaping this factor?
- Are there clear, actionable strategies for classroom practice?
- Would changing this factor significantly narrow existing gaps in achievement by gender or race/ethnicity?

After reviewing the evidence on the five noncognitive categories, in Chapter 8 we examine the implications of this work for student learning at three key points in an adolescent's educational trajectory: the middle grades, entrance to high school, and the transition to college. We present case studies on these three periods to shed light on the role of noncognitive factors in students' academic performance across educational transitions. The report closes with an interpretive summary and recommendations for practice, policy, and future research.

In this work, we try to develop a coherent and evidence-based framework for considering the role of noncognitive factors in academic performance and to identify critical gaps in the knowledge base and in the link between research and practice. We see this as a prerequisite for policymakers, practitioners, and education funders who would wish to assess the potential of noncognitive factors as levers for increasing student educational attainment. In our review, we found evidence to suggest that the best leverage points for improving student performance are in helping teachers understand the relationship between classroom context and student behaviors, providing teachers with clear strategies for creating classrooms that promote positive academic mindsets in students, and building teacher capacity to help students develop strategies that will enhance their learning and understanding of course material.

Our review shows that academic behaviors have the most immediate effect on students' course grades. In relation to behaviors, much of the recent attention to noncognitive factors focuses on the idea of developing students' "grit" or perseverance in challenging work. However, despite the intuitive appeal of this idea, there is little evidence that working directly on changing students' grit or perseverance would be an effective lever for improving their academic performance. While some students are more likely to persist in tasks or exhibit self-discipline than others, *all* students are more likely to demonstrate perseverance if the school or classroom context helps them develop positive mindsets and effective learning strategies. In other words, the mechanisms through which teachers can lead students to exhibit greater perseverance and better academic behaviors in their classes are through attention to academic mindsets and development of students' metacognitive and self-regulatory skills, rather than trying to change their innate tendency to persevere. This appears to be particularly true as adolescents move from the middle grades to high school, and it again becomes important in the transition to college.

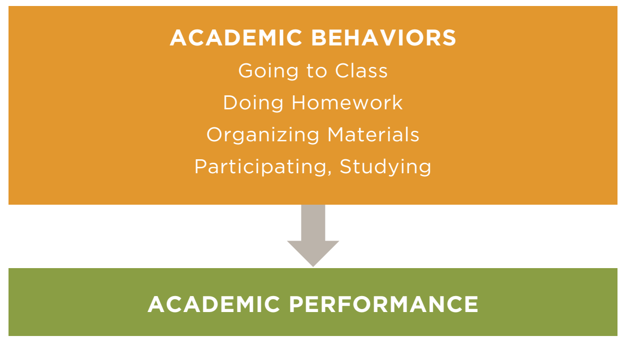
CHAPTER 2

Five Categories of Noncognitive Factors

Five General Categories of Noncognitive Factors Related to Academic Performance:

1. ACADEMIC BEHAVIORS
2. ACADEMIC PERSEVERANCE
3. ACADEMIC MINDSETS
4. LEARNING STRATEGIES
5. SOCIAL SKILLS

1. Academic Behaviors

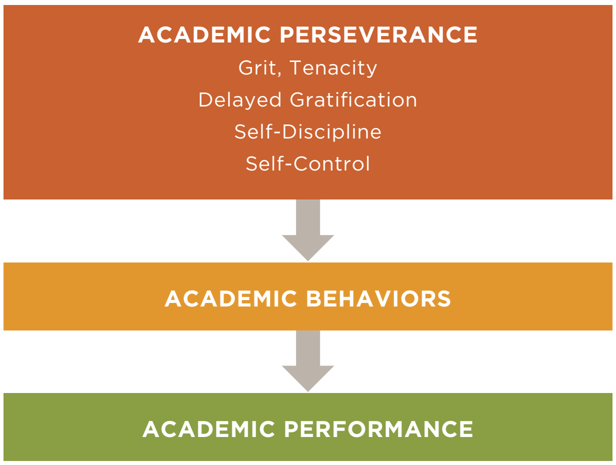


What does it take for students to graduate from high school, go to college, and persist to earn a degree? The list of potential answers to this question is long and extends far beyond content knowledge and academic skills. The noncognitive factors we considered for this review included: persistence, resilience, grit, goal-setting, help-seeking, cooperation, conscientiousness, self-efficacy, self-regulation, self-control, self-discipline, motivation, mindsets, effort, work habits, organization, homework completion, learning strategies, and study skills, among others. We pushed to clarify the meanings of a number of loosely defined concepts and to reconcile disparities between researchers from different disciplinary backgrounds (economists, psychologists, sociologists) who occasionally used different terms for similar constructs or the same terms to describe concepts that were measured quite differently. To synthesize the vast array of research literature on each of these concepts, we organized the wide range of traits, skills, behaviors, and attitudes into categories of similar constructs. We then created a conceptual framework, using empirical research and theory to hypothesize the relationships among categories and the relationship of each category to student academic performance. We describe each of the five categories briefly below, followed by a systematic review in the subsequent chapters of the quality of the research evidence in each category.

Academic Behaviors are those behaviors commonly associated with being a "good student." These include regularly attending class, arriving ready to work (with necessary supplies and materials), paying attention, participating in instructional activities and class discussions, and devoting out-of-school time to studying and completing homework. It is easy to see how these behaviors would directly relate to how well one does in a class. We start here in reviewing the relationship of noncognitive factors to academic performance because academic behaviors are most proximal to one's performance in school. Academic behaviors are the visible, outward signs that a student is engaged and putting forth effort to learn. Because they are observable behaviors, they are also relatively easy to describe, monitor, and measure. Academic behaviors are quite often an outcome of interest in evaluating interventions designed to improve students' school performance. Many programs, policies, and even curricula could reasonably be considered effective if they lead to an increase in student attendance, homework completion, studying, or class participation.

Academic behaviors are extremely important for achievement; we will show that virtually all other noncognitive factors work *through* academic behaviors to affect performance. We will return to this point in our review of academic perseverance, academic mindsets, learning strategies, and social skills, but it is hard to imagine how noncognitive factors could improve student performance *without* working through the classroom behaviors that directly shape academic performance. Chapter 3 provides a summary of the research on academic behaviors.

2. Academic Perseverance



Academic Perseverance describes a set of psychological concepts with a long research history. Broadly, academic perseverance refers to a student's tendency to complete school assignments in a timely and thorough manner, to the best of one's ability, despite distractions, obstacles, or level of challenge. However, evaluating the literature on the range of concepts under our catch-all heading of "academic perseverance" proved challenging. To persevere academically requires that students stay focused on a goal despite obstacles (grit or persistence) and forego distractions or temptations to prioritize higher pursuits over lower pleasures (delayed gratification, self-discipline, self-control). Academic perseverance is the difference between doing the minimal amount of work to pass a class and putting in long hours to truly master course material and excel in one's studies. While academic perseverance is—by definition—a critical factor for students' long-term educational attainment and is often the explicit goal of the growing focus on noncognitive factors, the literature that falls under the umbrella of perseverance is not conclusive in its implications for educational practice or its generalizability to a broad range of students. Chapter 4 provides a summary of the research on academic perseverance.

3. Academic Mindsets

Academic Mindsets are the psycho-social attitudes or beliefs one has about oneself in relation to academic work. Positive academic mindsets motivate students to persist at schoolwork (i.e., they give rise to academic perseverance), which manifests itself through better academic behaviors, which lead to improved performance. There is also a reciprocal relationship among mindsets, perseverance, behaviors, and performance. Strong academic performance "validates" positive mindsets, increases perseverance, and reinforces strong academic behaviors. Note that this reciprocal, self-perpetuating system also works in a negative loop. Negative mindsets stifle perseverance and undermine academic behaviors, which results in poor academic performance. Poor performance in turn reinforces negative mindsets, perpetuating a self-defeating cycle.

A long history of psychological research undergirds the concept of academic mindsets. This includes foundational work in goal theory (Dweck, 1986; Dweck & Leggett, 1988); social learning theory (Bandura, 1977; Rotter, 1954); attribution theory (Weiner, 1979); expectancy-value theory (Eccles, Adler, Futterman, Goff, Kaczala, Meece, & Midgley, 1983); and the concepts of self-efficacy (Bandura, 1986) and locus of control (Rotter, 1954). Psychology research has also addressed the way context and experience can undermine positive academic mindsets, such as the theories of learned helplessness (Seligman & Maier, 1967) and stereotype threat (Steele, 1997; Steele & Aronson, 1995). In Chapter 5 we review the literature on the relationship of four academic mindsets to academic performance, as well as the effects of learned helplessness and stereotype threat. Each of the four academic mindsets is briefly described here.

1. I belong in this academic community. The first mindset involves a sense that one has a rightful place in a given academic setting and can claim full membership in a classroom community. Educational theorists have long held that learning is a social activity and that understanding is constructed through interaction with others (Dewey, 1958; Vygotsky, 1978). Accordingly, students need to feel as though they belong to a community of learners and that their academic self is a "true" self (Harvey & Schroder, 1963; Oyserman, Bybee, & Terry, 2006). A long line of research evidence shows that having a sense of belonging in a school or classroom improves a student's academic performance.

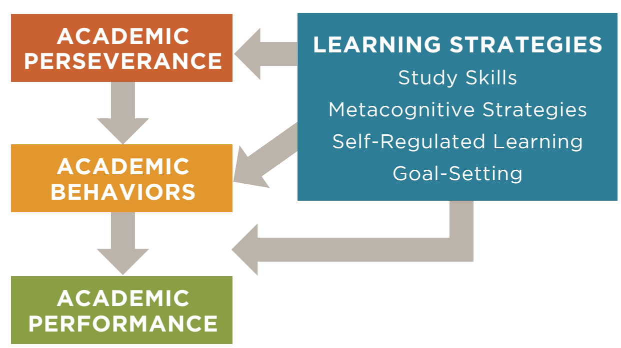
2. My ability and competence grow with my effort. The second mindset rests on the belief that one's academic ability can improve in response to one's efforts, rather than being fixed at a given level and outside of one's control. Notably, across the empirical literature, one's beliefs about intelligence and attributions for academic success or failure are more strongly associated with school performance than is one's actual measured ability (i.e., test scores).

3. I can succeed at this. A third mindset that impacts the degree to which students persevere in academic work and exhibit strong academic behaviors relates to beliefs about their abilities to succeed at a given task. Individuals tend to engage in activities that they feel confident in their ability to complete and to avoid those in which they lack such confidence (Bandura, 1986).

4. This work has value for me. A fourth mindset involves a student's sense that the subject matter he or she is studying is interesting and holds value. Value can be variously defined as the importance of doing well on a task (attainment value); gaining enjoyment by doing a task (intrinsic value); or serving a useful purpose or meeting an end goal that is important by completing a task (utility value) (Eccles et al., 1983).

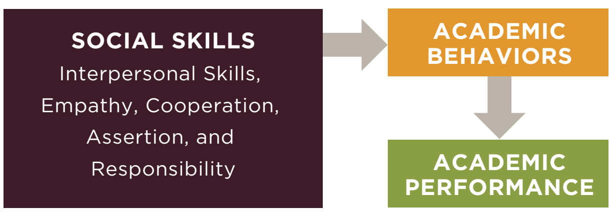
Overall, the evidence clearly demonstrates that the four academic mindsets outlined above each increase students' academic perseverance and improve academic behaviors, leading to better performance as measured by higher grades. When a student feels a sense of belonging in a classroom community, believes that effort will increase ability and competence, believes that success is possible and within his or her control, and sees school work as interesting or relevant to his or her life, the student is much more likely to persist at academic tasks despite setbacks and to exhibit the kinds of academic behaviors that lead to learning and school success. Conversely, when students feel as though they do not belong, are not smart enough, will not be able to succeed, or cannot find relevance in the work at hand, they are much more likely to give up and withdraw from academic work, demonstrating poor academic behaviors which result in low grades. Concepts such as stereotype threat and learned helplessness rest upon the same theoretical underpinnings and illustrate ways that positive academic mindsets can be undermined by negative contextual conditions or experiences, thus interfering with students' academic performance. Chapter 5 provides a summary of the research on academic mindsets.

4. Learning Strategies



Learning Strategies are processes and tactics one employs to aid in the cognitive work of thinking, remembering, or learning. Effective learning strategies allow students to leverage academic behaviors to maximize learning. These include strategies to help one recall facts (e.g., mnemonic devices); strategies for monitoring one's own comprehension (such as while reading or doing math problems); and strategies to self-correct when one detects confusion or errors in one's thinking. Learning strategies may also include goal-setting and time management, both of which help students manage the process of learning. Unlike the research on other noncognitive factors, which comes primarily from economists, motivation researchers, or developmental and social psychologists, the research on learning strategies also draws on work in cognitive science. Helping students to learn effectively is an area of research that bridges academic behaviors (e.g., studying), subject-specific cognitive domains of learning (e.g., understanding how to divide fractions in mathematics), metacognition, and self-regulated learning processes. Chapter 6 provides a summary of the research on learning strategies.

5. Social Skills



Social Skills are a fifth group of noncognitive factors which includes such interpersonal qualities as co-operation, assertion, responsibility, and empathy. Social skills are acceptable behaviors that improve social interactions, such as those between peers or between student and teacher. Social skills repeatedly appear in the literature as important for future work and life outcomes, although their direct relationship to academic performance is more tenuous.

Development of students' social skills has long been a focus of early childhood and elementary educators. In the primary grades, educators aim to develop students' social skills to enable them to work with peers and adults to accomplish academic goals. More recently, social skills have gained increasing attention as a critical factor for adolescents in connection with career readiness. Research has suggested that employers in the twenty-first century economy need workers with "people skills" that enable them to communicate effectively, work with diverse groups, and solve problems collaboratively (Casner-Lotto, Barrington, & Wright, 2006; Murnane & Levy, 1996). While the development of social skills may be an important educational goal in itself, particularly in the primary grades, social skills are also logically related to academic performance. For example, it stands to reason that cooperating in groups or participating appropriately in class discussions would lead to better academic performance. Perhaps social skills have a weak direct relationship with course grades because many classrooms—particularly at the high school level—still tend to rely on lecture-style instructional delivery which minimizes the social and cooperative aspects of learning. In contexts where individuals must work collaboratively in problem-solving teams, social skills are likely to be more directly related to performance.

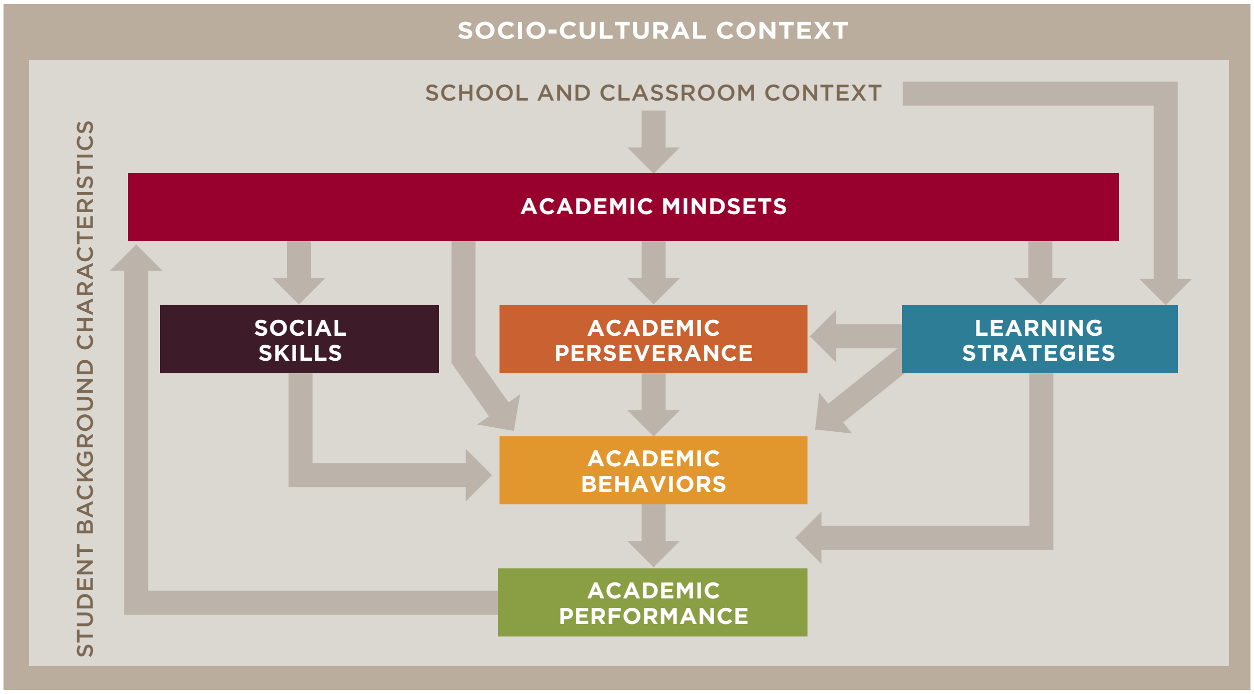
As with our other noncognitive factors, most of the research and theory behind the development of social skills suggest that their effects on academic performance are largely indirect; they are enacted through students' behaviors in the classroom. Thus, we conceptualize social skills as affecting academic performance primarily by affecting academic behavior. Chapter 7 provides a summary of the research on social skills.

Putting Noncognitive Factors into One Framework

In reviewing the literature on these five noncognitive categories, we tried to conceptualize the relationships among factors as well as the relationship of each factor to academic performance, as measured by grades. **Figure 2.1** illustrates our working understanding of these relationships, although, as our review will make clear, much more research is needed to test the relative strengths of the paths in this model, the importance of each category controlling for the others, and the ways they interact. We anticipate that many noncognitive factors are mutually reinforcing and that relationships are often reciprocal. We used one-way arrows to illustrate the strongest hypothesized effect of each category on academic performance, but we anticipate that students' academic performance, in turn, will very likely affect their behaviors, their mindsets, their social interactions, and perhaps even their use of learning strategies. While the actual relationships among these factors are no doubt messier and more complex than indicated in the illustration, our review of the research suggests support for the ordering displayed in the model. For example, mindsets have been shown to affect academic perseverance, which

FIGURE 2.1

A Hypothesized Model of How Five Noncognitive Factors Affect Academic Performance within a Classroom/School and Larger Socio-Cultural Context



affects academic behaviors (e.g., completing work), which affects students' academic performance.

Importantly, as seen in the diagram, we set the noncognitive factors model within a "School and Classroom Context." Any given school and classroom context will reflect a wide variety of variables affecting student motivation and opportunity to learn. For example, how supports are made available and to whom, grading structures and policies, available course tracks, the ways students are assigned to those tracks, the nature of the academic tasks students are asked to do, the relationships among student peers and their orientation toward academic work, the level of safety one experiences in school, and the availability of adequate resources for learning are all important parts of any school and classroom context. Some of these variables—e.g., grading structures, feedback, and norms of behavior—are quite proximal to students' course performance and have been shown to affect academic mindsets, academic behaviors, and/or academic performance.

Note that the school and classroom context box also includes the presence of "Student Background Characteristics." For simplicity's sake, our noncognitive factors model does not specifically illustrate how these individual characteristics are related to other factors, but we assume student background would affect virtually every aspect of the model. Student background would include all the individual characteristics a student brings to a learning situation. These include demographic variables such as race/ethnicity, age, gender, language, and socio-economic status, as well as family and neighborhood characteristics that might affect academic performance. A student's previous academic achievement (including both grades and test scores), prior knowledge, past experiences in school, and pre-existing academic mindsets are also part of his or her background characteristics. These individual academic characteristics have likely coalesced in a particular "academic identity" and degree of self-efficacy within the student, whether these are positively or negatively charged. We would anticipate that the student's previous schooling experiences and existing academic mindsets would affect his or her interpretation of any new classroom or academic work encountered. In this way, student background characteristics are very likely to mediate the relationships among the classroom context; the student's further development or enactment of noncognitive skills, behaviors, attitudes, and strategies in that classroom; and academic performance. We note too that classrooms consist of multiple individual students, creating peer effects as well as individual student effects.

Finally, we situate the model within a larger "Socio-Cultural Context" that shapes the structural mechanisms of schools and classrooms, as well as the interactions and subjective experiences of the human beings within schools. Opportunity structures in the larger society; economic conditions that shape employment opportunities as well as schooling costs; the presence of racism, sexism, and other types of discrimination that give rise to stereotypes and prejudice; and stark inequalities in resources across neighborhoods and schools all contribute to the larger context in which American students learn. The interrelationships between cognitive, psychological, and structural variables and school performance are exceedingly complex. We offer this model as a simplified framework for conceptualizing the primary relationships among these factors, for the purpose of framing our discussion.

The next five chapters provide more detailed evidence on each of the five noncognitive factors in the model. In Chapter 8, we offer three case studies to illustrate how these noncognitive factors interact to affect students' success during specific periods of academic development: in the middle grades, the transition to high school, and the transition to college. The case studies underscore the importance of context when considering the relationship between noncognitive factors and students' academic performance.

BOX 2.1

How We Organized Our Review of the Evidence

The next five chapters review the research on each of the five categories of noncognitive factors. For each set of factors, we first want to know about its relationship to academic performance (course grades). Does the research suggest that having more of a particular factor is related to getting better grades? If multiple factors affect grades, we want to know which factors are most important because we want to know which leverage points are likely to have the biggest payoff. What are the relative effect sizes, and where are we likely to get more "bang for the buck" if we want to improve student performance? Therefore, the first and most obvious criterion for judging the state of research knowledge in a field is to evaluate the quality of the existing research and the strength of effects.

But even if a set of noncognitive factors is clearly related to academic performance, that does not mean that educators or policymakers can do anything to leverage that fact. Validating the claim that schools would get high payoffs from working on noncognitive factors requires an evaluation of whether the supporting evidence is "actionable" for practitioners. To evaluate whether the research evidence is actionable, we ask whether it is clear that the relevant noncognitive factor is malleable (i.e., do we know it can be changed), whether it is affected by classroom context (i.e., do we know that teachers can change it), and whether there are research-based strategies for developing that factor (i.e., do we know how teachers can change it through classroom practice).

A critical tension in research on noncognitive factors is the question of which factors can be intentionally developed and which are traits or dispositions that either are not malleable or are not likely to be changed by schools. Even when certain noncognitive factors are shown to be malleable and are shown to be related to academic performance, it does not necessarily follow that teachers would be able to change the factor to improve student performance. Much of the existing research on noncognitive factors is correlational (merely showing a relationship between two factors) rather than causal; this makes unclear the extent to which particular factors can be intentionally developed in classroom and school contexts, as well as whether changing them would actually improve student performance. For example, evidence that students who report high levels of self-control have higher grades than students who report lower levels of self-control does not demonstrate that the latter group of students would start earning higher grades if they were to increase their self-control. Nor does evidence of a correlation between self-control and course performance provide any guidance to teachers on how they might improve students' self-control.

It is therefore not enough for researchers to merely *identify* factors associated with better academic performance. That is a first step, but teachers and administrators also need clear research evidence about *how and why* various factors influence student performance. Then they need a set of strategies designed for use in a classroom context, aligned with their regular instructional work, to address these factors in ways that are consistent with the research. Ideally, practitioners would also have a way to track change or growth in the targeted factor to assess whether their strategies are having an effect.

Experimental studies using randomized trials, when properly designed, can yield data on both malleability and causality. For instance, researchers might show that an intervention is effective both at getting students to increase their effort and at improving their grades in class. But the *mechanism* by which these changes happen is often unclear. In much of the research we review in this report, the experiments inadvertently create a "black box" in which the actual mechanisms of change cannot be observed, leaving teachers with little understanding of why a particular intervention worked and what it implies for their practice.

For research on noncognitive factors to be actionable for practice, then, we have to go beyond merely establishing which factors contribute to students' academic performance. We must also ask questions about malleability, the role of classroom context, and the availability of clear strategies that teachers can use to develop important noncognitive factors. By "classroom context," we are referring broadly to everything about a classroom that might influence student performance. This includes the teacher, curriculum, instructional practices, materials and resources, classroom policies, grading practices, behavior of peers, and all social and academic interactions that take place during a class period. All of these factors can influence whether or not students develop or choose to enact any of the five categories of noncognitive factors, in addition to affecting the development of students' content knowledge and academic skills.

Beyond this attention to classroom context in a broad sense, we are also interested in whether or not there are specific classroom-based strategies that teachers can use to intentionally support students' development of noncognitive factors. For example, if a high school teacher wants to help her students develop learning strategies to use while studying geometry, what ought she to do? How can a middle school teacher best develop students' homework habits? What specifically can college instructors do to help students place a higher value on the work they do in class? It is not enough to merely know that classroom contexts have an influence on noncognitive factors. Teachers also need to understand *how* these influences work and to have specific strategies to develop students' academic behaviors, perseverance, mindsets, learning strategies, or social skills directly as part of their day-to-day work in the classroom.

Finally, we also want to examine the evidence on whether attention to any particular set of factors could make a difference in reducing educational inequality. One of the most significant claims of the research on noncognitive factors is that gaps in school performance by race/ethnicity or gender could be reduced by focusing on certain noncognitive factors. Unfortunately, researchers often ascribe observed differences in students' grades and educational attainment to gaps in underlying noncognitive factors without actually measuring these factors or establishing that there are group-based differences in these factors. By accurately measuring noncognitive factors such as homework completion or self-efficacy across race/ethnicity or gender, researchers can start to pinpoint what factors might be contributing to existing achievement gaps. In this report, we examine whether claims that certain noncognitive factors could reduce gaps in student academic performance are supported by evidence that these factors are contributing to the gaps in the first place.

To accomplish the goals described above, we structure our review of the research in each chapter to address five key questions:

1. What is the relationship of each factor to student academic performance?
2. Is the factor malleable?
3. What is the role of classroom context in shaping the factor?
4. Are there clear, actionable strategies for developing the factor as part of classroom practice?
5. Is there evidence that attention to the noncognitive factor would address racial/ethnic or gender gaps in student achievement?

Evidence on Academic Behaviors

Academic Behaviors occupy an important place in our consideration of noncognitive factors because virtually *all* the ingredients that go into students' academic performance, whether cognitive, noncognitive, or metacognitive, are expressed *through* their academic behaviors. Academic behaviors such as completing class assignments and participating in classroom activities are how students develop and demonstrate their content knowledge and academic skills. Conversely, if a student thoroughly masters the material in a course but does not turn in homework or does not come to school to take a test, the teacher would be unable to judge what the student knows or is capable of doing. Behavior acts as a mediator of other cognitive and noncognitive factors to affect students' grades (Conrad, 2006). This is borne out by evidence as well as by theory.

What Is the Relationship Between Academic Behaviors and Academic Performance?

There is a great deal of evidence that academic behaviors play a central role in determining students' grades. For example, in one CCSR study, Allensworth and Easton (2007) looked closely at academic behaviors and their relationship to course grades and course failures for CPS ninth-graders. While students' prior test scores and background characteristics, such as gender, race/ethnicity, economic variables, school mobility, and age at entry into high school, together only explained 12 percent of the variation in ninth-grade course failures, students' absences and self-reported study habits explained an additional 61 percent of the variation in ninth-grade failures. In the Chicago study, attendance and studying not only strongly predicted course failures but also were the strongest predictors for getting high grades—more so than test scores or student background characteristics.

The single most important academic behavior may well be attending class. Attendance has a strong effect on students' academic performance, and this relationship holds true regardless of students' test scores. Moreover, small differences in attendance can have large impacts on students' grades. The lowest-achieving students entering high school in Chicago (those with eighth-grade test scores in the lowest national quartile) who had less than a week of absences per semester passed more of their ninth-grade courses than students who entered high school with test scores in the top quartile but who missed just *one more week* of class (Allensworth & Easton, 2007). The exact mechanisms whereby attendance exerts such strong effects on grades are unclear, and it may well be that different mechanisms are at work in different cases. Obviously students who are not in class do not benefit from lesson activities or instruction that they miss; this could create potential "holes" in their understanding that might impact subsequent course grades. Common teacher grading practices can also deal a strong blow to absent students' grades by disproportionately penalizing missing work. Critics have long argued for "no zero" policies to lessen the impact of late or missing assignments on students 'course grades, and several schools and districts have passed policies to that effect (e.g., Ashland SD, 2012; Dallas ISD, 2008; Pittsburgh Public Schools, 2009). Extended or repeated absences and truancy can indicate other problems interfering in an adolescent's education that would affect both attendance and course performance. But even where there are no apparent underlying issues, attendance has a stronger effect on grades and is more predictive of course failure than are students' test scores.

Beyond attending class, spending time on homework is another academic behavior shown to have a positive effect on students' grades in both middle school and high school (Cooper, 1989; Keith et al., 1993; Peng & Wright, 1994). Using a large, nationally representative sample of over 20,000 high school seniors from the High School and Beyond study, Keith (1982) conducted a path analysis and found that time spent on homework had a significant positive effect on grades across achievement levels, controlling for race, background, ability, and field of study (college preparatory versus vocational). Furthermore, Keith demonstrated a compensatory effect of homework; students who scored in the bottom third on achievement tests and spent one to three hours per week on homework were able to raise their grades to Bs and Cs, equivalent to students with test scores in the middle one-third who did not do homework. If the students with test scores in the bottom third spent over 10 hours per week on homework, they could raise their grades to mostly Bs, which was equivalent to the grades of top-scoring students who did not do homework.[3] A meta-analysis (Cooper, 2006) evaluating a range of homework studies in different contexts found that virtually all demonstrated positive and significant relationships between homework and grades.

Academic behaviors can affect grades both directly and indirectly. Directly, virtually all student grades are based on student work, and completing and submitting work are academic behaviors. One might argue whether or not the content and substance of the work should (or does in practice) account for a higher proportion of a student's grade than merely the act of submitting the work, but it is important to remember that in the *absence* of submitting work and attending class, a student will fail the course. In other words, while good academic behaviors might combine with content knowledge and academic skills to earn passing grades, poor academic behaviors all by themselves can earn failing grades. Academic behaviors can also affect grades directly if teachers award points to students specifically for the acts of completing assignments, participating in activities, or even attending class.

Academic behaviors can have an indirect influence on grades as well if, as a result of engaging in the academic behaviors, students complete higher-quality work or simply learn more content and develop more skills. Students who attend class regularly and do all of their homework are likely to know more or be able to do more as a result—which would contribute to earning better grades. Indeed, across several studies, time spent on homework had a positive effect on learning as measured by both grades *and* achievement test scores (Keith, 1982; Keith & Benson, 1992; Keith & Cool, 1992; Keith, Diamond-Hallam, & Fine, 2004; Natriello & McDill, 1986).

Academic behaviors might also affect students' grades indirectly by influencing the nature of student-teacher interactions. Teachers may have preference for students who exhibit positive academic behaviors—teachers may spend more time helping these students or more closely monitor their learning—such that students who demonstrate positive academic behaviors receive a differential instructional benefit that improves their performance in a class.

While it seems logical that attending class, studying, and completing homework will lead to better grades, there are also likely reciprocal effects—where students' success at earning high grades gives them encouragement to continue to work hard. As shown by the psychological research on mindsets, the grades students receive have a marked effect on their attitudes about school and about their own academic identities in ways that strongly influence their subsequent behavior and future school performance. While the nature of the relationships and various pathways between academic behaviors and other noncognitive factors is not yet entirely clear, the connection between academic behaviors and academic performance is strong.

Academic behaviors are so tightly bound up with each of the other noncognitive factors that they are sometimes used by researchers as proxies for these other factors. No one can directly "see" intangible characteristics such as perseverance, motivation, or a sense of belonging, but one can infer their presence or absence by the way a student behaves toward his or her schoolwork (e.g., through students' persistent effort at academic tasks, completing homework assignments, and working well with other students). Many of the studies of unobservable noncognitive factors (such as academic perseverance) are actually based on observable academic behaviors from which these unobservable factors are then inferred. For example, in a study of predictors of performance in introductory college-level courses, Kruck and Lending (2003) used students' early homework grades in the course as a measure of "student motivation or effort." Reasoning that these homework assignments are often optional, the authors concluded that "the more motivated students will do the earlier homework and quizzes and score higher grades than the less motivated students" (p. 10). Similarly, research shows that academic behaviors are largely interpreted by teachers as signs of student "effort." Where students receive a grade for effort, that grade is most often based on the teacher's observation of their academic behaviors (Brookhart, 1994, 2004; Frary, Cross, & Weber, 1993; Marzano, 2000; Nava & Loyd, 1992; Robinson & Craver, 1989; Stiggins, 1997; Stiggins, Frisbie, & Griswold, 1989).

However, the use of observable behaviors like homework completion to infer and measure unobservable noncognitive factors such as motivation or effort conflates what could be very distinct factors (feeling motivated versus doing homework), making it difficult to tease out the relationships between them or to ascertain the ways one factor might influence another to shape student academic performance. Conflating observable and unobservable factors creates the possibility of misdiagnosing poor academic behaviors in any given instance (erroneously attributing them to a lack of perseverance, for example) and makes it difficult to pinpoint the leverage points whereby teachers, parents, or others might intervene to help improve student performance.

Are Academic Behaviors Malleable?

Human behavior generally is viewed as malleable. While it may be difficult to change one's personality or one's core values, a basic tenet of psychology is that it is almost always possible to change one's behavior (Deci & Ryan, 1985; Skinner, 1953; Staats, 1963). Virtually all educational reform efforts rest on this basic assumption. Whether through new policies, programs, structures, supports, curricular materials, or instructional approaches, the premise underlying all efforts to improve schools is that students, teachers, and school leaders can be motivated, mandated, cajoled, or trained to act differently in the classroom. Students' academic behaviors *can* change. The important question is *how* educators can best facilitate these changes in ways that promote student learning and course performance.

What Is the Role of Classroom Context in Shaping Academic Behaviors?

The evidence is quite clear that classroom context shapes students' academic behavior. If we keep in mind that academic behaviors are the medium through which all other cognitive and noncognitive factors are expressed, then it stands to reason that any ways in which classrooms affect any of those cognitive or noncognitive factors could also shape academic behavior. For example, classrooms may affect students' mindsets by creating excitement about an upcoming project. If that excitement translates to more active engagement in and completion of the project, then the classroom context will have affected behavior by working through mindsets. Likewise, if classroom instructional practice helps students develop learning strategies that allow them to derive more tangible benefits from the time they spend studying, they may be more likely to study. If teachers present material in a way that makes it more accessible and students feel like they understand what is going on, students are more likely to engage in classroom discussions. Thus, classroom context shapes academic behavior indirectly through other noncognitive factors, as well as affecting behavior directly through behavioral expectations and strategies.

Are There Clear, Actionable Strategies for Developing Academic Behaviors as Part of Classroom Practice?

There have always existed a wide range of classroom-based and school-wide strategies for improving students' academic behaviors (e.g., increasing attendance, reducing tardiness, bringing materials to class, completing homework, promoting active participation in discussion). These mostly fall into the category of "local practice wisdom," and surprisingly few of these have been empirically studied on a large scale. For example, teachers use a range of strategies to support students in completing homework, such as: providing clear and explicit directions and expectations for assignments; requiring students to write assignments into planners (that schools often provide for this purpose); starting homework assignments in class to "get kids going" and to troubleshoot any problems before students get home; and setting up procedures for students to collect missed work when they are absent. Unfortunately, few of these individual teacher-selected strategies have been rigorously or systematically studied or evaluated.

Still, we do have evidence of the effectiveness of some classroom strategies focused on academic behaviors. Research suggests that academic behaviors such as course attendance and assignment completion can be affected by the degree to which students' performance is closely monitored, with teachers or other adult advocates intervening when students' behavior falls below expectations. CCSR's work in Chicago shows that course attendance and grades are better in schools where teachers provide close monitoring and support for students (Allensworth & Easton, 2007; Allensworth, Sebastian, Gwynne, & Pareja, 2012; Stevens et al., forthcoming).

Several programs external to the classroom that emphasize monitoring and support also have been shown to have positive effects on students' grades and retention in school. For example, programs in which teachers or other adult advocates monitor students' attendance and grades to provide support when students start having problems have been shown to significantly improve students' academic behaviors and performance. Potentially effective school-wide initiatives include student advisories (Galassi, Gulledge, & Cox, 1997; Van Ryzin, 2010) and programs such as Check & Connect and ALAS (Larson & Rumberger, 1995; Sinclair, Christenson, Evelo, & Hurley, 1998). Whole school reform approaches such as the Talent Development High School Model—which houses freshmen in a Ninth Grade Success Academy emphasizing closer student-teacher relationships and additional supports—have also been shown to improve students' academic behaviors as measured by attendance rates, course passing rates, and promotion rates to the next grade level (Kemple, Herlihy, & Smith, 2005).

In short, while teachers and schools utilize a wide range of home-grown strategies to improve students' academic behaviors, few such individual strategies have been formally evaluated by outside researchers on any large-scale basis. Some whole school reform models show effects on students' academic behaviors, but it is unclear which aspects of these comprehensive models were most responsible for changing student behavior. Moreover, short of adopting these models entirely or knowing which aspects of the model to replicate, the whole school reform research provides little clear direction to teachers, other than to emphasize the importance of ongoing monitoring and support—two elements which are also supported by other studies as important to students' academic behaviors.

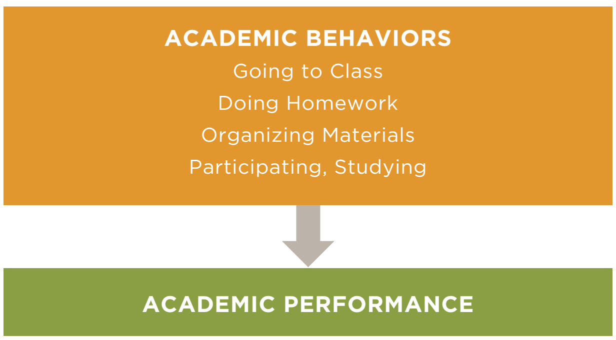
Would Changing Academic Behaviors Significantly Narrow Achievement Gaps?

While some researchers have claimed that differences in academic behaviors contribute to achievement gaps among different racial and gender groups (e.g., Duckworth & Seligman, 2006; Jacob, 2002), these differences only account for a limited portion of existing gaps. In Chicago, CCSR researchers looked at the extent to which students' attendance and study habits contributed to differences in students' grades by race/ethnicity and gender (Allensworth & Easton, 2007). The gender gap in GPA decreased by 21 percent after taking into account students' course attendance and study habits, and differences in failure rates decreased by one-third. Attendance and study habits explained none of the racial gap in grades, when comparing students with similar test scores and economic status. In fact, the racial gap increased once students' study habits were taken into account. African American students received lower grades than White students with similar test scores, attendance, and study habits.

In his analysis of data from over 10,000 students from the National Educational Longitudinal Study (NELS) which followed a nationally representative sample of eighth-graders from 1988 to 1994, Jacob (2002) found a slight gender difference in academic behaviors in eighth grade, when boys reported doing 5.87 hours of homework per week compared to girls who spent 6.21 hours per week on homework (0.34 hours per week difference). That gender difference in behavior decreased to 0.11 hours per week by twelfth grade, with boys and girls reporting weekly homework time of 9.74 hours and 9.85 hours respectively. Jacob did not report homework data by race/ethnicity.

Overall, there is evidence that academic behaviors explain part, but not all, of the gender gap in grades. There is little evidence that academic behaviors explain differences in grades by race/ethnicity, particularly when controlling for test scores and economic status.

Summary of Research on Academic Behaviors



Academic Behaviors are the most proximal noncognitive factors to student academic performance. Virtually all other factors that affect school performance—including content knowledge, academic skills, student background characteristics, and the full range of noncognitive factors—exercise their effect through students' academic behaviors. This suggests that there are multiple indirect pathways to improving academic behaviors (by targeting these other factors) in addition to those strategies that directly target behaviors. There is strong evidence that academic behaviors are a major determinant of course grades and that improving students' academic behaviors would increase students' course performance. There is also strong evidence that academic behaviors are malleable and affected by classroom context, and there are some clear strategies for classroom practice around monitoring and support. However, there is little evidence that working solely on students' academic behaviors would eliminate gaps in course grades by race/ethnicity or gender. Furthermore, given the pivotal role of academic behaviors in academic performance, the number of rigorous studies testing the effects of specific strategies to directly improve students' behaviors is surprisingly small.

CHAPTER 4

Evidence on Academic Perseverance

In Chapter 3, we made the case that academic behaviors are the noncognitive factor that most immediately affects a student's course performance. But high performers in school do not simply *do* the things necessary for good grades, they do them *well*. Academic perseverance is a concept that, in its most basic form, addresses student effort and the resulting *quality* of academic behavior. By quality we refer to the intensity, direction, and duration of a student's academic behavior. An academically perseverant student would behave in an engaged, focused, and persistent manner in pursuit of academic goals, despite obstacles, setbacks, and distractions.

Academic Perseverance requires not only an initial surge of momentum in a focused direction but also the ability to maintain that momentum regardless of what gets in the way. As a result, students with academic perseverance would continue working hard for a good grade in a challenging class even after failing several tests, and they would continue looking for new ways to understand difficult material instead of giving up. Academically perseverant students also would be more likely to achieve longer-term academic goals, such as earning consistently high grades over time, graduating from high school with a good GPA, qualifying for and getting admitted to a desired university, or completing a college degree. In essence, academic perseverance represents a desirable quality of academic behavior that seems essential for both short-term and long-term educational achievement and degree attainment.

The concept of "academic tenacity" has gained recognition in recent years as an important factor underlying students' academic performance. As it has been defined, however, this term incorporates a range of noncognitive factors that are conceptually quite distinct. In a working paper commissioned by the Gates Foundation, one of the most widely cited manuscripts on the topic, academic tenacity is defined as the "mindsets and skills that allow students to look beyond short-term concerns to longer-term or higher-order goals, and to withstand challenges and setbacks to persevere toward these goals" (Dweck, Walton, & Cohen, 2011, p. 5). This definition not only encompasses whether students work hard or see work through to completion despite obstacles but also incorporates the factors that affect perseverance—the mindsets and skills that underlie student persistence. Specifically, according to this expanded definition, whether or not students display tenacity can be affected by their academic mindsets (which encourage or inhibit continuing effort), their academic skills (which make it easier or harder to complete tasks), whether they have learning strategies (which make their efforts more effective), and their innate personality. While there is strong evidence that these factors are associated with academic perseverance, there are reasons for keeping them conceptually distinct from the degree to which one persists in academic work. As educators think about how to improve students' academic performance, they need to understand the specific mechanisms through which they can affect change in the degree to which students persist at tasks. Thus, we ultimately found it most helpful to separate out the demonstration of perseverance from the factors—such as mindsets—that influence it.

Even when we distill academic perseverance to center on the idea of persistent effort in school, the psychological literature identifies various kinds of persistence, each with potentially different implications for improving students' academic performance. In this review, we focus on two related concepts: "grit"—the degree to which students stay focused on a long-term goal despite obstacles; and self-control—whether students forego short-term temptations to prioritize higher pursuits (related to delayed gratification and self-discipline).

Grit and Self-Control

The idea of "grit," from University of Pennsylvania researcher Angela Duckworth, is one conception of perseverance that has gained much attention in the popular press. *The New York Times Magazine* recently ran a cover story on the importance of "character" to school and career success which prominently featured Duckworth's research (Tough, 2011). Another conception of perseverance is captured by the concept of self-discipline or self-control, and the related idea of delayed gratification. As we asked our five framing questions of the research on grit and on self-control, we found that these two sets of literature sometimes produced very different answers, with potentially different implications for classroom practice. In reviewing this work, we rely heavily on the work of Duckworth and her colleagues; she has been the most prolific researcher developing and studying these concepts over the last several years, and it is her work that is generally cited in this area.

Grit is how world-class performers and high achievers—whether musicians, athletes, doctors, actors, inventors, or business leaders—get to the top of their game. In a TED talk in 2009, Duckworth emphasized that it takes at least 10 years of sustained practice to truly become an expert in any given field (Duckworth, 2009). Grit is what allows a select group of people to sustain that effort. Duckworth, Peterson, Matthews, and Kelly (2007) refer to grit as "perseverance and passion for long-term goals" (p. 1087). They emphasize this *long-term* quality, noting that "gritty" individuals will work steadfastly on one significant goal over a prolonged period. Grit, they argue,

> …entails working strenuously towards challenges [and] maintaining effort and interest over years despite failure, adversity, and plateaus in progress. The gritty individual approaches achievement as a marathon; his or her advantage is stamina. Whereas disappointment or boredom signals to others that it is time to change trajectory and cut losses, the gritty individual stays the course. (pp. 1087-1088)

Duckworth and colleagues developed the Grit Scale, a 12-item self-report questionnaire, to measure what they saw as the two distinct dimensions of grit—consistency of interests and persistence of effort. Importantly, the Grit Scale was designed to identify a trait that was not specific to or dependent upon any given context but rather that would characterize an individual's general tendency to persist in pursuit of important long-term goals over several years duration. Gritty individuals are those who strongly endorse statements like "I am a hard worker," "Setbacks don't discourage me," and "I have achieved a goal that took years of work," and who dismiss as "not like me" statements such as "My interests change from year to year," "I become interested in new pursuits every few months," and "I often set a goal but later choose to pursue a different one" (Duckworth, Peterson, Matthews, & Kelly, 2007). Based on studies that link students' responses on the Grit Scale to later educational outcomes, Duckworth et al. conclude that grit "is essential to high achievement," over and above the contributions of intelligence and ability (p. 1088).

Duckworth and her colleagues draw a distinction between grit and self-control, conceptualizing self-control as the ability to avoid impulsive behavior and fulfill *short-term* obligations (Duckworth, Peterson, Matthews, & Kelly, 2007). Tied to self-control is the ability to delay gratification, because part of self-control involves resisting temptations to veer from one's course and being able to put off treats or rewards until one meets a goal or finishes a task. Self-control is largely a matter of making choices of one thing over another in the short term. Duckworth and Seligman (2006) give examples of how students might exhibit self-control in school-related situations by engaging in behaviors such as "reading test instructions before proceeding to the questions, paying attention to a teacher rather than daydreaming…choosing homework over TV, and persisting on long-term assignments despite boredom and frustration" (p. 199). The researchers reason that grit and self-control—as measures of long-term and short-term goal pursuits, respectively—could well have differential effects on academic performance. Where course grades require an ongoing series of small exercises of self-control (to overcome "hourly temptations"), educational attainment (e.g., a college degree) may well be more dependent on long-term persistence over years.

In multiple studies, Duckworth and colleagues sought to identify noncognitive factors that distinguished the very top performers among other high-achieving peers in a variety of contexts: West Point military academy, the Scripps National Spelling Bee, the University of Pennsylvania undergraduate psychology department, and a private preparatory school. The researchers were interested in two related questions: In elite settings, what besides intelligence or talent sets apart certain "exceptional individuals" who distinguish themselves as the best of the best? And what accounts for the difference between highly intelligent people who are high achievers and highly intelligent people who are not? The researchers wanted to understand if either grit or self-control helped to explain extraordinary achievement. Unfortunately, because these studies are focused on understanding variables that affect outstanding achievement among groups of high achievers, their findings cannot easily be generalized to broader populations. Still, their findings of relationships between grades and grit or self-control suggest that academic perseverance—however defined—does contribute to academic performance among students with strong academic skills.

What Is the Relationship Between Academic Perseverance and Academic Performance?

A number of studies have examined the relationship between academic perseverance—whether defined as grit or self-control—and educational outcomes. Two pertinent studies examined the relationship between college students' grades and their grittiness as measured on Duckworth's Grit Scale. In a relatively small sample of undergraduates at the University of Pennsylvania ($n = 139$), when controlling for SAT scores, grit was associated with college GPAs ($r = 0.34$), roughly equivalent to the association between GPA and SAT scores ($r = .30$). Interestingly, the students with higher grit scores tended to have higher GPAs but lower SAT scores than their less gritty peers, suggesting perhaps that what students lack in tested achievement they can make up for in grit or, alternatively, that students who score higher on tests are also more able to achieve high grades without as much dependence on grit. One should be cautious in drawing conclusions from these findings, however. The average SAT score of students in the University of Pennsylvania study was 1415, a score achieved by less than 4 percent of SAT test-takers nationally (Duckworth, Peterson, Matthews, & Kelly, 2007). It is unclear if the relationship they observed between grit and grades would hold with a more heterogeneous student population in a less elite context.

In the University of Pennsylvania study, grit was measured during the fall term and students reported their cumulative GPA at the same time; thus, the relationship between these measures could have been overstated if students' college performance at that time point influenced their self-reports of grit. Students who knew they were doing well in school (as evidenced by their grades) may have rated themselves more favorably as a result of this knowledge, while students who knew they were performing poorly may have rated themselves more harshly when completing the Grit Scale. A study by the same researchers of military cadets at West Point was longitudinal, with new cadets completing the Grit Scale upon entrance to the military academy. A year later, their grit scores were used to predict grades. In the West Point study, the observed relationship between grit and grades was much smaller than at Penn, although still significant ($r = 0.06$), suggesting that while grit measures might correlate highly with current grades, they may not be as strong a predictor of future academic performance (Duckworth, Peterson, Matthews, & Kelly, 2007).

In the West Point study, the researchers also tested the effects of self-control. They found a stronger relationship between grades and self-control (based on student reports on a self-control scale) than between grades and grit ($r = 0.13$ versus $r = 0.06$; Duckworth, Peterson, Matthews, & Kelly, 2007). The Brief Self-Control Scale (BSCS; Tangney, Baumeister, & Boone, 2004) includes items such as, "I am good at resisting temptation," "I have a hard time breaking bad habits," and "I do certain things that are bad for me, if they are fun," to which students respond on a five-point scale from "not at all like me" to "very much like me" (p. 323).

In a similar study of eighth-grade students at a selective magnet school, Duckworth and Seligman (2005) found self-control measures collected in the first semester—including students' self-reports of impulsiveness and self-control, combined with teachers' and parents' reports of students' self-control (e.g., ability to get things done, follow instructions)—added to the prediction of second semester grades beyond test scores and first semester grades alone (Beta = 0.08). They found a very high correlation between reports on students' self-control and grades (0.55 to 0.67), without controlling for prior semester grades. However, while the study used self-control reports from one point in time (semester 1) to predict grades in another point in time (semester 2), the context remained constant across time. At both time points, students were enrolled in the same school and were taking the same classes. This makes it impossible to disentangle the effects of the context on students' performance from the effects of their self-control or the effects of context on their ratings of self-control.

Thus, while there are studies that show relationships between grit or self-control and students' grades, these findings tend to be stronger when both dependent and independent variables are measured concurrently. When grit or self-control is measured before students have engaged in much of the coursework on which their grades are based, these measures show smaller relationships with (subsequent) performance. This suggests that the strong relationships in the cross-sectional analyses may occur because students' perceptions of their grit and self-control may be affected by their concurrent course performance. More research is needed that examines the relationship of various measures of perseverance with performance in a causal way—with perseverance measured prior to enrollment in courses and without questions on the scale that elicit responses that might be influenced by that performance.

Another series of studies that is often cited to emphasize the importance of self-control for academic achievement comes from an experiment conducted by Walter Mischel and colleagues, sometimes referred to as the "marshmallow" experiment (Mischel & Mischel, 1983; Mischel, Shoda, & Peake, 1988; Shoda, Mischel, & Peake, 1990). In this experiment, children at the Stanford University preschool were left alone with one marshmallow after being told they could have two marshmallows if they waited to eat the one until the experimenter returned. Follow-up studies showed a relationship between waiting for the second marshmallow and higher SAT scores many years later (Shoda, Mischel, & Peake, 1990).

While this study has been used to suggest that self-control in early childhood predicts later academic achievement, Mischel and colleagues found that wait time was only associated with later achievement under particular conditions. When the marshmallow was put in plain sight—which made it difficult for children to avoid thinking about it—and when the children were not given strategies for distracting themselves from thinking about the marshmallow, then Mischel saw differences in wait time that were later associated with higher SAT scores. Mischel's interpretation was that children who could wait longer for the second marshmallow were those with stronger cognitive skills; their higher cognitive skills in preschool allowed them to come up with their own means of distracting themselves while in full view of the marshmallow. The fact that they showed higher SAT scores many years later suggests that this interpretation was correct. However, the message from these studies is not necessarily that self-control predicts higher intelligence but that higher intelligence may make it easier to show self-control.

While the experiment does not provide evidence that self-control leads to better test scores independent of the effects of students' initial intelligence levels, it does provide evidence that whether children exhibit self-control depends on *context* (e.g., whether the marshmallow is in plain sight or not), and on whether the children are given *strategies* that allow them to complete a task successfully (i.e., distraction strategies provided by the experimenter), as well as on children's *cognitive skills* (i.e., whether they can come up with ways to distract themselves). Thus, while students may have different innate levels of perseverance as a personal trait, the degree to which they demonstrate *behavior* that appears perseverant depends on the context they are in and the skills and strategies that they possess, all of which can alter the difficulty level of the task in front of them.

Is Academic Perseverance Malleable?

To a large extent, the malleability of academic perseverance depends on how one defines perseverance. There is a great deal of evidence that students' persistence at tasks, and the degree to which they exhibit self-discipline, changes over time and in different situations. A person who appears perseverant in a particular setting with a particular task might appear unmotivated or half-hearted in another setting with another task. Moreover, changes in classroom context or in the psychological condition of students have been associated with an increase in persistent effort by students. This suggests that perseverance is malleable and responsive to context.

The concept of grit, however, was designed to be consistent across time and context. Duckworth and colleagues suggest that grit behaves like an inherent character trait—in other words, that it is fairly stable over time—and perhaps is most fruitfully understood in the context of the "Big Five" personality traits. Over the past several decades, personality psychologists have come to general agreement on grouping the myriad human psychological characteristics into five universal personality traits, each of which is expressed along a spectrum (such as introversion to extroversion). One of the Big Five—*Conscientiousness*—is the only personality trait that consistently shows a relationship to academic performance. In a meta-analysis, Porporat (2009) found the size of the effect of Conscientiousness on academic performance to be similar to the size of the effect of intelligence on academic performance. While Conscientiousness increases across the lifespan as individuals mature, psychologists generally agree that Conscientiousness is a "fixed trait," meaning that there is little evidence that interventions or environment can substantially change this aspect of a person's basic nature (Srivastava, John, Gosling, & Potter, 2003). Duckworth and colleagues (2007) suggest that grit should also be understood as a stable personality trait—perhaps a mistakenly overlooked facet of Conscientiousness. This does not mean that it is impossible to change a person's grittiness but rather that doing so would be difficult. Duckworth's current work focuses on how to intentionally cultivate grit and self-control, but to date there is little conclusive research showing grit to be a malleable factor.

Do the research and theory behind the concept of "grit" mean that teachers cannot change the degree to which students persist at challenging tasks in their classrooms? No. Even if one's innate tendency to persevere is hard to change, there is ample evidence that people can change the intensity, direction, and duration of their behaviors *despite* their personalities. In other words, whether or not a student has a gritty personality, he can learn to change the quality of his behavior—in effect to *act* perseverant even if that is not in his core nature (McCrae & Costa, 1994; Roberts & Del Vecchio, 2000).

Second, our focus here is on *academic* perseverance rather than perseverance in some general sense. When we make this distinction, the answer to the question of malleability in a given context becomes a resounding "yes." There is significant empirical evidence that students demonstrate different amounts of perseverance at academic tasks under differing conditions, supporting the idea that academic perseverance as a behavior in a specific context is highly malleable. The research suggests that, while there may be little return to trying to make students more gritty as a way of being (i.e., in ways that would carry over to all aspects of their lives at all times and across contexts), students can be influenced to demonstrate perseverant behaviors—such as persisting at academic tasks, seeing big projects through to completion, and buckling down when schoolwork gets hard—in response to certain classroom contexts and under particular psychological conditions.

What Is the Role of Classroom Context in Shaping Academic Perseverance?

In questioning what prevents many students from working hard in school, Dweck, Walton, and Cohen (2011) ask, "Is it something about [the students] or is it something about school?" (p. 2). While there are aspects of student characteristics that affect perseverance, as shown by the research on grit, overall the evidence suggests it mostly may be something about the school. The degree to which students persevere at academic tasks is quite responsive to changes in school and classroom context, although the effect of classrooms on perseverance works indirectly; in other words, classrooms make an impact on something else that then influences a student's perseverance.

The findings from the Mischel "marshmallow" study described earlier show that context plays a large role in whether children exhibit behaviors that may be viewed as impulsive or contrary to short-term goals. In the experiment, when the marshmallow was *shielded from sight* or the subjects were *given strategies* to avoid thinking about the desired object, children were less likely to act in an impulsive manner by taking the single marshmallow. This turns out to be very similar to the findings from research about the classroom antecedents of academic perseverance. Classroom contexts that are structured to support students' success at assigned tasks and that provide students with strategies to make the tasks easier are likely to increase students' perseverance and persistence in completing those tasks.

One way classroom contexts might affect academic perseverance is by influencing students' academic mindsets (classroom context → academic mindsets → academic perseverance). Think, for example, of a persistent and ambitious high school student who works hard to get to college, where she opts to take calculus in her freshman year. Her college instructor does a poor job of explaining the course material and grades harshly on quizzes, causing the student much anxiety. Her attempt to get help during the instructor's office hours ends with him denigrating her intelligence. After failing her second quiz in a row, she sees no way to be successful and drops the course. Despite the innate tenacity that got her to college in the first place, she gave up on calculus when, in a particular context, she thought it was futile to keep trying. The context in which this student tried to learn calculus gave rise to a mindset that she could not succeed, which affected her ability to persevere in that context.

Another way that classroom context can affect academic perseverance is by giving students opportunities to develop metacognitive and self-regulatory strategies. Where teachers share strategies with students that help them be more effective in their learning and allow them to more fully engage in academic tasks, students are more likely to persist despite difficulty. By building students' repertoire of learning strategies, classroom teachers can indirectly increase students' perseverance because they see a payoff from their efforts (classroom context → learning strategy → academic perseverance).

There is cross-sectional research that suggests a strong relationship between learning strategies and perseverant behavior. Bembenutty and Karabenick (1998) looked specifically at the relationship between what they called "academic delay of gratification" and various learning strategies. College students completed a series of items in which they had to choose between two activities, one that would contribute to academic success in a specific class and another that would provide more immediate pleasurable returns (e.g., "Go to a favorite concert, play, or sporting event and study less for this course even though it may mean getting a lower grade on an exam you will take tomorrow," or "Stay home and study to increase your chances of getting a higher grade" p. 333). The researchers found that students' reported use of metacognitive strategies such as planning, monitoring, and self-regulation was associated with increased likelihood to delay gratification and choose the academic task ($r = 0.49$). They found similarly strong relationships between academic delay of gratification and a host of other learning strategies (e.g., managing one's time and study environment, $r = 0.62$; effort regulation, $r = 0.58$; and cognitive strategies such as rehearsal, $r = 0.42$ and elaboration, $r = 0.38$).

In short, psychological research suggests that classroom contexts shape students' academic mindsets, which in turn affect their academic perseverance within that context. Likewise, classrooms can provide students with opportunities to develop learning strategies which have also been shown to increase students' academic perseverance.

Are There Clear, Actionable Strategies for Developing Academic Perseverance as Part of Classroom Practice?

If classrooms can support positive academic mindsets and help students build effective learning strategies, then classrooms could contribute significantly to increasing students' perseverance in completing school assignments and hence to improving their academic performance. Two potential classroom strategies for influencing academic perseverance are either to "teach" perseverance directly (changing the student) or to influence perseverance indirectly through other mechanisms (changing the context). First we explore strategies for increasing perseverant academic behavior by teaching these behaviors directly, and then we look at ways to increase perseverance indirectly by changing the context in which students learn.

Direct instruction around perseverance is most often seen with students with identified behavioral disabilities. Some psychological interventions are designed to improve particular aspects of perseverance for these students by teaching them behaviors associated with impulse control and persistence. Unfortunately, there is little rigorous research examining the long-term effectiveness of such interventions. Often, existing studies do not include a control group and only examine short-term outcomes—such as improvements that are observed at the end of the intervention. Rarely is there long-term evidence of their effectiveness, even six months after treatment. Most of the research on these interventions has been conducted with elementary-aged children, and there is little work studying effectiveness at the high school or college level. There is also little research that examines the effectiveness of these interventions on different types of populations, including nonclinical versus clinical populations, such as students with and without ADHD (Pelham & Fabiano, 2008; Durlak, Furhrman, & Lampman, 1991; van de Weil, Matthys, Cohen-Kettenis, & van Engeland, 2002). Thus, there is an insufficient research base on which to recommend these types of strategies.

A second approach to increasing students' academic perseverance focuses on changing school or classroom contexts in ways that would indirectly influence academic perseverance. As described previously, the literature suggests two distinct pathways: supporting positive academic mindsets and helping students develop effective learning strategies.

There is clear research evidence that students' mindsets have strong effects on their demonstration of perseverant behaviors such as persistence at difficult tasks. When students value the work they are doing, feel a sense of belonging in the classroom context in which they are working, feel capable of succeeding, and believe they will master challenging material with effort, they are much more likely to engage in difficult work and see it through to completion. Dweck, Walton, and Cohen (2011) explicitly suggest that the ways to improve academic tenacity are through interventions aimed at changing students' mindsets directly or by establishing classroom conditions that support the development of positive mindsets. When teachers can present tasks in ways that make success seem attainable, and when they provide students with the support and tools to be successful, students are more likely to engage and persist in those tasks (Dweck, Walton, & Cohen, 2011). What is less clear is whether these effects are lasting and transferable, e.g., whether—post such interventions— students would continue to behave in a tenacious manner if put in a different context. Nonetheless, the evidence is strong that context-specific interventions that increase academic perseverance can have clear payoffs in terms of improved academic performance within the targeted context.

Lastly, teachers may be able to increase academic perseverance by changing their instructional practice in ways that help students develop and practice effective learning strategies. While more research is needed to show a causal link between teaching learning strategies and students' perseverance in completing assignments, theory and correlational evidence strongly suggest it is an important mechanism. A continued discussion of the relationship between academic perseverance and other noncognitive factors is presented in Chapter 5 (Academic Mindsets) and Chapter 6 (Learning Strategies), along with a more detailed description of the classroom contexts that have been shown to contribute to building academic perseverance.

Would Changing Perseverance Significantly Narrow Achievement Gaps?

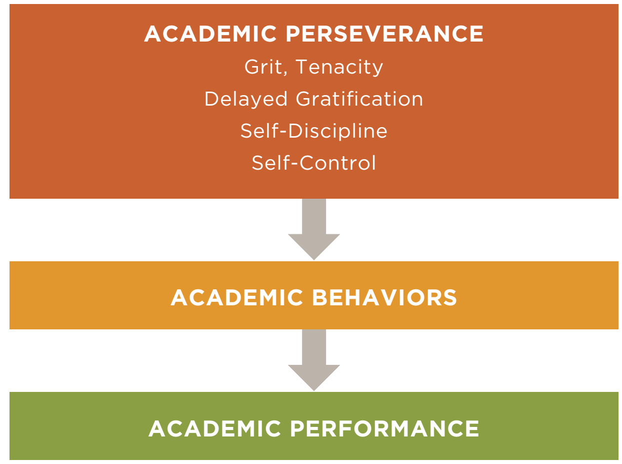
It is unclear from the empirical literature whether improving students' academic perseverance would narrow achievement gaps by race/ethnicity. Much of the research tying academic perseverance to student performance has been conducted on high-achieving students at elite institutions (Duckworth, Peterson, Matthews, & Kelly, 2007; Duckworth & Seligman, 2005, 2006). In a population of high-achieving, college-bound eighth-graders, Duckworth and Seligman (2006) did show a gender gap in self-discipline, with girls rated higher than boys in self-discipline by their teachers and parents as well as in their own self-reports. As a result of these differences in self-control, over the course of a year, girls spent roughly twice as much time on homework on average as boys. They found further that this gender difference in self-discipline explained about half of the gender difference in students' grades. However, this work is limited in scope in that self-discipline was measured concurrently with grades—potentially biasing the measurement and not allowing for causal inference—and it was conducted on a select group of already high-achieving students.

Bembenutty and Karabenick (1998) also looked at gender differences in academic delay of gratification in their study of college students. While girls showed higher mean levels of academic delay of gratification than boys, these differences were not statistically significant. The two studies taken together provide suggestive evidence that differences in self-discipline might underlie some of the gender gap in academic achievement, although much more work needs to be done in this area.

There is less research on racial/ethnic differences in academic perseverance. The two biggest racial groups in the Duckworth and Seligman study (2006) were White and African American students, comprising 55 percent and 32 percent of the sample, respectively, but the authors did not report differences in self-discipline by race. Bembenutty and Karabenick (1998) did report racial/ethnic comparisons by grouping White versus non-White students and found academic delay of gratification was significantly higher for non-White students ($p<.05$). This would not explain differences in achievement where White students outperform non-Whites. The broader research evidence on this point is mixed, with varying reports of higher levels of delay of gratification among Whites versus African Americans (Ward, Banks, & Wilson, 1991). There is a need for more research that shows whether there are consistent differences in academic perseverance among different subgroups of students. More longitudinal research and causal studies are needed to determine whether attempts to improve academic perseverance would be likely to improve academic outcomes for all subgroups of students.

Summary of Research on Academic Perseverance

A challenge of studying **Academic Perseverance** is that it is only evident through students' academic behaviors, and the research often conflates students' innate tendency to be perseverant with the actual behavior of doing work. Another complexity arises from how academic perseverance is defined and measured. On one hand, evidence suggests that grit is fairly stable as an individual trait. However, other work clearly shows that students are more likely to exhibit academic perseverance in contexts that promote positive mindsets or when they have the strategies to successfully manage classroom tasks.



Academic perseverance describes a quality of student engagement in success-oriented academic behaviors and attitudes that is empirically associated with increases in student grades. As such, increasing students' academic perseverance is appealing as a goal for both education policy and classroom practice. However, an isolated focus on academic perseverance as a thing unto itself may well distract reformers from attending to student mindsets and the development of learning strategies that appear to be crucial to supporting students' academic perseverance. As a field, we do not know how to make people innately grittier in a way that transfers across contexts. But the evidence suggests that finding ways to support positive academic mindsets can help students persevere in a given context, and that helping students build effective learning strategies is likely to lead students to more easily handle and hence complete difficult tasks.

While academic perseverance shows moderate relationships to student performance in cross-sectional designs (measuring both perseverance and performance at the same point in time), longitudinal studies find more modest relationships, making it difficult to establish evidence of a causal relationship between perseverance and performance. Although perseverance by race or gender have been suggested as an explanation for racial/ethnic or gender differences in student academic performance, there is little research that has examined this directly and no research that has studied it in a way that would allow for more than very modest causal inference.

CHAPTER 5

Evidence on Academic Mindsets

Academic Mindsets are beliefs, attitudes, or ways of perceiving oneself in relation to learning and intellectual work that support academic performance. The theory and empirical evidence on academic mindsets draws on a long history of psychological research. Most commonly, this research has involved correlational studies in which researchers administer questionnaires to measure student beliefs or attitudes, observe students performing academic tasks in either clinical experiments or natural classroom settings, and then analyze the relationship between their measurements of psychological factors and students' task performance.

Lately, mindsets have garnered much attention among researchers because several simple, short-term interventions directed at changing student mindsets have been shown to have surprisingly lasting effects on school performance. These studies suggest that "it can be as important to change people's...interpretations of the social world and their place in it—as it is to change the objective environment" of schools and classrooms (Wilson, 2006, p. 1252). The extensive body of research on mindsets further suggests that a psycho-social approach could have major implications for reform efforts aimed at closing racial/ethnic gaps in student performance and educational attainment.

In Chapter 2 we identified four academic mindsets shown to contribute to academic performance, which we express in the first-person from the point of view of a student:

1. I belong in this academic community;
2. My ability and competence grow with my effort;
3. I can succeed at this; and
4. This work has value for me.

As suggested in Chapter 4, each of these four academic mindsets is positively related to persistence at academic tasks. One of the mechanisms by which mindsets improve students' academic performance is by increasing their perseverance. This leads to improved academic behaviors which result in higher grades. We briefly summarize below the way each mindset affects perseverance.

1. I belong in this academic community. A student's sense of belonging in a school or classroom has a strong impact on academic performance (Battistich, Solomon, Kim, Watson, & Schaps, 1995; Cohen & Garcia, 2008; Furrer & Skinner, 2003; Goodenow, 1992; Goodenow & Grady, 1993; McMillan & Chavis, 1986; Ryan & Deci, 2000; Solomon, Watson, Battistich, Schaps, & Delucchi; 1996; Wentzel & Asher, 1995; Wentzel & Caldwell, 1997). Feeling part of a school or classroom community has significant psychological benefits for students and makes them more likely to engage in productive academic behaviors. In an extensive review of research on school belonging, Osterman (2000) concluded that:

> ...the experience of belongingness is associated with important psychological processes. Children who experience a sense of relatedness [in school]... perceive themselves to be more competent and autonomous and have higher levels of intrinsic motivation [than students with a low sense of belonging]. They have a stronger sense of identity but are also willing to conform to and adopt established norms and values. These inner resources in turn predict engagement and performance... [Students who experience belongingness] have more positive attitudes toward school, classwork, teachers, and their peers...They invest more of themselves in the learning process (p. 343).

Conversely, "rejection or the sense of exclusion or estrangement from the group is consistently associated with behavioral problems in the classroom (either aggression or withdrawal), lower interest in school, lower achievement, and dropout" (p. 343).

2. My ability and competence grow with my effort. Students who believe they can increase their academic ability by their own effort are more likely to work toward building competence, more likely to be self-motivating and persistent, and more likely to exhibit behaviors associated with higher academic achievement (Cury, Elliott, Da Fonseca, & Moller, 2006; Dweck & Leggett, 1988). In contrast, these researchers found that students who believe their academic ability is fixed and cannot be changed by their own efforts are more likely to be focused on discerning the opinions of others as to their level of ability, less likely to be self-motivating and persistent, and less likely to do well in school.

A closely related line of research draws on attribution theory, exploring students' attributions for success and failure. If students attribute an incident of poor performance to their lack of ability, they tend to withhold further effort when faced with a similar task (Kelley, 1973; Weiner, 1986; Vispoel & Austin, 1995). Conversely, if students attribute low performance to a lack of effort, they are more likely to increase effort on the next try. As Dweck (1975) summarized:

> The manner in which a child views an aversive event, such as failure, determines, in large part, the way in which he reacts to that event. Specifically, if a child believes failure to be a result of his lack of ability or a result of external factors beyond his control, he is unlikely to persist in his efforts. On the other hand, if a child believes failure to be a result of his lack of motivation, he is likely to escalate his effort in an attempt to obtain the goal. (pp. 682-683)

Believing that ability and competence grow with effort is associated with effort attributions. Notably, in the studies above and replicated elsewhere, beliefs about intelligence and attributions for academic success or failure are more strongly associated with school performance than is actual measured ability (i.e., test scores).

3. I can succeed at this. A third mindset that impacts the degree to which students put forth effort and exhibit strong academic behaviors relates to beliefs about the likelihood they will succeed at a given task. Individuals tend to engage in activities that they feel confident in their ability to complete and to avoid those in which they lack such confidence (Bandura, 1986). People's efficacy beliefs (the perception that they will be able to do something successfully) in both in-school and out-of-school contexts are positively associated with how long they will persevere at a given task, as well as their likelihood to bounce back when faced with adversity (Pajares, 1996). Conversely, when people do not believe they can succeed at something, they are unlikely to put in persistent effort (Oyserman & James, 2009, p. 381). Efficacy beliefs mediate the effect of skills and of other self-beliefs on performance as they impact the level of students' effort, persistence, and perseverance (Bandura, 1986; Bandura & Schunk, 1981; Bouffard-Bouchard, 1990; Lent, Brown, & Larkin, 1984; Pajares, 1996; Schunk & Hanson, 1985). When students believe they are likely to succeed in meeting academic demands in a classroom, they are much more likely to try hard and to persevere in completing academic tasks, even if they find the work challenging or do not experience immediate success. Believing one can be successful is a prerequisite to putting forth sustained effort.

4. This work has value for me. The degree to which students value an academic task strongly influences their choice, persistence, and performance at the task (Atkinson, 1957; Damon, 2008; Eccles et al., 1983; McKnight & Kashdan, 2009; Wigfield, 1994; Wigfield & Eccles, 1992). Learners are naturally motivated to learn when they perceive a task to be inherently interesting (McCombs, 1991, 1993, 1994). Bruner (1960) noted that "interest in the material is the best stimulus to learning" (p. 14). For example, in a small qualitative study, Lee and Anderson (1993) interviewed sixth-grade students while they were engaged in a classroom science activity. The researchers found that students who valued science prior to the activity were more likely to be "thinking beyond the lesson content and engaging in tasks beyond the requirements or expectations of the classroom" (p. 590). When students are interested in a subject or see a connection between academic tasks and their own future goals, students are more likely to expend persistent effort and exhibit academic behaviors that support school success.

In short, when students feel a sense of belonging in a classroom community, believe that their efforts will increase their ability and competence, believe that success is possible and within their control, and see work as interesting or relevant to their lives, they are much more likely to persist at academic tasks despite setbacks and to demonstrate the kinds of academic behaviors that lead to learning and school success. Conversely, when students feel as though they do not belong, are not smart enough, will not be able to succeed, or cannot find relevance in the work at hand, they are much more likely to give up and withdraw from academic work by demonstrating poor academic behaviors which result in low grades.

What Is the Relationship between Academic Mindsets and Academic Performance?

Drawing on this seminal research from the 1980s and 1990s, much newer lines of work involve implementing psycho-social interventions—often brief treatments or short-term programs designed to promote positive student mindsets—and then comparing the academic performance of students who experienced the intervention to a control group that did not. Researchers such as Carol Dweck, Daphna Oyserman, Greg Walton, and their colleagues have used randomized experiments to evaluate the effect of carefully constructed brief treatments focused on students' mindsets and find compelling evidence that these treatments have lasting effects on students' academic performance. Several intervention studies have tested the effect of promoting what researchers call a "growth mindset," wherein students ascribe to the belief: *my ability and competence grow with my effort*. Students with a growth mindset believe that academic ability is changeable rather than being fixed at a particular level, and they tend to attribute their academic performance to the amount of effort they put into their work, rather than to innate ability, luck, or other factors beyond their control.

In an early example of an intervention study targeting students' attributions for academic performance, Wilson and Linville (1982, 1985) showed a video to a group of first-year college students that depicted older students at the same university discussing their initial difficulty in college, expressly making the point that their performance and GPA improved over time. Students in the control group also received a booklet illustrating what claimed to be normative growth in college students' GPA over time. The researchers' goal was to expose the treatment group to the suggestion that academic setbacks upon entering college are common and not indicative of a lack of innate ability or some other unchangeable factor. The control group saw a video of the same older students discussing their academic interests, with no discussion of their grades or course performance. The entire treatment consisted of reading the booklet with the GPA information and viewing these brief videos. Although groups were randomly selected and looked similar on key variables before the experiment began, one week after the video screenings students in the treatment group outscored control group students on practice GRE questions. A year later, treatment students had higher college GPAs (0.27 grade point difference) and were 80 percent less likely to have dropped out of school than control students (reviewed in Yeager & Walton, 2011). The authors interpret the findings as evidence that students can be influenced to have a growth mindset, and that a growth mindset contributes to lasting improvements in academic performance.

In a study of the same underlying mindset, Aronson, Fried, and Good (2002) had college students write "pen pal" letters and a short speech about the nature of intelligence that were ostensibly being sent to encourage younger students in middle school. In the treatment group, the letter writers were supposed to promote the idea that intelligence is malleable (a growth mindset). In one control group, letter writers were supposed to write about the existence of multiple kinds of intelligence. A second control group did not engage in any letter writing. The researchers found that students in the treatment group had overall college GPAs that were 0.23 grade points higher than the control groups by the end of the following school term, with African American students in the treatment group also reporting more enjoyment of and engagement in school than African American students in either control group.

In another study on growth mindsets, seventh-grade students in a randomized treatment group participated in a weekly 25-minute advisory group for eight sessions in the spring where they learned that intelligence is changeable and that the brain is like a muscle which grows with use. Prior to the intervention, math grades for both groups had been declining over the course of the year. After the intervention, the math grades of students in the treatment group stabilized while the grades of students in the control group continued to decline, for an overall difference between groups of 0.30 grade points by year's end (Blackwell, Trzesniewski, & Dweck, 2007).

In a separate line of work building on expectancy-value theory (*This work has value for me*), Hulleman and Harackiewicz (2009) had ninth-graders write essays each month about weekly topics in science class. Students in the treatment group wrote about how the science topics applied to their lives. Students in the control group wrote summaries of weekly science topics. The researchers found that students in the treatment group who started out with low expectations for success saw sizeable improvements in their grades at the end of the semester relative to the control group (0.80 grade points difference). There was no significant difference in the grades of treated students who already expected to do well. The researchers concluded that interventions that increase the value of academic work for disinterested students can have positive effects on grades, though these interventions are not likely to affect students who are already positively disposed toward a subject.

The results of these various school-based interventions suggest not only that mindsets are important but also that changing students' mindsets can result in improvements in academic performance as measured by grades. This is clearly good news; it is important work that builds on earlier studies of academic mindsets, and it warrants investment in further research. The implications of the intervention studies, however, should be considered somewhat cautiously. To date, much of the intervention research has included small samples in single schools. Moreover, of the many recent reviews of psycho-social intervention research in education, most have been written by the same people who conducted the studies (see Dweck, Walton, & Cohen, 2011; Garica & Cohen, in press; Walton & Dweck, 2009; Walton & Spencer, 2009; Yeager & Walton, 2011). A broader evidence base would strengthen the claims from these authors. It is also unclear how interventions addressing various mindsets fit together: If a group of students was exposed to multiple interventions targeting different mindsets, would the effects be additive? Who is most likely to benefit from which interventions and under what circumstances? While many questions remain to be answered, the intervention evidence to date—particularly in combination with the earlier theoretical and empirical work upon which it is built—continues to make a strong case that mindsets are an important noncognitive factor in student academic performance.

Are Academic Mindsets Malleable?

The apparent success of the interventions cited above suggests that mindsets can be changed intentionally. Indeed, many of these studies demonstrate the malleability of the targeted mindset. Of 13 psycho-social intervention studies reviewed by Yeager and Walton (2011), several specifically measure the targeted psychological variables both before and after the intervention; all of these show changes as hypothesized by the researchers as well as expected differences in student performance (Aronson, Fried, & Good, 2002; Study 2 in Blackwell, Trzesniewski, & Dweck, 2007; Cohen et al., 2006; Hulleman & Harackiewicz, 2009; Oyserman, Bybee, & Terry, 2006; Walton & Cohen, 2007, 2011).

For example, in the Hulleman and Harackiewicz (2009) study intended to increase students' valuing of science through personal connection, we know that, of the students who did not expect to do well in science at the beginning of the study, those who wrote about science in connection with their own lives earned higher grades at the end of the course than those who just wrote summaries of science topics. After the intervention, students in the treatment group also had a higher interest in science and were more likely to indicate plans to take science-related courses in the future than were students in the control group. Walton and Cohen (2007, 2011) measured students' sense of belonging after an intervention meant to activate belonging uncertainty in the treatment group. As hypothesized, African American students who received the treatment had a lower "sense of academic fit" in computer science than African American students in the control group. Also, there were no significant differences in sense of belonging between Whites in the treatment and control groups, supporting the researchers' hypothesis that racial group stigmatization would interfere with African American students' sense of belonging in a way that would not be true for White students.

Blackwell, Trzesniewski, and Dweck (2007) provide contrasting examples of studies in which the malleability of mindsets is demonstrated and those in which it is can only be inferred. The researchers conducted a study in which seventh-graders participated in weekly workshops over eight weeks. Treated students learned math study skills as well as learning that the brain is like a muscle that grows with use. Students in the control group learned only the math study skills. In Study 1, psychological variables (students' implicit theories of intelligence and achievement-related beliefs) were only measured once, at the start of seventh grade, and then correlated with later achievement through seventh and eighth grades. In Study 2, after the eight-week intervention in which students in the treatment condition were taught that the brain can grow with use, the researchers tested the understanding of all students (treatment and control) about how the brain works, as well as measuring changes in their attitudes about the nature of intelligence (before and after intervention). They found that treated students changed their understanding of the brain, changed their beliefs about intelligence, and performed better than students in the control group. Unlike Study 1, Study 2 provides strong and direct evidence that mindsets are malleable.

While not all psycho-social intervention studies have taken this last step of including before and after measures of the targeted variable, those that do have shown changes in the targeted mindset in the expected direction as a result of the intervention. Overall, the evidence suggests that academic mindsets are malleable. They change as the result of experimental interventions, and they also respond to contextual conditions in natural classroom settings.

What Is the Role of Classroom Context in Shaping Academic Mindsets?

A long history of research literature suggests that mindsets are a product of the interaction between students and educational contexts, rather than being predetermined characteristics of individual students (Deci, 1992; Hattie, Biggs, & Purdie, 1996; Masten & Coatsworth, 1998; Stipek, 1986; Wang, Haertel, & Wahlberg, 1994; Yair, 2000). In fact, three of the four academic mindsets we have identified explicitly reflect the attitudes or beliefs of a student *in a specific context:* "I belong in *this* academic community," "I can succeed *at this*," and "*This work* has value for me." The fourth mindset, "My ability and competence grow with my effort," is likewise either reinforced or refuted by the context in which a student is expending effort to learn.

Classroom conditions have powerful influences on students' feelings of belonging, self-efficacy, and valuation of schoolwork and can also reinforce or undermine a growth mindset. Conditions in the classroom that have been shown to affect students' mindsets include the level of academic challenge and teacher expectations for success (Conchas, 2006; Rosenthal & Jacobson, 1968; Shouse, 1996; Wentzel, 2002); student choice and autonomy in academic work (Stefanou, Perencevich, DiCintio, & Turner, 2004): the clarity and relevance of learning goals (Grant & Dweck, 2003); availability of supports for learning (Gordon & Bridglall, 2006); grading structures and policies (Assessment Reform Group, 2002; Berliner, 1984; Black & Wiliam, 2004; Brookhart, 1994, 2004; Butler & Nisan, 1986; Covington & Müeller, 2001; Crooks, 1988; Harter, Whitesell, & Kowalski, 1992; Kaplan, Peck, & Kaplan, 1997; Weiner, 1979); the nature of the academic tasks students are asked to do (Bridgeland, DiJulio, & Morison, 2006; Eccles & Wigfield, 1995); the type, usefulness, and frequency of feedback on student work (Brookhart, 1994, 2004; Brophy, 1981; Cohen, Steele, & Ross, 1999; Hamre & Pianta, 2005; Harber, 2004; Stipek, 2001); and classroom norms of behavior and level of trust and safety (Bryk & Driscoll, 1988). As a National Research Council study concludes, positive engagement and self-efficacy in any given subject is contingent upon "creat[ing] a set of circumstances in which students take pleasure in learning and come to believe that the information and skills they are being asked to learn are important and meaningful for them and worth their effort, and that they can reasonably expect to be able to learn the material" (National Research Council and the Institute of Medicine, 2004, p. 14).

Research in both psychology and sociology emphasizes the importance of context in shaping an individual's identity and self-efficacy. Within schools and classrooms, students draw upon frames of reference shared with social groups that are important to them to determine how to act and "who to be" in school, which has implications for how they interpret the world of school and for their subsequent academic behavior

(Berger & Luckmann, 1966; Kaplan & Kaplan, 1982). Social context works powerfully with students' social identities to both define and constrain their sense of what is possible (Weick, 1995). The experience of membership in important social groups shapes students' sense of their own capabilities. As Oyserman & Fryberg (2006) explain, "We can become the kind of person that people of our group can become [and] we fear disappointing important groups by failing to attain group norms and standards" (p. 21). If students feel part of a learning community that values academic work, they are much more likely to share this orientation and act accordingly.

However, the need to meet group norms and standards becomes problematic for students for whom membership in particular social groups may be felt to be at odds with academic achievement. To the extent that students identify with a social group for whom academic achievement is not the norm, they may lower expectations for their own academic success to match those perceived as being normative for the group (Harvey, 1963; Harvey & Schroder, 1963). This effect of classrooms on student mindsets is particularly salient for racial/ethnic minority students and has led to a body of research on stereotype threat, which is addressed in **Box 5.1**.

School Transitions

The role of context in shaping students' academic mindsets becomes apparent when looking at what happens when students move from one school context to another (e.g., in the transition to middle school, high school, or college). Students are particularly vulnerable across school transitions, which are associated with declines in both academic performance and students' attitudes toward school (Alspaugh, 1998; Eccles, Lord, & Midgley, 1991; Hagborg, 1992; Harter, Whitesell, & Kowalski, 1992; Neild & Weiss, 1999; Simmons & Blyth, 1987). School transitions make contexts particularly salient, as students enter a new school milieu, have to reorient themselves to new social and academic demands, and have to renegotiate their sense of self, of academic competence, and of belonging in a new and unfamiliar social space. Many of the intervention studies discussed earlier were conducted on students in either the beginning of their first year in college or their entrance to middle school or junior high (seventh grade). Effective interventions aimed to normalize academic difficulty, bolster students' sense of belonging, or reinforce a growth mindset to inoculate students from declines in performance following a school transition.

One question that arises is whether these interventions would be as effective among students who were not changing schools. Blackwell, Trzesniewski, and Dweck (2007) found no significant correlation between students' theories of intelligence (fixed versus malleable) and their sixth-grade achievement; however in seventh grade (after entering middle school), having a fixed theory of intelligence was highly predictive of lower performance. In interpreting these results, the authors hypothesized about the role of context in activating the salience of particular mindsets: "In a supportive, less failure-prone environment such as elementary school, vulnerable students may be buffered against the consequences of a belief in fixed intelligence. However, when they encounter the challenges of middle school, [the evidence suggests that] these students are less equipped to surmount them" (p. 258). A fixed mindset constrains students from expending effort to adapt to higher intellectual demands because they do not believe that effort will be enough to overcome the limits of their academic ability.

Recursive Effects

Recent intervention research suggests that contexts contribute to what social psychologists call "recursive effects," which can magnify the interaction between contexts and student mindsets by launching this interaction in a positive or negative feedback loop. Consider the example of a ninth-grader who enters high school unsure of his academic ability and worried about finding friends. When he struggles with the problems on his first math assignment and has a hard time finding a lab partner in science class, he interprets these situations as evidence of his intellectual and social shortcomings. These experiences contribute to growing preoccupations with a lack of belonging and ability which then begin to undermine the student's academic performance, leading to further academic difficulties and lack of confidence. Though the student entered high school feeling unsure of himself, his interactions within the high school context and his participation in its routines reinforce his initial self-doubts and lead

BOX 5.1

Stereotype Threat

Stereotypes about minority students' intellectual inferiority are particularly salient in schools and classrooms. Minority students in the U.S. must struggle to disentangle their own personal narratives of ambition and achievement from dominant societal messages about worth, capability, and academic success sent often unintentionally by schools and teachers. A large body of empirical literature suggests that salient societal stereotypes about minorities' alleged intellectual inferiority or indolence can exert a powerful pull—described as *stereotype threat*—on minority students' self-perceptions, attitudes towards learning, and academic performance (Steele, 1997; cf. Steele & Aronson, 1995; Walton & Spencer, 2009; Walton & Cohen, 2007). Minority students' fears of confirming negative stereotypes about their intellectual ability may lead to underperformance on specific tasks or tests, as students' anxiety about stereotypes interferes with their cognitive processing. Over time, this cycle of threat and the frustration of underperformance may give rise to self-doubt and undermine minority students' commitment to education and achievement. Ultimately, such underperformance may well increase racial gaps in academic achievement and attainment. For example, Perry, Steele, & Hilliard (2003) argue that subtle American narratives about Black intellectual inferiority make the messages African American students receive about their academic capabilities seem ambiguous and even untrustworthy. How are students to know, the authors ask, whether a teacher's feedback is a genuine response to their work or a reaction to what they represent in American culture as an African American?

Previous research suggests that uncertainty about the genuineness of feedback—often termed *attributional ambiguity* by psychologists—can be threatening to minority students' identity and performance in academic settings, both when feedback is positive and when it is negative or harshly critical (Mendoza-Denton et al., 2010; cf. Crocker et al., 1991; Mendes et al., 2008). The mistrust created by uncertainty about teachers' feedback can lead students to discount that feedback, to disengage from specific tasks, and, over time, to disidentify with school altogether (Mendoza-Denton et al., 2010; cf. Major & Schmader, 1998; Steele, 1992, 1997; Cohen & Steele, 2002). A number of studies suggest that strong and supportive relationships with teachers can play a critical role in building a foundation of trust and establishing a basis for minority students to develop positive, stable academic identities (Flores-González, 2002). These relationships provide teachers and students with a platform for delivering and receiving critical feedback, linked to messages conveying high expectations, encouragement, and consistent support that can be used to construct a counter-narrative of success and achievement among minority students (Mendoza-Denton et al., 2008; Cohen & Steele, 2002; Perry, Steele, & Hilliard, 2003).

Intervention studies conducted to address the operation of stereotype threat and belonging uncertainty among minority students provide strong evidence that students' self-evaluations and attitudes respond to conditions and cues in the learning environment. Walton and Cohen (2007, 2011) find evidence that interventions that modify conditions aimed at subtly bolstering minority students' sense of belonging in academic environments substantially affect their performance. These findings suggest that many of the critical challenges facing racial and ethnic minority students in the formation of strong, positive mindsets for academic achievement can be alleviated through the careful work of creating supportive contexts that provide consistent and unambiguous messages about minority students' belonging, capability, and value in classrooms and schools.

Messages about belonging, ability, effort, achievement, success, and value (both one's own intrinsic value and the value of one's education)—intended and unintended, explicit and implicit—are at the core of building students' academic mindsets. Teachers and schools participate in creating school and classroom contexts that either foster the development of academic mindsets and strong, positive attitudes towards learning among minority students or thwart the development of these positive mindsets. Perry, Steele, and Hilliard (2003) suggest that adults need to play specific, predictable, and unambiguous roles in redefining both the content and import of the messages minority students receive about the relationships among belonging, ability, effort, success, and, ultimately, value.

to increasingly negative mindsets. These mindsets can become self-perpetuating as the student interprets his school experiences in a way that further undermines his self-efficacy and self-confidence. He withdraws effort from his schoolwork, which results in further poor performance. The ongoing interaction between the student and the school context thus creates a recursive, negative loop between academic mindsets, academic behavior, and academic performance.

It is by breaking this self-reinforcing cycle that interventions around mindsets can cause lasting improvements in achievement (Yeager & Walton, 2011). The theory underlying intervention work is that a well-timed intervention can change an adolescent's schooling trajectory by disrupting this recursive process and resetting the student on a more productive cycle where success and positive expectations are mutually reinforcing. Interestingly, many of these psycho-social interventions aim to *change student perceptions and interpretations* of the school and classroom context rather than changing the context itself.

Are There Clear, Actionable Strategies for Developing Academic Mindsets as Part of Classroom Practice?

There is strong evidence that mindsets matter for student performance, growing evidence that mindsets are malleable, and both a theoretical and empirical basis for the importance of context in shaping mindsets. Unfortunately, the research does not directly translate into classroom strategies that teachers can use to support positive mindsets in their students. Even in the case of experimental research that focuses on specific intervention strategies, it is not clear how these experimental strategies might be used more globally to improve educational contexts. Videotaped interviews of older students at a selective university talking about their difficulty in freshman year might be helpful to incoming students who are experiencing daunting academic challenges, but they provide little direction to the university on how best to support students so routine challenges would seem less overwhelming. Thus, a central tension arising from the research on academic mindsets revolves around how best to apply the research to improve student outcomes.

If we start with the premise that schools and classrooms often do not provide the positive psychological conditions that research shows to be important for building academic mindsets, then we have two potential approaches to address this. One approach would be to change institutional structures and practices so that students' everyday school and classroom experiences promote positive academic mindsets. Another approach would be to leave schools and classrooms as they are, but to use the findings from intervention research to help students achieve positive mindsets and thus inoculate students from potentially unsupportive environments.

This second option may have great appeal. Investing in a short-term intervention program aimed specifically at building or supporting students' academic mindsets seems like an easier route than reforming instructional practice or changing a whole school culture. Further, the research points to a variety of short-term interventions that have evidence of success in school settings—from programs focused on promoting the growth potential of intelligence to interventions for developing students' sense of belonging. Some of these interventions have become the basis of programs available for purchase by teachers or parents. This raises the possibility that investing in an intervention program could be a prudent way to build students' academic mindsets without changing existing school and classroom practices.

While intervention programs that target academic mindsets might benefit students and contribute to improved academic performance, there is also reason for caution in this approach. First, there are a number of very different intervention programs available: How should educators choose among them? The findings from many intervention studies seem to be consistent (the interventions lead to better school performance), but the treatments are quite different across the studies. Which is the right program for a given school? Furthermore, the effects in most of these studies were selective, affecting some students (e.g., African American college students, seventh-grade girls in math) while not having any impact on the performance of other students—suggesting that specific interventions must be tailored to the psycho-social needs of specific groups of students in particular contexts. How can schools accurately assess the needs of their students so as to apply the right intervention to the right subgroup? Would it be cost-effective to invest in multiple interventions that target different mindsets? Would the effects across these programs be additive or redundant?

Second, it is unclear how big the overall payoff to such interventions would be. While the effects of many of these interventions are significant, some are modest; they average on the order of about 0.3 GPA points. Investing in one of these strategies may be insufficient because they might only have a modest, one-time effect on achievement. There is also evidence that the effectiveness of interventions may be compromised if students become aware of their purpose (Sherman, Cohen, Nelson, Nussbaum, Bunyan, & Garcia, 2009). Thus, attempts to implement them as part of the normal course of school may not have the same payoff as the initial intervention under experimental conditions.

Third, relying solely on intervention programs while not addressing the larger psychological conditions embedded in existing school and classroom contexts will necessarily constrain the effects of the intervention. Learning that the brain is like a muscle that grows with effort motivates students to continue working hard to learn despite setbacks or early failures. But this message may lose its persuasive power if a student's school relies largely either on competitive, one-shot summative assessments to evaluate her performance or on other similar practices that reinforce the value of natural ability over persistent work. Likewise, programs designed to increase students' sense of belonging will have limited impact if their teachers do not know their names and do not recognize or address their particular interests or learning needs.

Instead of, or in addition to, relying on intervention programs to change student mindsets, another strategy involves changing institutional structures and practices so that everyday educational experiences lead students to conclude that they belong in school, that they can succeed in their academic work, that their performance will improve with effort, and that their academic work has value. While there is substantial evidence that changing teachers' instructional practices could improve students' academic mindsets, reforming instructional practice can be difficult. Still, improving classroom contexts would seem likely to have a larger and broader impact on student achievement and achievement gaps than one-time interventions that only can address a limited sample of students. And while interventions might be easier than instructional reforms in the short run, there is much evidence to draw upon in devising actionable classroom strategies.

The National Research Council and Institute of Medicine (2004) summarized decades of research to identify school conditions that promote strong student engagement and positive academic mindsets. These included: presenting students with challenging but achievable tasks; communicating high expectations for student learning and providing supports that allow students to meet these expectations; making evaluation practices clear and fair and providing ample feedback; reinforcing and modeling a commitment to education and being explicit about the value of education to the quality of one's life; providing students with opportunities to exercise autonomy and choice in their academic work; requiring students to use higher-order thinking to compete academic tasks; structuring tasks to emphasize active participation in learning activities rather than passively "receiving" information; emphasizing variety in how material is presented and in the tasks students are asked to do; requiring students to collaborate and interact with one another when learning new material; emphasizing the connection of schoolwork to students' lives and interests and to life outside of school; and encouraging teachers to be fair, supportive, and dedicated to student learning while holding high expectations for student work.

Many of the strategies that promote positive academic mindsets relate directly to classroom practices around grading and feedback on student work. Supporting positive mindsets around self-efficacy requires that teachers be transparent in their grading practices and explicit about how and why different aspects of student work will affect grades (Assessment Reform Group, 2002; Black & Wiliam, 2004). Instructional contexts that provide students with clear learning goals, and assessment practices that provide students with regular feedback on their progress toward those goals, are essential for creating a school or classroom culture where success is perceived as possible (Kellaghan et al., 1996; Marzano, 2000; Popham, 2000; Tyler, 1949; Tyler, 2000). Students also need repeated opportunities to demonstrate their learning. Giving feedback to students on their progress toward a goal becomes irrelevant if the classroom is not structured to provide students additional opportunity to learn and improve their performance. Researchers have also found that specific kinds of feedback are much better than others in promoting positive mindsets. Praising students for their effort or for their choice of strategy supports the development of a growth mindset and reinforces student effort and enjoyment of academic challenge, while praising students for their talent or ability tends to undermine student effort, cause students to be preoccupied with their ability, and lead to a withdrawal from academic challenge (Mueller & Dweck, 1998).

Classrooms that emphasize cooperation and a sense that everyone can achieve the learning goals are much more supportive of self-efficacy and a valuing of academic work than classrooms that emphasize competition and a zero-sum environment where only a limited number of students will earn good grades (Carr & Walton, 2011; Dill & Boykin, 2000; Johnson & Johnson, 2009; Johnson, Maruyama, Johnson, Nelson, & Skon, 1981; Midgley & Urdan, 2001; Roseth, Johnson, & Johnson, 2008; Slavin, 1995). In their review on academic tenacity, Dweck, Walton, and Cohen (2011) document a number of additional school and classroom practices that promote positive mindsets and increase academic tenacity. These include establishing trusting relationships that instill a sense of belonging, holding high expectations for students, and scaffolding challenging work so that students are able to reach high standards.

While research is clear that classroom context shapes student mindsets and that certain teacher strategies support these mindsets, it is difficult to know how to change classrooms on a broad scale without further research based in actual classrooms aimed at helping teachers acquire such strategies. One potentially fruitful place to start may be in exposing middle and high school teachers and college instructors to the research on academic mindsets and helping them understand the mechanisms by which classroom variables can affect student beliefs about themselves and their schoolwork. However, understanding psychological theory does not automatically lead to knowing what to do differently in one's instructional practice. There are few resources available currently that would translate social-psychological theory into classroom-based instructional practices that could be readily employed by teachers in a variety of school settings to support positive academic mindsets.

Would Changing Academic Mindsets Significantly Narrow Achievement Gaps?

A number of interventions targeting mindsets have been shown to reduce gender and racial achievement gaps. Positive academic attitudes and mindsets that support school performance are important for all students, but racial/ethnic minority students are more likely to face contexts with additional, distinctive challenges to the development of positive academic mindsets. A number of the interventions designed to change mindsets demonstrate large effects on racial/ethnic minority students—or on girls, in the case of math and science performance—suggesting that it is particularly critical to pay attention to the ways in which minority status may shape how students view themselves in relationship to a given learning context. Research on stereotype threat, in particular, suggests that racial/ethnic minority students could benefit from greater attention to academic mindsets.

Many psycho-social interventions are specifically designed to inoculate students against the negative effects of stereotype threat, and indeed they show differential effects on minority students. For example, Cohen, Garcia, Purdie-Vaughns, Apfel, and Brzustoski (2009) had African American and White seventh-graders complete brief writing exercises about values that were important to them. Compared to a control group, students in the value-affirmation group had higher grades, with low-performing African American students seeing the biggest increase in grades (0.41 grade points), sustained over two years. In the Walton and Cohen study (2011), first-year African American and White college students were shown videos designed to help them normalize academic difficulties in the transition to college rather than attributing them to their own personal or racial identity. The significant effect was on African American students' grade point average, which was 0.24 grade points higher than that of control group students from sophomore through senior year of college (Walton & Cohen, 2011) and reduced the racial achievement gap by 52 percent. The same intervention had no significant effect on the grades of White students.

Ultimately, whether a focus on mindsets can narrow current racial/ethnic or gender gaps in academic performance and college degree attainment depends on the size of these gaps relative to the size of the effects of mindset interventions. It also depends on how much of the achievement gap is caused by stereotype threat or other negative mindsets that would differentially harm minority students in the first place. There is evidence that negative mindsets exist among minority students, as well as among girls in math and science; interventions designed to target mindsets are differentially effective for these groups. Additionally, several studies demonstrate a measured difference in mindsets before and after intervention. There is theoretical reason to believe that the size of the effects of these interventions may actually underestimate the negative impact of stereotype threat and other threats to positive academic mindsets for minority students. The interventions in these studies are generally targeted to change students' construals of their academic environments. To the extent that these interventions are not able to fully counteract potentially harmful psychological messages in those environments or that other factors outside of those academic settings (family, peers, larger socio-cultural context) also exert negative pressures on students' academic performance, the effect sizes of these interventions will be lower-bound estimates of the size of racial/ethnic or gender performance gaps.

One limitation for psycho-social interventions targeting college students is that they may come too late to substantially increase the number of minority students who earn college degrees. This is, of course, true for any intervention aimed at college students. The number of minority students who have successfully made it into college already represents roughly half the age-eligible population nationally. In many urban school districts, half the entering ninth-grade class will not even graduate from high school. Of high school graduates, a large number of minority students either do not proceed to college or enroll in two-year colleges that have low rates of degree completion. Although the interventions targeted at changing the mindsets and improving the performance of college students are beneficial for students who make it to college, greater leverage points for reducing gaps in educational attainment would likely focus on students in the middle grades and early in high school.

There is strong evidence that mindsets affect student performance. Strong, positive mindsets make students much more likely to engage with academic work, demonstrate positive academic behaviors, and persist despite setbacks. Mindsets are shaped by school and classroom contexts, but they also are malleable at an individual level through experimental interventions. Generally the reported effects from intervention studies are moderate, about 0.2 to 0.3 grade points in size, although these effect sizes may underestimate the actual impact of mindsets on student achievement. It is unclear if mindset interventions transfer across contexts or if students would benefit from more than one intervention. Furthermore, different sets of interventions target different mindsets, and it is unclear whether one intervention would have added value on top of another. While numerous studies have identified specific aspects of classroom context that contribute to strong academic mindsets, a gap persists between research findings and teachers' intentional use of strategies to promote positive student mindsets. Because academic mindsets are so critical to strong student performance, figuring out how to bridge this research/practice gap seems to be a prudent avenue for future work.

CHAPTER 6

Evidence on Learning Strategies

Noncognitive factors are "noncognitive" only insofar as they are not measured directly by cognitive tests. In order to affect learning and academic performance, however, noncognitive factors must engage a student's cognitive processes. The use of **Learning Strategies** is one example of this. As a category, learning strategies encompass several related psychological processes: metacognition, self-regulated learning, time management, and goal setting. Together, these concepts constitute a group of learner-directed strategies, processes, and "study skills" that contribute to academic performance.

Learning strategies have important relationships with other noncognitive factors. Utilizing appropriate learning strategies can make students' academic behaviors more productive and effective, contributing to improved academic performance. As a result, learning strategies tend to increase students' self-efficacy (the *I can succeed at this* mindset), which in turn is related to increased academic perseverance when schoolwork gets challenging. There is also clear evidence that students either with higher self-efficacy or who place a high value on the work they are doing are much more likely to use metacognitive and self-regulatory strategies to engage in learning. Positive academic mindsets drive strategy use, which makes students' academic behaviors more persistent and effective, leading to improved performance. Successful academic performance, in turn, reinforces positive mindsets.

Conversely, a lack of effective learning strategies can contribute to poor academic behaviors and poor performance. Students are less likely to complete homework if they do not know how to organize themselves to get it done, and they are less likely to study for tests if they do not have study strategies that help them review effectively. Not completing homework and not studying have a depressive effect on students' grades. Poor grades in turn undermine positive student mindsets, which then can diminish students' academic perseverance. Likewise, students with low self-efficacy or who place a low value on the work they are asked to do are much less likely to use metacognitive strategies or to self-regulate their learning; their academic behaviors are less likely to produce learning and quality work, even when students do complete the work. Thus, learning strategies are an important component in a chain of noncognitive factors that shape students' academic performance.

Theorists and researchers have studied many concepts and processes in the broad category of learning strategies over several decades (much of this work is from the 1990s), but there is as yet no single agreed-upon model for what the various components of learning strategies are, how to measure them, or how they affect learning. Across this work, however, there is consensus on a number of points. First, learning strategies involve *metacognition*, defined as an individual's knowledge of and control over his or her cognition (Flavell, 1979; Hacker et al., 2009) or knowing how to monitor one's own understanding (Credé & Kuncel, 2008). Self-regulated learning refers to students' intentional use of metacognitive strategies to achieve learning outcomes (Zimmerman & Schunk, 1989). Rather than being general styles of learning, self-regulated learning and metacognitive strategies are goal-oriented efforts to influence one's own learning behaviors and processes. Students self-regulate their learning by focusing awareness on their thinking and selecting strategies and environments that will be most conducive to learning (Zimmerman, 2001).[4]

A second and related point is that students learn more effectively when they monitor their own learning processes, determine when they are having difficulty, and adjust their behavior and/or strategies to tackle the task at hand (Ford et al., 1998; Pintrich & De Groot, 1990; Winne & Hadwin, 1998; Zimmerman, 2001). Self-regulating learners monitor the process of their learning, ascertain how effectively they are addressing a given learning task, and adjust their efforts accordingly. The process of academic self-regulation can be compared to the thermostat of a furnace, which continually monitors the temperature in a room and responds by adjusting the output of heat (Boekaerts, Zeidner, & Pintrich, 2000). In the absence of this self-regulation, students are apt to give up prematurely, before fully mastering the work at hand, and gain less understanding from the time they do devote to learning.

Researchers also agree that self-regulated learning is a multi-phase process that involves a number of distinct tactics or strategies. These strategies are embedded in behavioral, emotional, cognitive, and executive operations and therefore encompass several simultaneous psychological tasks—which range from invoking judgments about one's personal cognitive abilities, assessing the factors involved in a particular task and how it will influence one's cognition, and selecting cognitive strategies which may facilitate performance (Paris & Winograd, 1990). Winne and Hadwin's (1998) model of self-regulated learning includes four phases. The first phase involves defining or identifying the learning task one is encountering: *What does the task require of me? How is it related to other things I've done? What do I know about this already? How hard will this be?* Once the student defines the task, the second phase involves setting goals in relation to the task and developing plans to reach those goals.[5] This planning aspect entails selecting strategies or tactics to meet the goals the student has set. The second phase also includes deciding on some kind of standard for success: *What will it look like if I've done this successfully?* In Phase 3 the student enacts the tactics/strategies and monitors what happens: *How well is this tactic working? Why didn't it work? Am I as good at this as I thought I was? Should I try a different strategy? Did I learn this well enough?* Phase 4 involves a major reconfiguration of the student's approach to future tasks, based on his or her cumulative experience. As such, Phase 4 only happens occasionally. Winne and colleagues emphasize that these four phases, while conceptually distinct, are recursive or iterative and are only "weakly sequenced" as they occur in the mind of the learner (Winne, Jamieson-Noel, & Muis, 2002).

Other researchers have offered different models of self-regulated learning, but all involve multiple steps or a diverse collection of strategies. Zimmerman (1990) defines self-regulated learning as consisting of "self-evaluation, organization and transformation, goal setting and planning, information seeking, record keeping, self-monitoring, environmental structuring, giving self-consequences, rehearsing and memorizing, seeking social assistance (peers, teacher, or other adults), and reviewing (notes, books, or tests)" (p. 7). Other researchers differentiate between three categories of learning strategies: *cognitive* strategies such as rehearsal, organization, and elaboration; *metacognitive strategies* such as planning, monitoring, and regulation; and *resource-oriented* strategies such as "creating a favorable learning environment, controlling attention, and sustaining concentration" (cited in Helmke & Schrader, 2001, pp. 13553-13554; see also McKeachie, Pintrich, Lin, & Smith, 1986; Snow & Swanson, 1992; Weinstein & Mayer, 1986). Within these three larger categories, researchers have specified additional levels of elaboration. For example, task awareness, strategy awareness, and performance awareness have been identified as distinct components of metacognitive knowledge (Reynolds, Wade, Trathen, & Lapan, 1989).

While learning strategies generally involve metacognition (monitoring one's understanding) or organizing time and resources (setting aside an hour with the TV turned off in order to read), other strategies are entirely cognitive and have the express purpose of increasing a student's understanding or transferring information into memory. Weinstein and Mayer (1986) identify three such subcategories of cognitive learning strategies: rehearsal strategies, elaboration strategies, and organizational strategies. Generally, the more a learning strategy involves manipulating or organizing material rather than just reviewing it, the more likely it is to result in deep understanding (Weinstein & Mayer, 1986). Winne (1996) describes "deep processing" as the application of studying tactics such as "retrieving concepts and ideas relevant to material currently being studied, monitoring relationships between new information and prior knowledge, assembling propositions into elaborated structures, rehearsing and transforming information into meaningful schemata, and metacognitively monitoring and adapting learning tactics according to the requirements of a task" (Winne, 1996, p. 344, with reference to Schmeck, 1988; Winne, 1985). Note that while these strategies involve both cognitive and metacognitive processes, they fall under the broad umbrella of noncognitive factors because—while they *contribute* to a student's mastery of content knowledge and skills—they are nonetheless *distinct from* knowledge and academic skills as measured by cognitive achievement tests. Still, the category of learning strategies brings us to a particular awareness of the inadequacy of the term *noncognitive*.

For learning strategies to be effective, students must accurately perceive the nature of a task and its demands, and they then must choose and enact appropriate strategies to meet those demands. Learning strategies may often be quite conscious and require focused effort, particularly when tasks are set within a domain of knowledge (e.g., molecular chemistry or the works of Emily Dickinson) that is unfamiliar to a student. As learners move from novice to expert status within a given domain, the selection and use of learning strategies become increasingly automatic (Ericsson & Smith, 1991; Winne, 1996), to the point where students may not even be aware that they are using strategies.[6]

A key component of students' ability to monitor their own thinking is what is called *judgment of learning* (JOL), meaning one's ongoing determination of how much one has learned and whether or not one's level of understanding at any point in time is adequate to the task. This is another important characteristic that distinguishes "expert" learners from less effective students: more accomplished learners know what they know and they know what they have yet to learn; hence, they can tell when they need to put in more effort to accomplish a goal. Researchers studying undergraduates' metacognitive strategies concluded: "One of the critical barriers to success for many students may be their inability to objectively assess their mastery of the academic tasks they are facing" (Isaacson & Fujita, 2006, p. 39), and hence they withdraw effort too soon.

There is considerable evidence that students learn more when they have better metacognitive strategies and use them to facilitate and self-regulate their learning. However, there are several limitations in the research on metacognition and self-regulated learning (see Lennon, 2010). First, most studies are cross-sectional (with evidence collected at only one point in time), yielding little information about how self-regulation may change during adolescence and making it difficult to link strategy use directly with subsequent academic performance. Of equal importance, "this field of research is still struggling to develop a widely accepted assessment" of self-regulated learning (Lennon, p. 85), with studies using a variety of different instruments to measure similar concepts and a heavy reliance on student self-reports to measure metacognitive strategy use (Winne, Jamieson-Noel, & Muis, 2002). Recently, much of the work on self-regulated learning is within the context of online or computer-assisted instructional delivery (Azevedo, 2005; Hadwin et al., 2007; Winne et al., 2006).

What Is the Relationship Between Learning Strategies and Academic Performance?

Despite the limitations noted above, research shows that students who utilize self-regulation strategies tend to perform better in classroom tasks and activities. Pintrich and DeGroot (1990) examined the self-regulated learning, motivational orientation, and classroom academic performance of 173 seventh-graders in science and English. Using the Motivated Strategies for Learning Questionnaire (MSLQ), a self-report scale[7] that measured student self-efficacy, intrinsic value, test anxiety, self-regulation, and use of learning strategies, they found that students with high self-efficacy used metacognitive strategies more and were more self-regulating than students with low self-efficacy. While self-efficacy and intrinsic value were both strongly associated with self-regulation and strategy use, these motivational variables themselves did not predict performance directly. Rather, it was through students' use of self-regulation strategies that motivational variables affected performance (academic mindsets: self-efficacy/value → learning strategies → academic performance). Self-regulation was the strongest predictor of student performance in both English and science, with significant relationships across a number of measures of achievement (semester grades, as well as grades on seatwork, exams/quizzes, and essays/reports). The authors conclude that teaching students to use self-regulatory strategies in the classroom is vitally important, as the use of such strategies "is essential for academic performance on different types of actual classroom tasks" (p. 38).

McKeachie, Pintrich, Lin, and Smith (1986) tested the validity and reliability of the Motivated Strategies for Learning Questionnaire (MSLQ) to measure college students' motivation and use of learning strategies. They showed strong predictive validity of the motivational subscales and good internal reliability. The motivational scales were related to academic performance in the expected direction, with the learning strategies scales indicating a positive relationship to course grades.

Pokay and Blumenfeld (1990) examined the use over time of both subject-specific strategies and general metacognitive strategies in high school geometry classes. The researchers looked at the relationships among motivation, learning strategies, and academic performance for 283 geometry students in three high schools. At the beginning of the yearlong course, students were asked to complete a questionnaire about their perceptions of ability in math, the value they placed on the class, the likelihood they would be successful in the class, and their use of learning strategies. The authors also obtained students' geometry grades at two points in the course, as well as their prior algebra course grades which were used as a measure of entering math achievement. Early in the course (after proofs were first introduced), the use of specific geometry strategies, metacognitive strategies, and effort management strategies (as well as prior algebra achievement) were all significant predictors of course performance, accounting for 41 percent of the variance in grades. Interestingly, later in the course, metacognitive strategies were the only type of strategy use that predicted grades. These findings suggest that subject-specific strategies may be more useful when a student is learning a new subject such as geometry, and that some level of subject-area proficiency may be necessary before the use of meta-cognitive strategies can lead to successful outcomes.

In another high school study, Zimmerman and Martinez-Pons (1986) identified 14 commonly used self-regulated learning strategies and developed a structured interview tool called the self-regulated learning interview schedule (SRLIS). The SRLIS was used to assess the use of metacognitive strategies of high-achieving and low-achieving tenth-grade students attending a middle-class suburban high school. The researchers found that students' total score for self-regulated learning strategies was the best predictor of both English and math performance (Zimmerman & Martinez-Pons, 1986). Strategy use predicted with 93 percent accuracy students' membership in the high- versus low-achievement groupings.

Finally, researchers explored cross-cultural patterns of high school students' use of self-regulation strategies and their predictive value for academic success. In Australia and Japan, Purdie and Hattie (1996) found within-country patterns of strategy use, such that exchange students from one country were likely to exhibit the strategy use patterns in their host country. However, Japanese students in both countries relied more heavily on memorization strategies than did Australian students. Across both countries, students who viewed learning as understanding (as compared with learning as memorizing, learning as knowledge, or learning as performing academic tasks, for example) used a wider variety of learning strategies and were more likely to engage in strategy use in order to learn, as compared with students with other conceptions of learning (Purdie, Hattie, & Douglas, 1996). In another international study, Nota, Soresi, and Zimmerman (2004) found that Italian students' use of self-regulation strategies in high school—particularly organizing and transforming—predicted their high school course grades as well as their college grades.

Collectively, research provides evidence that knowing and understanding how and when to use learning strategies are associated with higher overall learning and better academic success. These relationships were demonstrated with students in middle grades, high school, and college, across a variety of subject areas, in the United States as well as internationally.

Are Learning Strategies Malleable?

Research supports the idea that metacognitive strategies are malleable and can be developed or learned. Many of the studies reviewed thus far measured strategy use and performance concurrently. While these studies show strong relationships between the two, they leave open the questions of whether learning strategies can be effectively taught and, if so, if teaching such strategies results in improved performance. The research demonstrating malleability uses two common experimental formats. The first involves teaching a skill where students' competence with that skill is measured before and after the skill training. The second measures the aptitude of learners who have been trained in a particular skill against a group of learners who have not had any skill training. While much evidence links learning strategies with better grades, the weakness of many of these studies is their reliance on student self-reports of strategy use or teacher reports on the basis of observable student behavior (Lennon, 2010; Winne, Jamieson-Noel, & Muis, 2002).

Learning strategies can be domain specific, and much of the research focuses on the effects of strategy use on either reading and literacy or mathematics performance. In a meta-analysis by Haller, Childs, and Walberg (1988), the average effect size of metacognitive instruction on reading comprehension across 20 studies was 0.72, a very large effect. Seventh- and eighth-graders benefitted most from metacognitive strategy instruction, which is consistent with Piaget's theory that the formal operational stage of cognitive development occurs around age 12 (Flavell, 1963). During this developmental stage, children begin to think about abstract ideas as well as developing deductive reasoning skills and systematic planning, making it an ideal time to introduce learning strategies that draw upon these processes. The most effective metacognitive strategies were awareness of textual inconsistency and self-questioning to monitor and regulate comprehension. Researchers also found that reading comprehension was greatest when instruction combined the use of several metacognitive strategies rather than focusing on only one or two (Haller, Childs, & Walberg, 1988).

Hattie, Biggs, and Purdie (1996) meta-analyzed 51 studies in reading and other subject areas and found that the average effect sizes due to training in cognitive and metacognitive skills were 0.57 on performance, 0.16 on study skills expertise, and 0.48 on positive affect. While they found memorization techniques to be highly effective for low-level learning tasks such as simple recall of formulas, procedures or facts, learning strategies that aid in higher-level learning require much more from both teacher and learner. Teaching such strategies in the context of the subject-area classroom is much more effective than teaching strategies or study skills in isolation. Findings show training has immediate benefits, but it is unknown if the positive effects of training persist and transfer to other contexts. For students to be able to transfer learning strategies from one context to another,

> the student needs to understand the basis of how the strategy works, when and under what circumstances it is most appropriate, what it requires of the learner; to the extent that this conditional knowledge is properly understood, the strategy may be deployed in contexts "farther" from those in which it was first learned…the further the extent of transfer, the more conditional knowledge and the deeper the content knowledge required. (p. 130)

Dignath et al. (2008) meta-analyzed research investigating whether primary school children could be taught self-regulation skills which would benefit reading, writing, math, science, and self-efficacy. Overall, across 48 studies, self-regulation training produced a weighted effect size of 0.62 on academic performance, using a variety of tactics.

Use of learning strategies in mathematics has also been shown to be malleable. Several studies tested whether math performance benefited from "metacognitive prompting" in which students were asked such questions as "what is this problem about?" or "what steps are you using to solve the problem?" Such cues led to better math performance by prompting students to identify problem structure and task characteristics, draw upon prior knowledge, and evaluate the appropriateness of strategies to solve problems (Butler & Winne, 1995; Kramarski & Gutman, 2006; Kramarski & Zeichner, 2001; Mevarech & Kramarski, 1997; Schoenfeld, 1987; Winne, 1979). There is similar evidence across all major school subjects that learning strategies can be effectively taught (Graham & Harris, 1994; Pressley & Woloshyn, 1995; Wood, Woloshyn, & Willoughby, 1995).

Even if students are not taught learning strategies directly, researchers hypothesize that they learn them anyway. Winne (1996, 1997) refers to this process as "bootstrapping" as students learn to appropriately apply new strategies to learning tasks by trial and error or by observation of the strategy use of others. As reviewed in Chapter 5, students with positive academic mindsets—who value the work or the content area, believe they can succeed in learning it, feel a sense of belonging in a class, and/or believe their efforts will lead to better performance—are more likely to work to acquire strategies to help them learn new material. Regardless of the mechanism whereby new strategies are acquired and applied, there is clear evidence that learning strategies are malleable and can be taught or otherwise developed in students from preschool to college and across a wide range of subjects.

A limitation of the research on learning strategies is its reliance on self-reporting to determine the effectiveness of metacognitive skills training. In any given study, researchers cannot be sure whether metacognitive strategies have actually been "learned" and put to use or if students are simply telling researchers what they think they are supposed to say, based on the content of the training. Conversely, there is evidence that strategy use becomes increasingly automatic as students develop expertise, meaning that students use strategies without being consciously aware that they are using them (Ericsson & Smith, 1991; McKoon & Ratcliff, 1992; Rabinowitz & McAuley, 1990; Schoenfeld, 1985; Winne, 1996). This, too, can confound research based on student self-report of strategy use.

Some of the research is further limited by not specifically addressing student motivation to engage in the strategy use being studied. Researchers often make the assumption that students will be motivated and see the value of participating in the additional tasks and putting forth the additional effort required to utilize strategies to improve learning. A long line of research has shown a strong relationship between student motivation (e.g., academic mindsets) and strategy use, and attention to this relationship is sometimes missing from experimental studies of learning strategies.

What Is the Role of Classrooms in the Development of Learning Strategies?

The development of students' self-regulation and metacognitive strategies is crucial if schools are to teach adolescents to become effective learners. Students can improve their learning by paying attention to their thinking as they read, write, and solve problems. Many metacognitive strategies are subject-specific, meaning that strategies that help one learn math may be different from the strategies one would employ while reading history. Content-area classrooms are therefore primary sites for the development of students' learning strategies.

Beyond being places where the direct teaching of strategies could most beneficially occur, classrooms play another important role in students' use of learning strategies. Across several of the studies reported earlier, researchers found strong relationships between motivational factors and strategy use. As seen in Chapter 5 on academic mindsets, classroom context is a critical factor in the development of positive academic mindsets, which have been shown to have a strong positive relationship to strategy use in learning.

Pintrich and DeGroot (1990) found that seventh-graders' self-efficacy in science and English, as well as the degree to which they valued those subjects, were strongly related to their use of cognitive strategies and self-regulated learning strategies. Likewise, Pokay and Blumenfeld (1990) found that high school students who placed a high value on learning geometry were much more likely to use learning strategies of all kinds in geometry class. This is consistent with Paris, Lipson, and Wixson's (1983) earlier conclusion that it was not enough for students to know about learning strategies; only when students truly valued the work in a class did they voluntarily use strategies they knew about. To the extent that classrooms foster academic mindsets that help students believe that *I can succeed at this* and *This work has value for me*, they play a crucial role in encouraging students' use of learning strategies shown to improve academic performance. Further, teachers can directly teach students how to most effectively learn course material through the use of both subject-specific and more general learning strategies.

Are There Clear, Actionable Strategies for Developing Learning Strategies as Part of Classroom Practice?

All students can benefit from classroom instruction that builds metacognitive skills and learning strategies, such as monitoring, planning, and self-regulating. Self-observation and self-evaluation are critical metacognitive skills that enable students to self-regulate their behaviors and become effective learners (Bandura, 1986; Zimmerman, 1990). When teachers provide timely, ongoing feedback through formal and informal assessments (e.g., discussions, papers, or tests), students are better able to understand which strategies worked for them and where they need to improve. Prompting students to complete self-assessments of their performance provides them with opportunities to practice self-reflection and critique of their learning.

Students benefit when they learn subject-specific metacognitive strategies in the context of subject-area learning. Ironically, they are more apt to be able to transfer strategies across contexts when those strategies are first introduced and learned in very specific contexts. (Bransford et al., 2000). For example, Haller et al. (1988) point out that reading comprehension can be taught by engaging metacognitive strategies through a variety of mental activities involving awareness, monitoring, and regulating. One important metacognitive activity associated with reading consists of training students to be aware when they are not comprehending what is being read and then devising strategies to redirect and compensate for poor comprehension. Rereading, backward and forward search strategies, self-questioning, contrasting textual information with prior knowledge, and comparing main ideas with each other and with details from the text are all examples of learning strategies that may facilitate better understanding while reading.

Another effective instructional practice for teachers is to encourage students to talk about their thinking processes when planning out an academic task. Blakey and Spence (1990) offer the strategy of paired problem-solving where one student talks through a problem by describing his thinking processes while his partner listens and asks questions to help clarify thinking. Similarly, in reciprocal teaching (Palincsar, 1986), a "dialog between teacher and students that involves summarization of the text, question generation, clarification, and predictions about what will next occur in the passage" promotes enhanced learning through the direct teaching of these metacognitive strategies (p. 188). Other strategies enlist teachers to model for students their thinking process while engaged in a task (a "Think Aloud") which in turn provides students with the necessary language to talk about their own thinking processes.

Advances in technology and curriculum development are providing opportunities for teachers to take a more active role in promoting and teaching learning strategies, as reviewed by Bransford et al. (2000). For instance, White and Fredericksen (1998) used an innovative software tool called the Thinker Tools Inquiry Curriculum when teaching physics to typical seventh-, eighth-, and ninth-grade students in urban public middle schools. This is a physics curriculum which allows students to perform virtual physics experiments and compare their results with experiments performed using actual objects. The curriculum encourages students to use a metacognitive approach by highlighting the inquiry cycle and bringing awareness to students' own process of investigation, with time to reflect on their questions and the inquiries of others. Students learn not only about physics but also about processes of inquiry.

In one study, younger students who participated in Thinker Tools outperformed older students taking a traditional physics curriculum. Despite their younger age and lower pretest scores, the Thinker Tools participants (in grades seven through nine) scored higher than traditional physics students in grades 11 and 12 on qualitative problems in which they were asked to apply the basic principles of Newtonian mechanics to real-world situations. By using "an inquiry-oriented, model-based, constructivist approach to science education" that emphasizes metacognitive skills, Thinker Tools "appears to make science interesting and accessible to a wider range of students than is possible with traditional approaches" (White & Fredericksen, 1998, pp. 90-91, as quoted in Bransford et al., 2000, p. 217).

Teachers can use instructional strategies that promote self-regulation without technological aides. For instance, planning and time management are improved when students keep a detailed log of their use of time for one week and use the log to plan their future use of study time (Weinstein & Mayer, 1986). Researchers have also found that if students visualize completing their homework and intentionally think about ways to make it more challenging, it increases the likelihood that they will finish their work and be more deeply engaged in it (Snow, Corno, & Jackson, 1996). Researchers at the University of Victoria in British Columbia teach an on-campus course for college freshmen called "Learning Strategies for University Success," designed to help students develop a toolkit of strategies to learn more effectively and overcome academic challenges in all of their other university courses. A key part of the learning strategies course involves identifying the kinds of challenges one is encountering and then applying appropriate strategies to move forward in learning.

Duckworth, Grant, Loew, Oettingen, and Gollwitzer (2011) tested an intervention on high school students preparing for the PSAT exam using "mental contrasting" and "implementation intentions," two self-regulation strategies previously shown to improve goal commitment and goal attainment in adults. Mental contrasting involves juxtaposing one's vision for a desired future with the constraints or obstacles that might impede reaching one's goals. Implementation intentions refer to the identification of action steps to achieve one's goals, in the form of if-then statements: "if I encounter this obstacle, then I will take these steps." In the Duckworth et al. intervention, 66 students completed written exercises in May of tenth grade regarding the PSAT exam they planned to take the following October. Everyone answered some preliminary questions about their goals for the PSAT and their intentions to use practice tests to prepare for the exam over the summer. Students in the treatment group wrote more extensively about visualizing the successful completion of their goals for completing practice tests and identified foreseeable challenges to their test-preparation plans. Treated students also developed "if-then plans" which involved identifying specific action steps for how they would respond to the challenges they anticipated in completing their summer study goals. Students in the control group wrote about influential people or events in their lives. The May writing intervention took less than an hour total. In July students each received a PSAT practice booklet in the mail, which was collected immediately after completion of the PSAT exam in October. In analyzing the results of the intervention, researchers found that students in the treatment group had completed over 60 percent more practice items over the summer than students in the control group. The authors conclude that

> the present investigation suggests that adolescents can learn relatively simple self-regulation strategies that dramatically improve their ability to attain long-term academic goals. Teachers and schools may therefore consider whether their missions should extend to modelling and instructing students directly in optimal self-regulatory strategies, as well as offering structured opportunities to practice them. (Duckworth et al., 2011, p. 24)

Teaching adolescents to become learners depends in large part on the identification of effective strategies that teachers can share with students to help them achieve their academic goals.

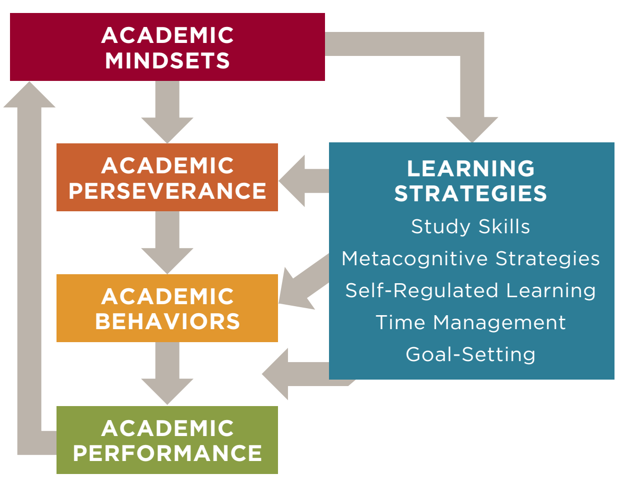
Beyond what we learn from research, practitioners are also a source for classroom practices designed to increase students' awareness and use of learning strategies. In the July 19, 2011, online issue of *Education Week Teacher*, middle school teacher Cossondra George offered teachers a variety of instructional strategies to help students "become responsible for their own learning" by explicitly modeling techniques for notetaking, reading, and studying. George had suggestions for demonstrating literacy techniques in class such as previewing reading passages and restating main ideas in one's own words; modeling how to take notes using a sample passage and giving students time to take notes in groups and compare strategies; encouraging students to set personal learning goals and dedicating time in class to reviewing progress toward those goals on a regular basis; and showing students different approaches to studying for tests, including using note cards to quiz themselves, making up test questions for one another, or playing review games. George also encouraged teachers to advise students to set aside small chunks of study time several days in a row rather than cramming the night before a test. All of these suggested instructional practices are consistent with the research on learning strategies.

Would Changing Students' Use of Learning Strategies Significantly Narrow Achievement Gaps?

There was very little evidence across studies about measured differences in learning strategies by race/ethnicity or gender. None of the research we reviewed reported collecting or analyzing data about students' race or ethnicity. While several studies included gender in their analysis, only the study of high school geometry students by Pokay and Blumenfeld (1990) reported differences in strategy use by gender. Girls used more learning strategies than boys, particularly early in the geometry course. The researchers suggest that this difference in strategy use could account for the finding that boys with low math self-concepts earned lower grades than girls with low math self-concepts, controlling for prior achievement. However, boys with high math self-concepts outperformed girls with high math self-concepts, leading the researchers to conclude that perhaps motivational factors "may be more facilitative for boys' achievement, whereas strategy use may be more facilitative for girls' achievement" (p. 48).

Further research is necessary to see if these conclusions are borne out. As with the other categories of noncognitive factors, the lack of research evidence does not mean that there are no differences in learning strategy knowledge or use by race or gender. Rather, this is a significantly under-investigated area about which we currently know very little. Hopefully future studies will examine these questions directly.

Summary of Research on Learning Strategies



We know that academic behaviors are the most proximal lever for improving student academic performance: better attendance, more studying, and higher homework completion rates would go a long way in improving students' grades. The evidence suggests that using appropriate learning strategies makes each of those academic behaviors more effective, resulting in deeper learning and higher performance. The use of effective metacognitive and self-regulation strategies may lead students to more actively engage in strong academic behaviors. After all, students are likely to spend more time studying, doing homework, and coming to class if they feel that engaging in such behaviors will lead to academic success. While much of the research is correlational rather than causal, there is a clear link between the use of learning strategies and academic performance.

Research also shows that students who place a high value on the work in a class and who believe they will be successful at it are much more likely to use metacognitive and self-regulated learning strategies when doing that work. Academic mindsets and use of learning strategies have a strong and consistent positive relationship across a wide variety of studies in several different subject areas with students in middle grades, high school, and college. This suggests that classrooms are important both as sites for the explicit teaching of learning strategies and as contexts that set motivational conditions for learning and strategy use.

We found numerous examples of short-term studies designed to evaluate the effectiveness of particular programs or the teaching of specific strategies, usually involving researchers specifying the strategies they wanted to test. However, we could not find any studies of teachers' "natural practice" in developing students' learning strategies or of the effectiveness of existing practice across grade levels and academic subjects. We also found little longitudinal research on any potential long-term effects of learning strategy use on student motivation and academic performance. This is surprising, given the important role of learning strategies in facilitating student understanding of course material and improving students' grades. The learning strategies course at the University of Victoria is the only formalized example we found of explicit instruction in learning strategies designed to improve student performance across subject areas.

CHAPTER 7

Evidence on Social Skills

Social behaviors or **Social Skills** have been linked to academic performance in elementary, middle, and high school, although the preponderance of this research is at the elementary grade level, with a particular focus on primary grades (DiPerna & Elliott, 1999; Feshbach & Feshbach, 1987; Green, Forehand, Beck, & Vosk, 1980; Gresham & Elliott, 1990; Lambert & Nicholl, 1977; Wentzel, 1991). The effect of social skills or behaviors on academic performance is often unclear from the literature. Most studies of social skills come from a broader field of research on social and emotional learning.[8] Gresham & Elliott (1990) give an expansive definition of social skills as "socially acceptable learned behaviors that enable a person to interact effectively with others and to avoid socially unacceptable responses" (p. 1). Such skills include cooperation, assertion, responsibility, empathy, and self-control (Malecki & Elliott, 2002). The Collaborative for Academic, Social, and Emotional Learning (CASEL) lists five "social-emotional learning core competencies" of self-management, self-awareness, social awareness, relationship skills, and responsible decision-making. Examples of ways students demonstrate responsible decision-making include "studying and completing their homework and [using] problem-solving and relationship skills to overcome obstacles" (Greenberg et al., 2003, p. 470). Given the overlap of social behaviors, mindsets, and academic behaviors in much of this work, it is difficult to extract the "social skills" components from other noncognitive factors in this body of research. For the purposes of our review, where research focused on social skills in combination with other factors, we tried to isolate the findings on social skills. However, because studies tend to confound social skills with other variables, we were not able to always isolate the effects of social skills from other noncognitive factors.

What Is the Relationship Between Social Skills and Academic Performance?

There is evidence that work on students' social-emotional skills can have positive effects on school performance but, again, most of this research examines other noncognitive factors in combination with social skills. In a longitudinal study following students through grades one, three, and six and at age 16, researchers found that "socio-emotional adjustment in school" was predictive of achievement test scores at every time point (Teo, Carlson, Mathieu, Egeland, & Sroufe, 1996). Much of the work done in the area of social skills training programs focuses on younger children (pre-K and elementary grades) and often measures results in terms of improved behavior rather than measures of academic performance (Bierman, 1986; Bierman & Furman, 1984; Bierman, Miller, & Stabb, 1987; Coie & Krehbiel, 1984; Ladd, 1981). CASEL published a review of research on 80 programs focused on "social and emotional learning" (SEL), only 20 of which even considered academic outcomes; others were directed toward substance abuse prevention, violence prevention, healthy sexual development, and overall promotion of health (Collaborative for Academic, Social, and Emotional Learning, 2003).

A recent meta-analysis of school-based interventions for enhancing social and emotional learning in students from kindergarten to high school concluded that there were positive effects of social-emotional interventions on academic achievement (Durlak et al., 2011). They found that, in the 35 studies that included academic achievement measures, SEL interventions had an average effect size of 0.33 on student grades and 0.27 on achievement test scores, the latter translating to a percentile difference of 11 percent. Grades only improved in studies where classroom teachers were responsible for delivering the intervention (as opposed to delivery by nonschool personnel). Unfortunately, this analysis cannot disentangle the effect of "social skills" from myriad other social-emotional development concepts. Search terms used to identify relevant studies for Durlak and colleagues' meta-analysis included: *social and emotional learning, competence, assets, health promotion, prevention, positive youth development, social skills, self-esteem, empathy, emotional intelligence, problem-solving, conflict resolution, coping,* and *stress reduction*, and studies qualified for inclusion if they targeted the development of at least one of these skills (Durlak et al., 2011, pp. 408-409).

One theory behind social-emotional learning is that the effects on academic performance are largely indirect, enacted through students' behaviors in the classroom. In other words, if one could develop students' competencies in the areas of self-awareness, self-management, social awareness, relationship skills, and responsible decision-making, then students would engage in more positive social behaviors and have fewer problems with misconduct and less emotional distress, resulting in more engagement in the classroom and hence better test scores and grades (Collaborative for Academic, Social, and Emotional Learning, 2003; Greenberg et al., 2003). Therefore, social skills may improve learning by enhancing social interaction that gives rise to learning (Vygotsy, 1978; Bandura, 1997) or may minimize disruptions to learning and thus have an indirect effect on students' grades (social skills → learning → grades).

Alternatively, it could be that teachers value prosocial behavior; they reward "good" social behavior directly with higher grades while penalizing behavioral interruptions with lower grades (social skills → grades). Indeed, studies of classroom grading practices show that teachers often do include student behavior as a factor when calculating grades. In one study of 307 middle and high school teachers, 37 percent reported including student behavior in their grades (Cross & Frary, 1999). In another study of district and school grading policies, while only 11 percent of school board and district documents specifically mentioned student behavior and attitude as a criterion in grading, 21 percent of school-level documents in those same districts acknowledged behavior and attitude as a factor considered in students' grades (Austin & McCann, 1992). This suggests that social skills may improve student performance not because they improve learning, but because they are sometimes considered directly in the calculation of students' grades.

Evidence from elementary and middle school suggests that social skills increase academic performance because they allow students to participate productively in classroom activities that foster learning. Slavin's work (1995) on the positive associations between cooperative learning and academic achievement would contribute to this idea. Likewise, Wentzel (1993) found that prosocial behavior (e.g., helping, sharing, and cooperating) and antisocial behavior (e.g., breaking rules and fighting) of sixth- and seventh-grade students (n = 423) each significantly and independently predicted GPA, although only prosocial behavior predicted achievement test scores. In a study of both positive social skills and problem behaviors in third- and fourth-graders in an urban Massachusetts district, Malecki and Elliott (2002) found that student social skills were positively correlated with concurrent grades, while problem behaviors were negatively correlated with concurrent grades. Positive social skills also predicted future academic performance. The study's findings affirmed earlier research by Wentzel (1991) that social skills acted as "academic enablers in school environments" for the elementary students they studied (Malecki & Elliott, p. 18). Wentzel (1993) found that most of the positive effects of social skills on grades were mediated by academic behaviors. She suggested that students who exhibit positive social skills in the classroom (e.g., cooperation or willingness to follow rules) would likely finish schoolwork as expected by their teachers.

A serious limitation of the studies showing a link between social skills and academic performance is that almost all are correlational rather than causal, meaning that measures of social skills and academic performance are taken at the same time. They generally do not provide evidence of the direction of the association between social skills and achievement: Do positive social skills contribute to increased learning, while problem behaviors decrease learning? Or does academic success contribute to positive social and academic behaviors in school, while academic difficulty contributes to problem behaviors? It is likely that social skills and academic performance are mutually reinforcing, but current research does not answer these questions definitely.

Most of the work showing relationships between social skills and grades was done at the elementary school level. Perhaps social skills have a weak direct relationship with course grades in high schools because most high school classrooms tend to minimize the social and cooperative aspects of learning. In contexts where individuals must work collaboratively in problem-solving teams, social skills may be more directly related to performance. Longitudinal studies at the middle school and high school levels are needed if we are to better understand the potential effects of social skills on academic performance over time and the mechanisms whereby social skills may impact grades.

Are Social Skills Malleable?

There is extensive research on social skills training programs that shows they are generally effective interventions, although the methodological strength of these studies varies (Quinn, Kavale, Mathur, Rutherford, & Forness, 1999; Beelmann, Pfingsten, & Losel, 1994; Coleman, Pfeiffer, & Oakland, 1992; Boyle & Hassett-Walker, 2008; McGinnis & Goldstein, 1997). Many of these programs address skill deficits of elementary school aged children, and effect sizes generally vary as a function of the extensiveness and scope of the particular program. Programs that are led by well-trained professionals are more likely to produce change, and outcomes are greater for normal populations of children than children who exhibit clinically significant deficits. Intervention programs address a range of outcomes, which include problem-solving skills training, interpersonal relationship development, coping skills enhancement, and aggression replacement training. Those programs that draw upon behavioral skill-building approaches have also been found to lead to more enduring change, compared to those that do not focus on a specific behavioral skill. Programs designed to be implemented on a formal, school-wide level include those aimed to address problem behaviors in students through such approaches as behavior modification (Lee & Axelrod, 2005; Sarafino, 2001), or, more recently, School-wide Positive Behavior Supports (SWPBS) or Positive Behavioral Interventions and Supports (PBIS) programs (Bradshaw, Reinke, Brown, Bevans, & Leaf, 2008). In their meta-analysis of 213 universal, school-based social-emotional development programs, Durlak et al. (2011) found an average effect size of 0.69 on social-emotional skill performance, indicating that indeed social skills such as emotions recognition, stress management, empathy, problem-solving, or decision-making skills can be intentionally developed through school-based programs.

What Is the Role of Classrooms in Shaping Social Skills?

Schools and classrooms play an important role in shaping students' social skills. Even where educators view poor student social behavior as a property of individual children that has to be addressed, the strategy for changing student behavior often involves implementing school- or classroom-level systems or programs of behavioral supports. Nonetheless, there is often little acknowledgement that school and classroom systems and structures might be implicated as either causing or exacerbating poor social behavior. A review of the What Works Clearinghouse Personal/Social Development outcome domain reveals that the majority of interventions are focused on "character education" at the elementary and middle school levels. The handful of school-based programs—such as Too Good for Violence (Hall & Bacon, 2005), Skills for Adolescence (Eisen, Zellman, & Murray, 2003), and Connect with Kids (Page & D'Agostino, 2005)—that show positive effects on behavior involve scripted curricula intended to be taught by teachers trained specifically by the curriculum developer. These curricula often include role-playing and cooperative learning exercises that promote good classroom citizenship. Research on these programs focuses on behavioral outcomes that are not tied directly to academic performance.

Durlak et al. (2011) emphasize the importance of school and classroom contexts for positive social-emotional functioning. In addition to "person-centered explanations of behavior change," they note that research also demonstrates that interpersonal, instructional, and environmental factors affect students' social behavior and academic performance, including:

> …(a) peer and adult norms that convey high expectations and support for academic success, (b) caring teacher-student relationships that

> foster commitment and bonding to school, (c) engaging teaching approaches such as proactive classroom management and cooperative learning, and (d) safe and orderly environments that encourage and reinforce positive classroom behavior (e.g., Blum & Libbey, 2004; Hamre & Pianta, 2006; Hawkins et al., 2004; Jennings & Greenberg, 2009). It is likely that some combination of improvements in student social-emotional competence, the school environment, teacher practices and expectations, and student-teacher relationships contribute to students' immediate and long-term behavior change (Catalano et al., 2002; Schaps et al., 2004). (Durlak et al., 2011, p. 418)

In reviewing the research on SEL, they note that effective SEL programming fosters students' social-emotional development "through establishing safe, caring learning environments involving peer and family initiatives, improved classroom management and teaching practices, and whole-school community-building activities" (Cook et al., 1999; Hawkins et al., 2004; Schaps, Battistich, & Solomon, 2004), further noting that "together these components promote personal and environmental resources so that students feel valued, experience greater intrinsic motivation to achieve, and develop a broadly applicable set of social-emotional competencies that mediate better academic performance, health-promoting behavior, and citizenship (ref. Greenberg et al., 2003)," (Durlak et al., 2011, p. 407).

Are There Clear, Actionable Strategies for Developing Social Skills as Part of Classroom Practice?

Social and emotional skills programs we reviewed are primarily geared for elementary-aged students or are designed to move students in special education programs into a mainstream or inclusive classroom. In their review of "universal" school-based programs, meaning those designed for all children in a school rather than particular subpopulations of students, Durlak et al. (2011) note such programs generally involve teaching students to process, integrate, and selectively apply social-emotional skills in appropriate ways, given students' stage of developmental, as well as contextual and cultural norms (Crick & Dodge, 1994; Izard, 2002; Lemerise & Arsenio, 2000). By systematically teaching and modeling SEL skills and giving students opportunities to practice and apply them in a variety of situations, the goal is to encourage students to include SEL skills "as part of their daily repertoire of behaviors (Ladd & Maze, 1983; Weissberg, Caplan, & Sivo, 1989.)" (p. 406).

All the research reviewed here was based on intervention programs designed to develop students' social-emotional competencies which include social skills in addition to other noncognitive factors. Effective training programs involved sequenced step-by-step approaches that actively involved students in skill development over extended periods of time and had clear and explicit goals, and programs were most effective when implemented with fidelity (Bond & Hauf, 2004; Durlak, 1997; Durlak et al., 2011, Dusenbury & Falco, 1995; Gresham, 1995). Unfortunately, this leaves little direction for classroom teachers wanting to support the positive development of social skills in their students outside of a formal program.

Would Changing Social Skills Significantly Narrow Achievement Gaps?

The research cited here gives little indication as to whether changes in students' social skills would narrow racial and/or gender achievement gaps. In attempting to validate their Academic Competence Evaluation Scale (ACES) and its relation to social skills and problem behaviors, DiPerna and Elliott (1999) found differences between White and minority students on teacher-report measures of interpersonal skills, among other measures of academic competence. Overall, minority students were given ratings lower than White students on each of the ACES components, yet further analyses were not able to determine whether the differences were a function of the instrument or of actual sample differences between White and minority students. Malecki and Elliott (2002) found no significant differences between White and minority elementary school students in social skills or problem behaviors at two time points. They noted higher correlations between teacher assessments of social skills and academic competence for White students than minority students. Wentzel (1994) found that White middle school students were perceived to be more prosocial by their peers and teachers and more likely to pursue prosocial and academically responsible goals than African American students. In the same study, girls scored higher than boys in social goal pursuit, social behavior, social acceptance, and perceived support. Attempting to isolate the effects of both prosocial and antisocial behavior, Wenztel (1993) finds a significant negative relationship between antisocial behavior and academic achievement (as measured by GPA), but does not indicate the extent to which this relationship differs significantly by race or gender.

These findings are limited in the conclusions that can be drawn about social skills differences in adolescents. The correlational nature of most research on social skills makes causal interpretation difficult, and in none of these studies do the authors offer interpretations of measured racial/ethnic or gender differences when they found them. Additionally, much of this work looks at social skills in elementary and middle school contexts; it is likely that social skills will manifest differently as young people progress through adolescence and enter high school and college settings that require different ways of interacting with one's environment.

Beyond the difficulty in determining causation, another issue looms large in the discussion of social skills and achievement gaps: the disproportionate number of minority students, and African American males specifically, who experience disciplinary action in school because of behavioral infractions (Gregory, Skiba, & Noguera, 2010). Given the racial and gender disparities in patterns of disciplinary action, it is necessary to consider whether certain aspects of social skills (i.e., antisocial behavior) are interpreted differently for different groups of students. In the report, *America's Youth: Transitions to Adulthood* (2011), the National Center for Education Statistics (NCES) reports that 57 percent of high-school-age African American males had been suspended[9] in 2007, a significantly higher percentage than any other grouping of students by race or gender.

In synthesizing the literature on the "discipline gap" and how it potentially affects the achievement gap, Gregory et al. (2010) point to research that suggests minority students may experience undue disciplinary action in school. The authors consider several explanations for the disproportionality in discipline patterns, including demographic background information, prior achievement, and differential behavior as possible student-level contributors (Anderson, 1999; Bauer et al., 2008; Brantlinger, 1991; Kuther & Fisher, 1998; McCarthy & Hoge, 1987; Stewart, Schreck, & Simons, 2006; Wallace et al., 2008; Whelage & Rutter, 1986), and differential selection and processing as potential school-level contributors (Skiba et al., 2002; Vavrus & Cole, 2002; Whelage & Rutter, 1986). Overall the literature suggests that race is the most significant of student characteristics that explains the discipline gap. While correlational evidence suggests that exposure to violence and low achievement are also related to the discipline gap, race still remains as a strong predictor. Socio-economic status had little effect, and one study found that African American students in a higher-income suburban school district still were more likely to be suspended (Rausch & Skiba, 2004). Gregory et al. (2010) also highlight research suggesting that schools may be disproportionally responding to antisocial behavior with harsher punishment for minority students than for White students who display similar behavior (McFadden et al., 1992; Skiba et al., 2008; Wallace et al., 2008).

As it stands, further research is needed to disentangle how discipline patterns, antisocial behavior, and social skills are related, and how each affects academic outcomes or contributes to group-based achievement gaps. The correlational evidence available does not either specify the mechanisms through which these factors may affect academic performance or accurately specify causal direction.

Summary of Research on Social Skills

In our model of noncognitive factors, **Social Skills** have the weakest evidence of a direct relationship with grades, in part because measures of social skills or social-emotional competencies overlap extensively with other noncognitive factors. Without more concise boundaries delineating the concept of social skills, the existing evidence cannot distinguish the effects of social skills from other effects. Social skills are important for adolescents as they prepare for future work and interacting in the "real world," but social skills are less utilized in the way classrooms are currently structured where independent tasks and assignments largely determine a student's individual grade. The exception to this may be when the context of the classroom focuses on collaboration and group work; in this situation, stronger social skills may prevail as having a stronger, direct relationship with grades. More research is needed which takes school and classroom context into consideration in examining how social skills may contribute to grades and learning for adolescents across a variety of school settings.

CHAPTER 8

The Role of Noncognitive Factors in School Transitions

Throughout this review, we argue that if research and initiatives around noncognitive factors are to be useable, we need to move beyond evidence from isolated studies to a broader framework that situates the discussion within classrooms and schools. Making the research actionable requires addressing three problems. First, we need to be much more specific about *what matters and why*, which means understanding what noncognitive factors most shape school performance during adolescence and how these factors interact. Second, we need to understand *when noncognitive skills matter*, which means situating the research evidence within a framework of the cognitive, social, and academic development of adolescents. Are there key developmental points of intervention? When in students' school careers is the development of specific skills, behaviors, attitudes, or strategies most critical in shaping academic performance? And, third, we need to understand *how* critical noncognitive factors can be taught or developed. We illustrate how these issues come together with case studies of three transition points in students' academic careers—the middle grades, the transition to high school, and the transition to college.

CASE STUDY 1

Noncognitive Factors in the Middle Grades Context

The story of the middle grades illustrates how the elements of our conceptual framework come together—how context influences academic mindsets, and how mindsets shape the development of noncognitive factors. The specific focus on the middle grades highlights the importance of considering students' developmental stage when setting up a context where they are likely to be successful.

As shown in this case study, students' developmental stage interacts with the types of tasks they face to promote or discourage academic mindsets that foster engagement and academic success in school.

In the late 1980s and early 1990s, developmental psychologists studying adolescents focused on understanding a critical phenomenon: for many early adolescents, the middle grades are characterized by decreases in school performance and engagement. These declines are observed both in measures of school performance (e.g., grades) and in attitudinal measures of students' confidence in their academic abilities, motivation, and attitudes toward school (Anderman & Maehr, 1994; Blyth, Simmons, & Carlton-Ford, 1987; Roderick, 1991).

The story that emerged is critical for understanding the role of noncognitive factors—particularly academic perseverance—in declining motivation and school performance during early adolescence. Developmental psychologists have long described cognitive changes in early adolescence, particularly how students begin to have new capacities for formal thought, regulation of behavior, and attributions (e.g., distinguishing between "working hard" and "lacking ability"). How-ever, instructional environments in the middle grades often do not take into account these new capacities or help students develop the academic mindsets and learning strategies they need to successfully take on and persist in new academic demands. As early adolescents are starting to equate having to work hard with lacking ability, changes in classroom environments and teacher practices begin to emphasize the relative ability of students and to reward students for whom achievement comes easily rather than those who have to put in effort to achieve. At the same time, there is evidence that early adolescence is a key window of opportunity where students are cognitively ready to develop new learning strategies and skills around persistence.

Cognitive Change During Adolescence

Developmental psychologists have long characterized adolescence as a period marked by major developmental shifts in children's cognitive and emotional capacities, including the ability to take the perspectives of others, to self-regulate, and to engage in more formal thought. Piaget characterized adolescents as developing the capacity for "formal operations" and being able to consider multiple dimensions of problems and develop more sophisticated approaches to processing information (Flavell, 1963). It is clear that adolescents begin to "think" differently than they had as children. Until recently, however, the mechanisms for why these changes in cognition occur were not clear. Recent research in neurobiology using brain imaging has filled in these important pieces of the puzzle. The prevailing evidence suggests that the prefrontal cortex matures later than other regions of the brain, developing during adolescence. The prefrontal cortex is the area of the brain that controls “executive functioning” and is linked to social cognition, specifically the ability to see the perspectives of others. In addition, brain synapses—the timing and pathways that the brain uses to process information—also advance significantly during adolescence. Deborah Yurgelun-Todd provides a succinct account of these changes:

> Adolescence is a critical period for maturation of neurobiological processes that underlie higher cognitive functions and social and emotional behavior.... The prefrontal cortex matures later than other regions and its development is paralleled by increased abilities in abstract reasoning, attentional shifting, response inhibition and processing speed. Changes in emotional capacity...are also seen during adolescence...In summary, brain regions that underlie attention, reward evaluation, affective discrimination, response inhibition and goal-directed behavior undergo structural and functional re-organization throughout late childhood and early adulthood. (Yurgelun-Todd, 2007, abstract)

Thus, as children enter early adolescence they begin to use their brains and process information differently: they think more abstractly, they problem-solve differently, and they have greater capacity to use information to shape behavior. This information processing difference is reflected in adolescent behavior. First, an increased capacity for perspective-taking means that, as students enter the middle grades, adolescents become much more aware of how others see them. The perceptions of others, in turn, begin to shape adolescents’ views of themselves to inform their behavior. Second, an increased capacity for decision-making and control means that adolescents become autonomous social actors—they become players in their environment in real ways, making motivation, coping, choices, and relationships ultimately more important to shaping their behavior. Third, the ability for more abstract thought and self-assessment means that adolescents begin to make decisions about motivation and engagement on the basis of feelings of competence, their valuation of the task for both present and future, and their feeling of belonging and social connectedness.

The increasing salience of the distinction between ability and effort during early adolescence is a prime example of how these cognitive shifts converge to influence students’ academic performance. Covington (1984) argues that younger children are not able to distinguish between ability and effort. However, as adolescents enter the middle grades, they begin to equate working hard with a lack of ability (e.g., the greater the amount of work required, the less able I must be). Research finds that adolescents’ beliefs about learning and the nature of intelligence fundamentally shift to underscore the importance of ability as a latent characteristic (Dweck & Leggett, 1988; Nicholls, 1986, 1989; Nicholls & Miller, 1985). The salience of social comparison heightens a sense of vulnerability and exposure—underscoring a perceived relationship between working hard and a lack of underlying ability. This heightened sense of vulnerability, combined with a growing sense of self-efficacy and a greater recognition of the ability to manipulate their environments through their behavior, underlie adolescents’ decisions about whether to engage or withdraw effort in classroom settings. In an effort to not look dumb, adolescents may adopt behaviors and strategies to avoid failures—devaluing challenging tasks, self-handicapping, and withdrawing effort altogether.

In summation, the accelerated development of students’ cognition during early adolescence sets the middle grades apart as a key window of opportunity and of risk. On the one hand, during early adolescence, children are developing the capacity to define and establish goals, regulate their behavior, and articulate an increasingly clear sense of themselves as efficacious learners. On the other hand, students’ failure to develop strategies and skills during the middle grades can both create skill deficits and reinforce maladaptive patterns of withdrawal and disengagement. Central to addressing declines in school performance is attending to adolescents’ conceptions about the nature of intelligence and hard work. Given these changes in students’ attribution of efforts, developing approaches to teach students that ability is not fixed would appear to be critical and a high payoff approach to addressing declines in engagement during adolescence as well as improving the degree to which students persevere in academic tasks.

What is critically important about the body of knowledge in the middle grades is that declines in motivation and engagement are not inevitable. Indeed, the general conclusion that arose in this work was that declines in school engagement in this period are largely the product of classroom and school environments. So what goes wrong in the middle grades?

What Goes Wrong: Stage-Development Mismatch in the Middle Grades

In the 1980s, Jacquelynne Eccles and Carol Midgley began a series of seminal studies that situated the problem of declining student motivation and effort during the middle grades within school and classroom contexts (Eccles, Lord, & Midgley, 1991; Eccles & Midgley, 1989; Eccles, Midgley, & Adler, 1984). Eccles and her colleagues argued that changes in middle grades classroom environments and teacher practices, coinciding with developmental changes in adolescent cognition and social behavior, help to explain declines in students' effort, grades, and attachment to school across the transition to middle school. The story is simple: there is a mismatch between the developmental needs of adolescents and the conditions set by teachers within middle grades classrooms. Paradoxically, at a time when adolescents are becoming developmentally ready to assert increasing personal autonomy and assume greater responsibility for their learning, middle grades classrooms become more (not less) restrictive, placing greater emphasis on teacher control and diminishing opportunities for student choice and independence. Second, at a time when early adolescents become increasingly sensitive to social comparison, instructional practices in middle grades classrooms tend to reward ability over effort and highlight social comparison. Third, at a time when adolescents develop the ability to engage in more complex, abstract forms of problem-solving, the academic demand of class assignments declines during the middle grades—schoolwork often becomes less (not more) challenging. Thus, Eccles and her colleagues conclude that declines in school performance largely resulted from a developmental mismatch between the needs of adolescents and their school environment. They summarize the differences observed between elementary and middle school classrooms:

> First, junior high school classrooms, as compared with elementary-school classrooms are characterized by a great emphasis on teacher control and discipline, less personal and positive teacher-student relationships, and fewer opportunities for student decision making, choice and self-management… Second, the shift to junior high school is associated with an increase in practices such as whole-class task organization, between-classroom ability grouping and public evaluation of the correctness of work, each of which is likely to encourage the use of social comparison and ability self-assessment leading to a decline in the motivation of all but the most able students. Third, there is evidence that class work during the first year of junior high school requires lower-level cognitive skills than class work at the elementary level. Finally, junior-high-school teachers appear to use a higher standard in judging students' competence and in grading their performance than do elementary school teachers, which leads to a decline in the grades received by most students. (Eccles, Lord, & Midgley, 1991, pp. 533-534)

Research on motivation theory would suggest that these contextual conditions and teacher practices work to undermine rather than promote engagement in learning among early adolescents.

Teaching Adolescents To Be Learners in the Middle Grades

The misfit between the developmental capacities and needs of adolescents and the structures and demands of middle grades classrooms helps us understand the widely observed declines in effort, grades, and school attachment. At a critical moment, adolescent students and teachers are moving farther apart rather than converging in their needs and demands. What we also know, however, is that we can close the gap between students' needs and classroom practices. These studies suggest that the intentional choices adults make about assignments and the structure of middle grades classrooms can set conditions that give students opportunities to develop the academic mindsets and learning strategies that will lead them to persevere towards their goals and act in a persistent manner.

Creating successful school and classroom contexts requires that students be developmentally ready to meet new challenges; that learning environments be structured to give students scaffolded opportunities to engage in and wrestle with new challenges; and, finally, that schools and classrooms be intentionally structured to support teachers and students in that work over time. Evidence from developmental psychology suggests that students entering the middle grades are developmentally ready to tackle and solve a variety of new types of problems; however, extensive research finds that middle grades classrooms provide few meaningful opportunities for students to take ownership of and engage in this work.

CASE STUDY 2

Supporting Positive Academic Behaviors in Ninth Grade

While developmental psychologists in the 1990s were studying the transition into middle school and junior high school to explain declines in school engagement during early adolescence, education researchers began to focus attention on the transition to high school as a potentially important point of intervention to address school dropout.

The Transition to High School as a Critical Point of Intervention

In one of the first studies to draw attention to the high school transition, Roderick (1994) found a clear pattern that distinguished the academic trajectory of dropouts from graduates. Students who later dropped out of high school experienced dramatic declines in their grades and attendance—and equally as dramatic increases in course failures—as they moved into high school, regardless of the grade in which they dropped out. Indeed it was largely during normative school transitions that the academic trajectories of dropouts diverged from those of students who would later graduate.

This finding—that a student's capacity to manage the high school transition plays a unique role in predicting school dropout—has now been replicated in multiple studies (Allensworth & Easton, 2007; Felner, Ginter, & Primavera, 1982; Neild, Stoner-Eby, & Furstenberg, 2008; Roderick & Camburn, 1999). In Chicago, CCSR researchers estimate that the link between ninth-grade course failure and eventual dropout is so strong that each additional failed semester course in the first year of high school is associated with a 15 percentage point decrease in the probability of graduating. In other words, failing one full-year course in ninth grade decreases the likelihood of graduating by 30 percentage points (Allensworth & Easton, 2007).

Why would a student's performance in this one period of time be so strongly linked to school dropout? In this case study, we draw on findings from studies of ninth grade at CCSR and research from other places to summarize what we know about why students' school performance declines so significantly, the role of noncognitive factors, and the link to school dropout.

To summarize the story we have assembled, as students start high school, particularly in urban areas, they experience dramatic increases in the complexity of their school environment—in the number of classes and teachers they interact with, in the academic demands of their coursework, and in the size of their school and peer groups. Students must learn to deal with increased independence and more diverse academic demands. They must negotiate and manage relationships with a new set of peers and multiple teachers. This is an important developmental period for the formation of academic behaviors.

The problem is that high school environments are not structured to support the development of those academic behaviors. High school teachers, moreover, are often ill equipped to develop these skills in their students. Thus, at the same time that adolescents are facing new academic and developmental challenges, they experience striking reductions in support and in the monitoring of their performance. Not surprisingly, many students have difficulty managing these new demands. While grade failure in Chicago is not common in the middle grades, ninth-grade failure is widespread. Over half (53 percent) of ninth-graders in Chicago fail at least one semester of a course; 41 percent fail two or more.

Most educators assume that high rates of course failure in ninth grade and declines in students' grades upon entrance to high school are due to students' low skills: the problem, the argument runs, is that students do not have the academic skills to meet the new higher levels of content demands in high school courses. However, the evidence does not support that explanation. Indeed, what is particularly important about the high school transition is that students' grades drop in ninth grade because of dramatic changes in their *academic behaviors*, and this decline occurs among students with strong academic skills as well as among students with weak skills. Because few, if any, teachers are making ninth-grade students come to class and get their work done, they come to view as optional key behaviors like regular attendance, studying, and completing homework. The changes in academic behaviors during the transition to high school are striking. Absences in Chicago nearly triple between eighth and ninth grades, and students' homework completion declines dramatically.

The good news is that these declines in academic behaviors and school performance are largely avoidable. While high schools cannot directly change the entering skills or family background of their students, they can intervene to ensure that students are attending class regularly and they can monitor and intervene quickly when students begin to fall behind in their homework. As we will discuss, efforts in Chicago to improve the proportion of students who are "on-track" to graduation have led to significant increases in the proportion of ninth-graders passing their classes. Evaluations of interventions, such as Talent Development High School's Ninth Grade Success Academies, similarly find that interventions designed to improve support for freshmen are effective in reducing course failure and create impacts that are sustained over time.[10]

Ninth Grade: A Place Where Students "Get Stuck"

School transitions are a challenging time for any adolescent. Studies consistently find that, on average, students' grades, attendance, and attitudes towards school decline following a normative school move—whether they are making the transition to middle school, junior high school, or high school (Blyth, Simmons, & Carlton-Ford, 1983; Crockett, Petersen, Graber, Schulenberg, & Ebata, 1989; Eccles, Lord, & Midgley, 1991; Feldlaufer, Midgley, & Eccles, 1988; Felner, Ginter, & Primvera, 1982; Roderick, 1994; Schulenberg, Asp, & Petersen, 1984; Seidman, LaRue, Aber, Mitchell, & Feinman; Simmons, Black, & Zhou, 1991; Simmons & Blyth, 1987). Urban and minority students are particularly at risk. Urban adolescents' school performance, involvement, and perception of the quality of their school environments decline markedly as they move to middle school and high school (Reyes, Gillock, & Kobus, 1994; Roderick, 1994; Seidman et al., 1994; Simmons, Black, & Zhou, 1991).

Declines in school performance, however, are even more striking in the transition to high school in urban areas because of high rates of absenteeism and course failure. Course failure makes the impact of the ninth-grade transition particularly acute. Failing individual subjects in high school takes on a significance that it did not have in elementary school. In a system where progress is measured by credits accumulated toward graduation, the failure of even one or two classes retards expected progress and represents a large barrier to advancement. Academic failure also undermines school engagement and a sense of belonging, leading students to begin adopting negative school attitudes and behaviors with an eventual downward spiral in performance (Kaplan, Peck, & Kaplan, 1997; Roderick & Camburn, 1996). Just as importantly, without adult intervention, there is little recovery from failure. Students who fail a course in the first semester are at increased risk of failing additional courses the next semester (Roderick & Camburn, 1999).

Lack of credit accumulation is critical to the link between the ninth-grade transition and school dropout. In a review of research on the high school transition, Ruth Neild (2009) characterized ninth grade as a "place in the educational progression where students…are at increased risk of getting stuck" (p. 56). Using data from Philadelphia, Neild and her colleagues found that one-third of dropouts had never accumulated enough credits to move to sophomore standing, even though they had been enrolled in high school for several years. Roderick (1996) documented a similar pattern in Chicago: nearly half (46 percent) of Chicago students who left high school at age of 17 or older left with fewer than five credits (never having completed ninth grade) after being enrolled approximately three years; 70 percent had fewer than 10 credits.

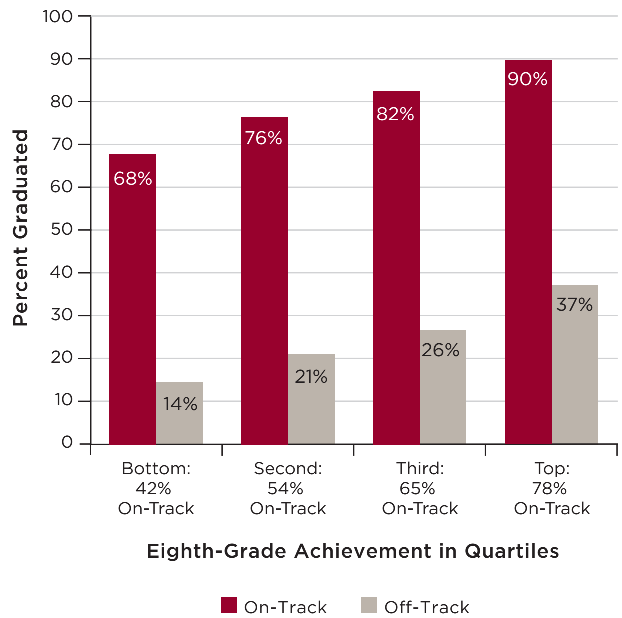
Ninth-Graders with Strong Attendance and Good Grades Are More Likely to Graduate

The importance of ninth-grade course failures was brought into sharp focus with the development of CCSR's on-track indicator. The on-track indicator assesses whether freshmen were "on-track" to graduate on time by having failed no more than one semester of a core subject and having completed enough credits by the end of ninth grade to be promoted to tenth grade.[11] In 2005, 40 percent of CPS first-time freshman were off-track at the end of ninth grade. Ninth grade "on-track" proved to be a powerful leading indicator of graduation. Student who are on-track at the end of ninth grade are nearly four times more likely (81 versus 22 percent) to graduate four years later than students who are off-track.

Importantly, students' course performance in ninth grade has an impact on the likelihood of graduation independent of their academic skill levels. Many educators attribute high rates of course failure to students not being academically ready to manage new high school environments. In this view, course failure is simply a reflection of what skills students bring with them into high school. The evidence, however, is that while academic difficulty in ninth grade is more prevalent among students with low achievement, it is not isolated to these students. Figure 8.1 presents ninth-grade on-track rates and graduation rates by students' entering achievement. Of students who entered CPS high schools with eighth-grade test scores in the third quartile (roughly equivalent to being in the third quartile on

FIGURE 8.1

Four-Year Graduation Rate by Freshman On-Track Status and Incoming Reading and Mathematics Achievement (Students Entering High School in 2000)



Source: From Allensworth, E., and Easton, J.Q. (2005). *The on-track indicator as a predictor of high school graduation.* Chicago: University of Chicago Consortium on Chicago School Research. p. 9.

national norms), fully 35 percent were off-track at the end of freshman year, and only one-quarter (26 percent) of those who were off-track graduated. Thus, many freshmen who entered high school with test scores at or above national norms had difficulty in the transition, and that difficulty was a significant predictor of whether they would graduate. Conversely, many students with weaker skills managed to be successful freshman year and, if they did so, they had much higher probabilities of graduating than students with higher entering achievement who fell off-track in ninth grade. This does not mean that entering test scores do not matter. Ninth-graders with lower test scores were more likely to be off-track. But the difference in graduation rates between high- and low-achieving students was not nearly as large as the difference in graduation rates between those ninth-graders who were on- and off-track within achievement levels. What this means is that a student's freshman year performance shapes his or her chances of graduating independent of prior achievement (Allensworth & Easton, 2007).[12]

Academic Behaviors, More Than Tested Achievement, Predict Course Failure in Ninth Grade

The pattern in **Figure 8.1** suggests that being on-track in ninth grade is more important than a student's tested achievement in shaping the likelihood of school dropout. In fact, if we try to predict ninth-grade course failure using students' eighth-grade test scores, we only explain 8 percent of the variation in failure rates across students (Allensworth & Easton, 2007). Students' background characteristics—such as gender, race/ethnicity, economic variables, school mobility, age at entry into high school—are also not very predictive of ninth-grade performance. Background characteristics combined with test scores only explain 12 percent of ninth-grade failures (Allensworth & Easton, 2007). Thus, students' academic skills and backgrounds provide only a small indication of whether students will succeed when they enter high school.

The central reason that we cannot predict course failure well is because most students who fail courses in freshman year do not fail because they lack the academic skills to succeed. Rather, students fail courses because they are not attending class, are not doing homework, and are not studying. New evidence from CCSR's more recent high school transition study suggests that the declines in grades and increases in failure between eighth and ninth grades are driven by quite dramatic changes in academic behaviors. This begins with attending class. Students who entered ninth grade in Chicago in the fall of 2008 were absent from school on average for about 10 days when they were in eighth grade. Half of those absences were excused; half were unexcused. The next year, when these students entered ninth grade, their unexcused absences quadrupled. Just one year later, they missed on average 27 days of school, with 21 days being unexcused absences. That is equivalent to missing over five weeks of class.

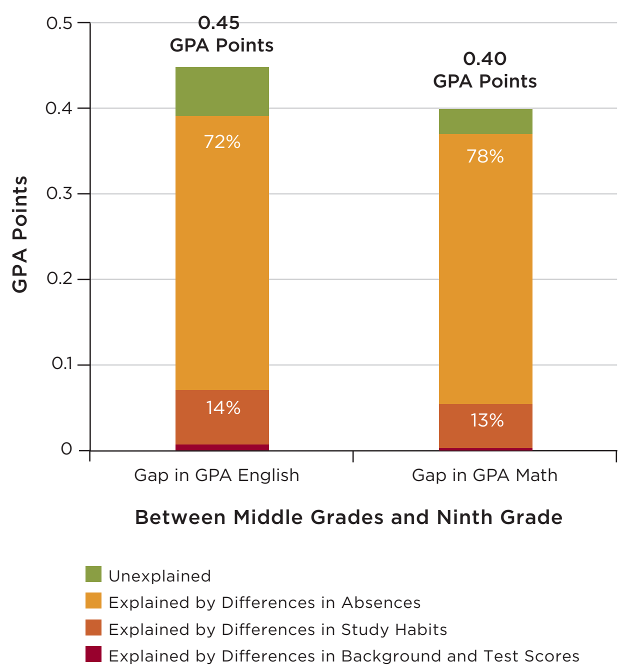
Students' study habits also decline as they move from eighth to ninth grade. Every two years, CCSR surveys Chicago students in grades six through 10 about their study habits. Because students answer the same questions in middle school and high school, we can compare what they say about how they study in high school (ninth and tenth grades) to what they said when they were in middle school (seventh and eighth grades). On average, study habits decline by about a fifth of a standard deviation in ninth and tenth grades, compared to seventh and eighth grades (Stevens et al., forthcoming).

After entering high school, students are less likely to report that they: set aside time to do homework, study for tests, do well on schoolwork that isn't interesting, and study before going out with friends.

How important are these changes in attendance and student effort? In Chicago, students' grades in both English and math are almost a half of a grade point lower in ninth grade than they were in eighth grade. **Figure 8.2** presents an analysis of how much of the decline in students' GPA in freshman year can be attributed to changes in academic behavior (Rosenkranz et al., forthcoming). The decline in grades can be explained almost completely by the increase in absences and the decrease in good study habits.

FIGURE 8.2

Reasons for Decline in Grades from Eighth to Ninth Grade



Source: From Rosenkranz, T., de la Torre, M., Allensworth, E., and Stevens, W.D. (Forthcoming). *Free to Fail Research Series: Grades drop when students enter high school.* Chicago: University of Chicago Consortium on Chicago School Research. p. 3.

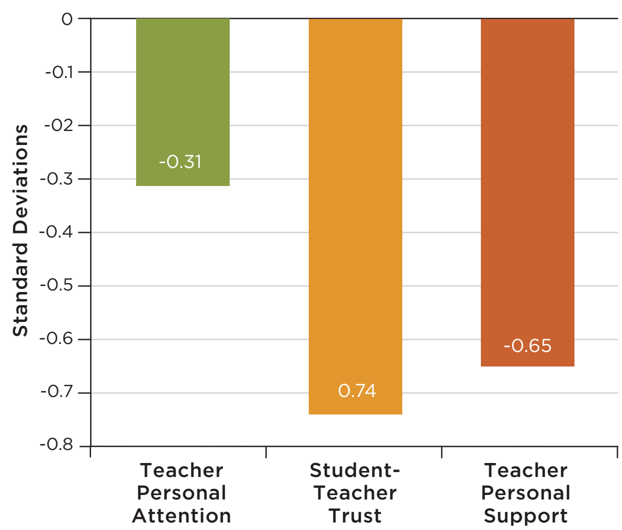
A Ninth-Grade Problem, Not a High School Readiness Problem

A common response to the problems students encounter in ninth grade is to assume that students are not "ready" for high school; we assume that if we could identify earlier the students who are at risk, we could support them to more successfully navigate the high school transition. Abrupt changes in academic behavior, however, complicate the story: these trends suggest that, contrary to expectations, it is actually extremely difficult to identify which students will struggle in the transition to high school. There is a group of students who show poor academic behaviors in the middle grades, failing at least one course or missing school frequently. Those students who have course failures or very poor attendance in the middle grades are very unlikely to graduate from high school; certainly, we can identify them early because their middle school performance is quite different from that of their peers (Balfanz & Neild, 2006). The problem is that many later dropouts who had difficulty in the transition to high school did not raise warning flags in eighth grade. For example, Balfanz & Neild (2006) found that using middle grade indicators only identifies about 50 percent of eventual dropouts. This means that a substantial portion of dropouts are students who exhibit better academic behaviors in eighth grade; then in a very short time period, they are not demonstrating those behaviors. This highlights the importance of context for students to enact expected academic behaviors. It is the change in environment that leads students to show worse academic behavior when they move to high school.

What is it about the high school environment that leads students to demonstrate worse academic behaviors? Paralleling the middle grades case study, it appears that changes in students' academic behavior reflect both students' struggle to meet developmental challenges and the lack of a developmentally appropriate adult response from schools and teachers—what Eccles has termed "stage-environment" mismatch (Eccles & Midgley, 1989). The change that is most immediately apparent to students when they move to high school is the decline in adult control of their behavior (monitoring) and decreases in academic support. Looking again at changes in Chicago students' responses to surveys across time (**Figure 8.3**), the same students assessed their relationships with their teachers quite differently in the middle grades and in high school (Johnson et al., forthcoming). The CCSR surveys include measures of the personal attention students receive from teachers, of the level of trust students feel towards their teachers, and of the personal support students feel they receive. The trend across the transition to high school is uniform across all three measures.

FIGURE 8.3

Differences Between Middle Grade and Ninth-Grade Student Perceptions



Source: From Johnson, D.W., Stevens, W.D., Allensworth, E., de la Torre, M., Rosenkranz, T., and Pareja, A.S. (Forthcoming). *Free to Fail Research Series: Student-teacher relationships decline at a critical time.* Chicago: University of Chicago Consortium on Chicago School Research. p. 1.

Across the transition to high school, students feel broadly less supported by their teachers. At the same time, ninth-grade students also appear to become aware that there is much less adult monitoring of their behavior occurring in high school. Students can more easily skip class—a behavior largely unheard of in Chicago's K-8 system. These declining measures of teacher attention and support suggest that high school teachers are also much less likely to monitor and control students' effort in class or to make sure they get their homework done. When students begin to struggle with more challenging material in classes, getting help becomes their own responsibility—ninth-grade teachers rarely force students to catch up or seek assistance when they need it, compared to teachers in eighth grade.

There are several possible reasons for this decline in support. First, high school teachers are teaching upwards of 150 students; outside of the window of time they have available during class, they may simply have too many students to monitor, to know well, or with whom to develop supportive relationships. Second, Farrington (2008) finds that many teachers strategically withhold support to help students develop independence. High school teachers generally do see ninth grade as a pivotal year—a time when students must learn to become more independent in order to succeed. Many teachers believe that students are most likely to develop the academic behaviors associated with independent learning if teachers refrain from "hand holding" as students struggle to adjust to new institutional demands. By withdrawing support, many teachers believe they are forcing students to "step up"—to take greater responsibility for their own learning—which will allow them to be successful in high school. In essence, students are supposed to learn the importance of academic behaviors by suffering the consequences when they fail to exhibit them.

Unfortunately, a significant portion of students cannot consistently meet these developmental challenges on their own; without adult guidance and support, students have few strategies to draw upon. When students exhibit poor behaviors (skipping class, not completing homework, missing deadlines), the consequences for these behaviors come swiftly in the form of low or failing grades. In Chapter 3, we presented evidence on the direct link between grades and academic behaviors, and here we see that link in action. Grades are not only the most proximal tool teachers have to influence students' academic behaviors; grades are essentially derived from behaviors. If a student does not turn in homework, the homework grade becomes an F.

These patterns can quickly become a vicious cycle: The consequences to students of poor academic behavior may be immediate and costly, but merely suffering these consequences may not help students adapt to their new environment and improve their behaviors. From the student perspective, the work demands of high school can seem overwhelming and the directions or expectations unclear. On top of that, they begin accumulating poor grades despite their efforts. From the teacher perspective, frustration with student behavior is compounded by their own lack of effective strategies to turn things around. Under deteriorating conditions, the threat of failure too often becomes teachers' primary tool for addressing students' poor academic behaviors.

If we step back and consider the research literature, what are the noncognitive factors that most strongly influence academic behaviors? Students who are equipped with effective learning strategies and possess academic mindsets of belonging, relevance, self-efficacy, and the valuing of effort are most likely to exhibit positive behaviors and the academic perseverance to succeed in their courses. Classrooms that build these strategies and support these mindsets are characterized by clear goals and high expectations for student success, the teaching and practice of strategies that help students become effective learners, significant levels of teacher monitoring and support, multiple opportunities for students to achieve success, and an absence of fear of failure.

Ironically, in attempting to help ninth-graders build the independent academic behaviors that are essential for high school success, teachers often end up creating classroom conditions that completely undermine the development of academic mindsets that would support those behaviors. By focusing narrowly on changing student behaviors through punitive grading practices, teachers lose sight of what really matters: creating classroom conditions and employing instructional practices that help students develop positive academic mindsets and learning strategies that research shows will lead to improved academic behaviors.

The Avoidable Failure

Of the three cases we present in this report, the transition to high school is the period where the evidence is strongest about what matters, the link between noncognitive factors (in this case, academic behaviors) and student outcomes is clear, and the connection to the classroom and the day-to-day work of school is evident. We also have strong evidence that schools can influence students' freshman-year performance.

The experiences of two urban school districts—Philadelphia and Chicago—illustrate how intentional programming and supports for incoming freshmen in the transition to high school can make a significant difference in students' ninth-grade performance and can have lasting effects on high school performance and graduation rates. MDRC evaluated the effects of the Talent Development High School Model's Ninth Grade Success Academy in seven low-performing high schools in Philadelphia (Kemple et al., 2005; Kemple & Herlihy, 2004). The Talent Development High School (TDHS) Model was developed in response to national research showing increased failure rates and large declines in attendance and academic performance, particularly for low-income and minority students as they entered high school.

A central feature of the TDHS model is the Ninth Grade Success Academy, designed to combat key problems common to low-performing urban high schools. To address the problem of student anonymity, Ninth Grade Success Academies have their own separate space from the rest of the high school, and teachers and students are grouped in small learning communities to foster closer and more personal relationships among students and adults. To combat low student expectations, all ninth-graders are programmed into rigorous college preparatory courses that meet in 90-minute blocks and have an emphasis on real-world projects that are aligned with the interests of students. To address poor prior preparation of incoming students, TDHS puts students in double-blocked English and math classes to provide them with additional time and support, as well as "catch-up courses" and a "Twilight Academy" as flexible options for students who need either additional focused instruction to prepare them for an upcoming class or who need to make up missing course credits. All ninth-graders also take a Freshman Seminar "designed to prepare students more broadly for the demands of high school" by combining "study skills, personal goal-setting, and social and group skills" (Kemple et al., 2005, p. 23). While these components are not necessarily framed in the language of academic mindsets, the Ninth Grade Success Academies are designed to support students to believe that they belong in the academic community, that the work is relevant, and that they can succeed with effort.

According to a rigorous analysis by MDRC, the seven Talent Development High Schools in Philadelphia "produced substantial gains in attendance, academic course credits earned, and promotion rates during students' first year of high school. These impacts emerged in the first year of implementation and were reproduced as the model was extended to other schools in the district and as subsequent cohorts of students entered the ninth grade" (Kemple et al., 2005, p. iii). The TDHS schools experienced a 28 percentage point increase in students passing algebra and a 9.5 percentage point increase in the proportion of ninth-graders promoted to tenth grade (Kemple et al., 2005). Matched control high schools, in comparison, showed little improvement. Early evidence also suggests that these ninth-grade improvements were sustained through tenth grade and are correspondingly translating into improvements in high school graduation rates.

CPS took a different approach to supporting incoming students in the transition to high school. Building off the CCSR research about the "on-track indicator" and the importance of students' performance in ninth-grade classes, CPS added schools' "freshman on-track" rates to its accountability metrics and provided data supports to help high schools monitor the performance of its ninth-graders. Using freshman transition programs, "on-track labs," and new watch lists and data tools, CPS high schools began to focus on ensuring that high school freshmen attend school regularly, get appropriate interventions and support, and pass their classes. Between 2007 and 2011, the ninth-grade on-track rates in CPS increased from 57 to 73 percent district-wide, with one quarter of traditional high schools showing improvements of over 20 percentage points. This means that a significantly smaller number of students was failing courses as a result of the additional monitoring and support provided by the high schools. In preliminary analyses of cohort data, it appears that the percentage of students on-track at the end of freshmen year held constant or increased by the end of sophomore year, even though students did not receive additional supports after they became sophomores.

The evidence from both Philadelphia and Chicago suggests that educators can structure school and classroom contexts in ways that wrap developmentally appropriate supports around students as they enter high school, resulting in better academic behaviors in he form of improved attendance and higher rates of homework completion which translate to improved academic performance and a reduction in course failures. The early indications from both cities are that strong supports for students in ninth grade may act as protective factors that carry students forward with better performance throughout high school. There is a strong theoretical basis for this effect. If increased monitoring and support help ninth-graders to develop strong academic behaviors and if a more personal learning environment supports them in building academic mindsets of belonging and self-efficacy, students are likely to demonstrate more persistence in their schoolwork and to earn better grades.

Ninth grade is a crucial point of intervention; as students enter high school they encounter institutions that demand much of them but provide little in the way of appropriate supports, as evidenced by systematic increases in absence and failure, even from students who performed well in eighth grade. Ninth-grade course failure sets up students for further failure. Not only do they face structural barriers in trying to regain missing credits, but the research on noncognitive factors suggests that these experiences may foster negative or counterproductive mindsets as students feel like they do not belong and cannot succeed in high school. Conversely, by coupling interesting and challenging classes with appropriate monitoring and support, there is evidence that high schools can help students build good academic behaviors and positive academic mindsets that may well provide them with a critical foundation that can carry them forward to high school graduation.

CASE STUDY 3

The Postsecondary Transition

Research evidence has identified a number of promising strategies for building and sustaining school environments and classroom contexts that support the development of the strong academic behaviors that ninth- and tenth-grade students need to succeed in the transition to high school. However, much less is known about what either high schools or colleges can do to ensure students' success in higher education.

More In, Fewer Out: Educational Attainment in the Twenty-First Century

Put bluntly, too few students attend college, and fewer still complete four-year college degrees. The U.S. is facing a crisis of educational attainment. As U.S. President Barack Obama observed in his 2009 State of the Union address, some three-quarters of the fastest growing occupational sectors in the American economy require more than a high school diploma; yet, barely over half of Americans have the education to qualify for those jobs. Beginning in the last two years, for the first time in U.S. history, American retirees have greater levels of educational attainment than young adults entering the workforce (OECD, 2011). This is, President Obama noted, "a prescription for economic decline."

At the center of this crisis in educational attainment is the college retention puzzle: why do so few students who enroll in college complete their degrees? Over the last two decades, there have been substantial increases in the numbers of minority and first-generation students enrolling in college; however, gaps in college graduation by race and income have remained steady or widened (Bowen, Chingos, & McPherson, 2009). Across all racial/ethnic groups, just over half of students who enroll in college graduate; over the last decade, it has taken college graduates progressively longer (five and six years, in many cases) to complete their degrees (Bowen, McPherson, & Chingos, 2009). Why has college completion not kept pace with college enrollment? Could noncognitive factors represent part of the solution to the college retention puzzle? This is perhaps the most critical issue on the national education policy agenda. However, despite the urgency of this effort, research evidence remains limited.

Weak Preparation and Declining Financial Aid Only Partially Explain Low College Degree Attainment

The national policy discussion around college retention has generally seized on two explanations of why the U.S. is failing to produce greater numbers of college graduates:

- Weak academic preparation for college coursework, particularly among African American and Latino students; and
- The combination of rising college costs and the declining value of financial assistance (Roderick & Nagaoka, 2008).

While there is clear evidence that prior academic achievement and financial constraints affect college retention, new research strongly suggests that a range of additional factors, including noncognitive factors, plays a critical role in students' postsecondary success. Academic mindsets interventions targeting students' sense of belonging, for example, have shown significant effects on both college retention and grades, However, as a growing number of researchers has begun to recognize, none of these explanations of low attainment accounts for college context. Previous research finds that students with similar levels of academic achievement and college qualifications (e.g., similar grades and test scores) have substantially different college outcomes, largely driven by where they attend college (Allensworth, 2006; Bowen, Chingos, & McPherson, 2009; Roderick, Nagaoka, Coca, & Moeller, 2008).

Colleges are not interchangeable; vast institutional differences exist in how colleges organize and structure the tasks associated with students' academic and social transitions, reflected in the tremendous variation in institutional four-year graduation rates—ranging from over 90 percent of each incoming cohort to under 10 percent. Colleges vary in whether and how they approach and support students' social adjustment, in how they provide academic resources and support, in how (and how much) financial aid is distributed, and in whether and how the campus climate itself is organized to support positive interactions with peers. On the one hand, despite the growing public attention paid to college readiness, there remains relatively little empirical evidence on what precisely it means for students to be "college ready." On the other hand, evidence shows that where students attend college will ultimately determine whether and in what measure their incoming academic achievement and/or noncognitive factors will affect their college persistence. In colleges with low institutional graduation rates (often those that provide few of the developmentally appropriate intellectual and/or social opportunities, challenges, and supports that stretch and grow students), even well-developed noncognitive factors are unlikely to improve students' probability of graduating on time.

How Colleges Organize and Structure the Tasks of Transition Matters

In *Potholes on the Road to College*, CCSR researchers documented the links between CPS students' social capital for college-going, their academic achievement in high school, and their likelihood of enrolling in college (Roderick, Nagaoka, Coca, & Moeller, 2008). That research showed that even highly qualified minority and first-generation college students struggle during the college search and application processes, in large measure because of deep social capital deficits. These students have access to few resources for college-going in their communities, putting them at substantial disadvantage during competitive admissions processes. High-achieving CPS students and others like them, researchers concluded, were especially dependent on the support and direct assistance of high school staff members—primarily counselors and teachers—to focus and refine college searches; to close gaps in college knowledge (Conley, 2007); and particularly to manage the complex process of applying for federal, state, and college scholarships and financial aid. However, while high schools may effectively attenuate the negative impact of social capital deficits in the college choice process, they do not eliminate those deficits as students enter college. Ultimately, college retention is influenced more by the institutional characteristics of colleges than by students' entering characteristics.

Substantial prior research demonstrates that college retention is substantially driven by how colleges organize and structure the tasks associated with students' academic and social integration. Previous studies show that institutional characteristics of colleges are connected with student activities and behaviors that broadly promote social adjustment to campus (e.g., living on campus, attending college full-time, being involved in campus activities, having strong social networks) (Berger & Milem, 1999; Cragg, 2009; Hurtado & Carter, 1997; Oseguera & Rhee, 2009; Pascarella et al., 1986; Ryan, 2004; Scott, Bailey, & Kienzl, 2006; Thomas, 2000; Tinto, 1987; Titus, 2004; Titus, 2006a; Titus, 2006b). Likewise, previous research also connects institutional factors with college retention, including how colleges structure students' interactions with faculty, per-student expenditures on instruction, and student academic support (Arum & Roksa, 2011; Astin, 1993; Berger & Milem, 1999; Bradford et al., 1997; Cragg, 2009; Gansemer-Topf & Schuh, 2006; Nagda et al., 1998; Pascarella et al., 1986; Ryan, 2004; Scott, Bailey, & Kienzl, 2006; Tinto & Goodsell-Love, 1993). How colleges structure students' financial aid packages—particularly whether financial aid is provided in the form of grants or loans—also affects student retention (Bailey & Kienzl, 2006; Blanchfield, 1972; Braunstei, McGrath, & Pescatrice, 2000; Cabera, Nora, & Castaneda, 1992; Cragg, 2009; DesJardins, Ahlburg, & McCall, 1999; Hu & St. John, 2001; Li & Killian, 1999; McDonough & Calderone, 2006; Nora, Barlow, & Crisp, 2006; Oseguera & Rhee, 2009; Somers, 1995; Somers, 1996; St. John et al., 1994). Finally, multiple studies have shown that whether and how colleges structure campus climates to minimize particular challenges minority and/or first-generation college students face related to cultural transitions not experienced by their peers affects college persistence for those students (Astin, 1993; London, 1989; Phelan et al., 1991; Pike & Kuh, 2005; Terenzini et al., 1996; Tierney, 1999; Titus, 2006a).

Noncognitive Factors Matter, But How?

How colleges organize and structure students' experiences on campus affects college retention, but to what extent are the differential effects of institutional characteristics due to student noncognitive factors? What do we know about which noncognitive factors are associated with college retention, and what do we understand about how the college context affects the salience of those factors? Which noncognitive factors matter and how? The research evidence on these questions is surprisingly weak.

College Requires Strong Academic Mindsets and Intellectual Engagement

Previous research suggests somewhat vaguely that in the transition to college, students must become new kinds of learners, not only harnessing a growing body of content knowledge across high school and college courses but also developing and deploying key academic mindsets and learning strategies. In addition to the quality and rigor of students' high school classes, research on the expectations that college faculty hold for students in college courses underscores the importance of developing students' academic mindsets during high school: their beliefs that ability and competence grow with effort; the notion that they can be successful in college coursework; and the conviction that courses are relevant and valuable (Conley, 2003, 2007; Farkas, 2003). Conley (2003, 2005) provides one of the most widely recognizable models of college readiness. He argues for the importance of a broad array of skills and knowledge that students putatively need to succeed in college, variously referred to as "tools" or "habits of mind" (p. 39), described in detail elsewhere as

> …critical thinking, analytic thinking and problem solving; an inquisitive nature and interest in taking advantage of what a research university has to offer; willingness to accept critical feedback and to adjust based on such feedback; openness to possible failures from time to time; and the ability and desire to cope with frustrating and ambiguous learning tasks. (Conley, 2003, p. 8)

Conley's work also contrasts the "conceptually oriented curriculum" of colleges with the "content-based curriculum" of high schools, arguing that, in order to succeed at the college level, students must master "interpretation," "thinking skills and habits of mind," "independent work, initiative, sustained effort, inquisitiveness, and attention to detail and quality" (pp. 75-76). Despite the breadth and intuitive appeal of Conley's framing, however, it is critical to note that the intellectual demands and institutional climates students encounter in the transition to college will depend in large measure on where they choose to attend college. In colleges and universities with higher institutional graduation rates—a rough proxy for the quality of the college environment and the social and academic supports available to students there—students are likely to face new and more complex demands from college faculty and their peers. Previous studies suggest that college faculty in these institutions expect and demand a higher level of intellectual engagement from students—one which requires students to cultivate a thoroughgoing inquisitiveness and an engagement with intellectual problems and puzzles without clearly evident solutions (Conley, 2005). Conversely, high school students who enter nonselective four- and two-year colleges may encounter similar or even diminished levels of academic demands as compared to those they faced in high school courses.

Students Also Face Challenges Becoming Integrated Into the Social and Academic Life of College Campuses

In addition to mastering not only new course content but also new ways of learning and engaging with peers, adults, and course materials, prior studies of college departure underscore that students must be prepared to translate existing knowledge and skills into a new context, becoming integrated into the social and institutional life of colleges. For minority and first-generation college students, the transition to the college environment may also represent a first encounter with an unfamiliar and sometimes subtly hostile racial climate. Extensive research in social psychology suggests that minority and first-generation college students experience strong but often imperceptible racial pressures on college campuses, which can undermine minority students' sense of belonging (Yeager & Walton, 2011) and their commitment to obtaining a college degree, undercut their academic behaviors, and even artificially depress their cognitive performance (Steele, 1992, 1997).

Steele argues that racial minorities, particularly African Americans, must compete with the stigma attached to highly racialized images that exist across various social spaces and actively work to perpetuate pre-existing notions of intellectual inferiority. On the one hand, previous research suggests, actively attempting to combat stereotypes about minority intelligence can become an exhausting performance in which one comes to understand that proving one's knowledge in one realm can have no bearing on another; thus, being accepted in one educational setting does not automatically "vouch" for students' skills in the next class setting (Steele, 1992). As a result, over time, minority students may feel a loss of control over their academic performance and a loss of scholarly identity, ultimately resulting in poor academic performance, perhaps particularly among higher-achieving students (Steele, 1992). The direct and indirect effects of such identity threats may ultimately undercut not only minority students' confidence but also their commitment and attachment to the goal of obtaining a college degree, particularly in educational settings where professors fail to convincingly separate academic potential from incoming skill sets (Steele, 1992). Recent research in psychology, highlighted elsewhere in this report, suggests that isolated, relatively short interventions targeting students' sense of belonging in school can produce significant and lasting effects (Walton & Cohen, 2007; Walton & Spencer, 2009; Yeager & Walton, 2011). This research suggests that the effects of students' self-perceptions—as well as the underlying perceptions themselves—are largely context-dependent. Although promising, this line of research has yet to fully explore how particular dimensions of college context may attenuate or exacerbate the negative effects of stereotype threat and low sense of belonging.

Students' Academic Goals and Sense of Self-Efficacy Modestly Predict College Retention

Beyond the limited evidence linking students' academic mindsets and particularly their sense of belonging with college outcomes, there is also modest empirical support for the notion that students' goals, self-efficacy, and study skills also influence college retention. Robbins et al. (2004) conducted a meta-analysis of 109 studies examining the relationship between noncognitive factors, sorted along nine broad, theoretically determined constructs (Robbins et al., 2004). They found a very modest association between college retention and three noncognitive factors: academic goals, academic self-efficacy, and academic-related skills. Academic goals were measured using constructs including goal commitment, commitment to the goal of college graduation, preference for long-term goals, desire to finish college, and valuing of education. Academic self-efficacy was measured using constructs including academic self-worth, academic self-confidence, course self-efficacy, and degree task and college self-efficacy. Academic related skills were measured using constructs including time management skills, study skills and habits, leadership skills, problem-solving and coping strategies, and communication skills (Robbins et al., 2004, 267). However, beyond the confusing, overlapping array of concepts and terms, findings such as these suggest little about how these factors affect students' college retention prospects and provide no information whatsoever about the malleability of these constructs or their responsiveness to context. While important, these results are little help to policymakers and practitioners seeking to identify appropriate levers for improving students' college persistence and degree attainment.

Other studies, including recent work by the College Board (Schmitt et al., 2011), ACT ENGAGE (Le, Casillas, Robbins, & Langley), and private, for-profit corporations (Gore, Leuwerke, & Metz, 2009) have sought to capitalize on the limited evidence connecting noncognitive factors with college outcomes by developing research-based survey tools to measure high school students' noncognitive skills. Marketed at the intersection of practitioners' concerns about college retention and institutional decision-making surrounding college admissions, these products attempt to transform the limited insights of the existing research base into early indicators of students' college prospects. In these products, information about students' noncognitive factors is viewed as complementing existing information about students' prior academic achievement (e.g., high school GPA and standardized test scores) to give college admissions staff a fuller view of an applicant's potential for success . However, as Schmitt et al. note in a report for the College Board, the incremental validity of the measures of noncognitive factors used is small, and the measures themselves may be especially subject to manipulation by test-takers (e.g., in situations where individual scores might be used in college admissions decisions). These limitations suggest that, despite the interest in tools measuring students' noncognitive preparation for college, there is substantial warrant for skepticism about their validity and broader utility.

Context Matters: College Choice and the Postsecondary Transition

Taken together, the prior research linking noncognitive factors to college outcomes suggests at least three conclusions: first, while there are strong theoretical reasons to believe that noncognitive factors are connected with college outcomes, there is still little empirical research directly exploring these connections, especially between noncognitive factors and college retention. Additionally, research studies have yet to explicitly explore the ways in which the importance of various noncognitive factors examined may be driven by specific elements of the college context. This first conclusion strongly points up a second: the large body of research on institutional strategies for improving college retention strongly suggests that colleges substantially influence students' experiences and outcomes in the transition to college. However, to this point, the existing research base has not investigated in detail how the institutional contexts of college campuses may influence the relative importance of particular noncognitive factors. In short, while existing literature suggests strongly that noncognitive factors matter in college, we still understand much less about how those factors matter—and how much—depending on where students choose to attend college.

Finally, there is much about the connection between noncognitive factors and college retention that we simply do not know. What empirical evidence exists suggests some connection between students' mindsets, behaviors, and skills, on the one hand, and their outcomes in college on the other—but research has provided far too little useful evidence on what these factors really mean, whether they are in fact amenable to change, and whether they can be manipulated effectively in the high school context. These are not reasons to believe that noncognitive factors do not matter in the transition to college. On the contrary, these are reasons, we argue here, for researchers to double down on the bet that high schools and colleges each have a role to play in setting institutional and classroom-level contexts that foster students' intellectual and noncognitive growth. In one sense, research on the college transition lags far behind what we know about the middle grades and the transition to high school: there is a great deal of ground to be made up in bringing up to speed our understanding of how noncognitive factors matter in the transition to college and what we can do about it.

CHAPTER 9

Interpretive Summary

Leveraging Noncognitive Factors to Improve Student Outcomes

Since the mid-1980s, test score-based accountability has dominated American public education. This movement took on the force of federal law in 2001 with the No Child Left Behind Act, as every state in the country administered standardized tests to measure student and school performance. Ask any teacher, principal, or educational administrator about goals for the year; increasing test scores is the most likely response.

President Obama's first address to Congress signaled a shift in educational priorities. He committed his administration to ending the dropout crisis in the nation's public high schools and ensuring that by 2020 America would once again lead the world in the proportion of its population with college degrees. This shift has brought a host of education policies geared at increasing academic demand: adding graduation requirements, increasing participation in advanced coursework, and setting more rigorous curricular standards. The widespread adoption of the Common Core State Standards reflects an agreement across states to set a higher bar for college and career preparation.

What has not been talked about is that a shift to making high school and college completion our national educational goal requires a corresponding shift in educational policy and practice, *away from a focus on test scores* and toward a new emphasis on developing the cognitive and noncognitive factors that lead students to earn high course grades.

The emerging recognition of the importance of noncognitive factors to young people's long-term success raises new challenges for teachers seeking to prepare their students for college and careers. It also creates a conundrum for educators who have been told to focus on raising test scores, not only for purposes of accountability but also because test scores have been touted as strong indicators of student learning and college readiness. The evidence on the relationship between noncognitive factors and student grades—and between grades and long-term outcomes—challenges this focus on tests. If teachers want their students to be successful—both within their current courses and in their future endeavors—then teachers must attend to students' engagement in class material and their coursework performance, not just their tested performance. To make this shift, educators need to understand how best to help adolescents develop as learners in their classes. This should not be framed as an *additional* task for teachers, though for many it may mean teaching in new ways. By helping students develop the noncognitive skills, strategies, attitudes, and behaviors that are the hallmarks of effective learners, teachers can improve student learning and course performance while also increasing the likelihood that students will be successful in college.

The importance of students' grades—rather than test scores—for later outcomes requires that we better understand how to structure classrooms and schools in ways that improve student effort and performance in the daily tasks of the classroom. Of all the challenges posed by the implementation of the Common Core State Standards, this may be the greatest: if we are truly to be a nation of college-goers, we must not only raise the bar on *what* students learn but we must also leverage an understanding of noncognitive factors to teach adolescents *how* to become effective learners. In the absence of developing students as learners, current reform efforts are unlikely to succeed at increasing students' readiness for college.

This report grew out of the understanding that it is not enough to know that noncognitive factors matter for learning. Researchers from a range of disciplines have provided evidence that such factors are important to students' grades and long-term educational outcomes. However, little work has been done to bring clarity to this wide-ranging evidence, to examine its relevance for practice, or to review actionable strategies for classroom use. Our goal was to develop a coherent and evidence-based framework for considering the role of noncognitive factors in academic performance. We conclude by summarizing the most promising levers for change as well as critical gaps in the knowledge base and in the link between research and practice.

Students Earn High Grades When They Show Perseverance and Strong Academic Behaviors

The best ways to improve students' perseverance and strengthen their academic behaviors is through *academic mindsets* and *learning strategies.* This is the central point emerging from our review. Academic behaviors and perseverance reflect the level of students' engagement in their work— the degree to which they are coming to class, completing assignments on time, participating, studying, trying to master material, taking time to do challenging work, and sticking with a task until it is done well. Students who do these things get higher grades, and students who do not do them struggle academically. This becomes increasingly true as students transition from the middle grades to high school and on to college. Strong academic behaviors and academic perseverance are the noncognitive *outcomes* that teachers want to achieve in developing their students as learners. These are the noncognitive factors most directly associated with good grades.

It is hard to change academic behaviors and academic perseverance directly without addressing academic mindsets and effective learning strategies. Ironically, trying to directly change behaviors and perseverance is not the best lever for improving students' academic performance. The critical levers for improving student grades seem to be through the development of academic mindsets and learning strategies. Academic mindsets strongly influence the degree to which students engage in academic behaviors, persevere at difficult tasks, and employ available learning strategies. In turn, the use of appropriate learning strategies strongly influences the quality and effectiveness of academic behaviors and helps students stick with a task and persevere despite obstacles. Thus, building students' academic mindsets and teaching them appropriate learning strategies are the best ways to improve academic behaviors and perseverance, which leads to better grades. Unfortunately, these are often areas in which teachers have little training. In the absence of a strong framework that clarifies the role of schools and classrooms in the development of noncognitive factors and a toolbox of strategies to effectively support this development, teachers often attribute differences in students' academic behaviors and perseverance to individual characteristics of their students—something they cannot control.

Unfortunately, teachers often misdiagnose poor academic behaviors and lack of perseverance not as a lack of strategies or a problem with mindsets but as indications that students are not motivated or do not care. Students who are not working hard in school are often diagnosed as being lazy or lacking motivation, with teachers seeing these as personal characteristics that students bring with them to the classroom. The conclusion that follows is this: if students would just work harder and not give up, they would do better in school; their academic performance is poor because either they do not care enough to try or they lack the grit or determination necessary for success.

Our research framework of noncognitive factors sheds a different light on the phenomenon of students who exhibit poor academic behaviors. Perhaps what looks like a lack of caring or persevering could be a student indicating that she is convinced that she cannot do the work. Another student may not have effective strategies for engaging in classroom tasks. Students who cannot see the relevance of a class may have difficulty finding a way to engage in the work. Others may withdraw from participating in classroom activities because they are afraid of public failure or feel ostracized by their peers. In our own research, we find that the vast majority of students want to succeed in school, but many obstacles get in the way of their putting forth effort.

Developing adolescents as learners requires paying attention to students' mindsets, skills, strategies, and behaviors as well as their content knowledge and academic skills. If students are not demonstrating strong academic behaviors, teachers need to be able to determine and address the obstacles that deter their learning. We hope that the framework presented in this report can serve as a tool to diagnose potential underlying causes for weak engagement and poor academic behaviors and to develop strategies for re-engaging students as learners.

School and classroom contexts play a crucial role in shaping these noncognitive factors in individual students. Within a given course, students' sense of belonging, self-efficacy, and interest will be shaped by their experiences in the classroom, their interactions with the teacher and fellow classmates, their prevailing beliefs about their own ability, and the nature of the work they are asked to do. Their endorsement of a growth mindset will be shaped by the structure of learning opportunities and assessment practices, as well as by the messages they receive from teachers that emphasize ability or effort. Likewise, students are not likely to develop learning strategies in the absence either of explicit instruction or classwork that requires the use of such strategies.

It may be most helpful to think about noncognitive factors as properties of the interactions between students and classrooms or school environments. Rather than being helpless in the face of students who lack perseverance and good academic behaviors, teachers set the classroom conditions that strongly shape the nature of students' academic performance. The essential question is not how to change students to improve their behavior but rather how to create contexts that better support students in developing critical attitudes and learning strategies necessary for their academic success. Thus, teaching adolescents to become learners may require educators to shift their own beliefs and practices as well as to build their pedagogical skills and strategies to support student learning in new ways. Academic behaviors and perseverance may need to be thought of as creations of school and classroom contexts rather than as personal qualities that students bring with them to school.

The Role of Noncognitive Factors in Academic Performance: Implications for Research

The role of noncognitive factors in students' academic performance has gained increasing attention from both researchers and practitioners in recent years. While some very interesting and promising work has emerged recently, the state of the research evidence and the development of practice models still lag far behind the high level of interest. In this review, we were focused primarily on the implications and actionable pathways for teachers and classrooms that emerge from the research evidence. For this reason, we asked a different set of question of the research literature than one might ask in a traditional literature review conducted by an academic in this field. For each noncognitive factor, we asked:

- How is this factor related to academic performance?
- Is this factor malleable?
- What is the role of classroom context in shaping this factor?
- Are there clear, actionable strategies for classroom practice?
- Would changing this factor significantly narrow existing gaps in achievement by gender or race/ethnicity?

With this lens, we saw four major challenges that must be addressed if research on noncognitive factors is going to be useful for educational practice.

1. The need for conceptual clarity. One of the primary challenges to making research accessible to practitioners and relevant to policy is the lack of conceptual clarity among the many noncognitive factors that affect student performance. Much of the research conflates constructs that are conceptually very distinct. For example, work on social-emotional learning has used the demonstration of academic behaviors as indicators of having social-emotional core competencies (e.g., using studying and completing homework as measures of responsible decision-making). Likewise, academic tenacity has been described not only as showing persistence in tasks despite obstacles (the usual connotation of the word *tenacity*) but also as the mindsets that encourage tenacity—such as self-efficacy, sense of belonging, and a growth mindset. However, perseverance, mindsets, and behaviors are each conceptually distinct categories—a student can have a strong sense of self-efficacy but still not participate in a given class, for example. To really understand the mechanisms by which noncognitive factors affect academic performance requires conceptual clarity and a delineation of each step in complex interactive processes.

2. The need for direct evidence. A related shortcoming of some of the existing research is that researchers sometimes use noncognitive factors as a “catch-all” explanation for differences in student achievement without directly identifying or measuring specific factors. Some very influential research merely infers the existence of noncognitive factors when researchers are unable to find a measured cognitive explanation for differences in educational or workforce outcomes across different groups. In Heckman and Rubinstein’s (2001) seminal study of the economic returns to a GED, for example, they attribute wage differences between GED recipients and high school graduates to differences in noncognitive skills without directly measuring any noncognitive skill differences or demonstrating their direct relationship to wages. Heckman and Rubinstein acknowledge this, explaining that there are too many different traits subsumed under the name “noncognitive skills” and no one way to measure them all. What they then attribute to differences in “noncognitive skills” is simply the difference in wages between high school graduates and GED recipients that could not be explained by tested achievement. Their evidence that noncognitive skills matter rests on their interpretation of the error term in statistical analysis, rather than the empirical identification of specific skills, traits, or behaviors that contribute to wage differences.

Clearly identifying and measuring specific noncognitive factors becomes particularly important when we try to understand why there are differences in educational attainment by race/ethnicity, gender, or income. Knowing what to do to reduce these gaps requires knowing the extent to which they reflect underlying differences between groups in specific noncognitive skills, beliefs, behaviors, or strategies, or whether attainment differences are better explained by other factors entirely. Without identifying or measuring what these important noncognitive factors are, research does little to help practitioners or policymakers take action to impact differences in students’ noncognitive factors as it is not clear what they need to address.

It is also possible that practitioners might develop strategies that are ineffective or even counterproductive if researchers do not make clear distinctions between evidence on noncognitive factors and inference about them. For example, a much-cited study by Brian Jacob (2002) found that students’ grades in middle school predict a large proportion of the gender gap in college enrollment and attributed differences in grades to noncognitive factors, reasoning that “conditional on cognitive ability, [grades are] determined by a variety of non-cognitive skills such as the ability to follow directions, work in groups, pay attention in class, and organize materials” (p. 591). The study did not actually measure students’ ability to follow directions, work in groups, pay attention, or organize materials, and provided no evidence that there are gender differences in these behaviors. (It did measure time spent on homework and found that girls spent slightly more time per week than boys.) Yet practitioners might conclude from Jacob’s assertion that they should invest time in further developing boys’ academic behaviors. In fact, there are many different potential explanations for why boys in the middle grades have lower GPAs than girls, explanations that should be investigated if the GPA gap is to be addressed. For example, teachers might discriminate against boys when grading work. Parents could give boys more freedom to do their homework alone while monitoring their daughters more closely. Ten years ago, the American Association of University Women (AAUW) attributed the same gender differences we observe today—girls get better grades; boys get higher test scores—to gender bias in testing. Each of these interpretations is plausible, and there is nothing wrong with interpretation and debate; for research to be relevant for practitioners, however, it is important to delineate what is actually known from what seems promising but needs further study.

3. The need for more research on the role of school and classroom context in students’ development and demonstration of noncognitive factors. Throughout this review, we have noted the role of classroom context in shaping noncognitive factors. Ultimately the practical goal of research on noncognitive factors is to help individual students become stronger learners who earn higher grades. This might suggest that a primary strategy to improve students’ grades would be to focus on developing noncognitive factors as characteristics of individuals—implying that the “fix” is at the individual level. However, the research evidence to date suggests that trying to change noncognitive factors at the individual level in isolation from context may not be effective in the long term. Our case studies of school transitions highlight the importance of context for the enactment of noncognitive factors. For example, the large rise in absences and decline in studying behaviors when students move into high school show that students who exhibit strong academic behaviors in one context might not do so in another. To what extent are noncognitive factors located within individuals in ways that are transferable across context, and to what extent are they dependent on context?

Intervention studies of academic mindsets suggest some long-term effects on student achievement. However, it is not clear if they are helping students perform better in a particular context or whether they have changed something fundamental about each student's academic identity that will transfer across contexts. For example, seventh-graders who benefit from a growth mindset intervention have been shown to improve their performance during seventh grade with lasting effects to eighth grade, but we do not know what will happen as these students move from middle grades to high school. Likewise, interventions that normalize difficulty in the first year of college or increase the sense of belonging of African American students on elite college campuses improves their college performance, but we do not know if these benefits transfer from college to the workplace. Teaching students learning strategies seems promising, but again there is little research on its effectiveness across school contexts. At this point, we do not know to what extent interventions that focus on individuals can have lasting impacts on their engagement in learning across contexts.

We also want to recognize the role of the larger school context in shaping student performance. Throughout this review, we have looked at evidence on the role of classroom context and the availability of classroom strategies, but we know that teachers do not work in isolation. School-wide initiatives and structures, as well as school culture and environment, play a role in shaping students' experiences and performance in the classroom (Bryk, Sebring, Allensworth, Luppescu, & Easton, 2009). Research is also needed on the role of school contexts in promoting positive academic mindsets and on the work of school leaders in providing supports and professional development for teachers to build their capacity to address noncognitive factors in the classroom. Whether the best approach to leveraging noncognitive factors to improve student performance is through changing school and classroom contexts to be more supportive of students as learners or through targeting interventions at the individual level to address individual challenges depends in large part on the transferability of effects across contexts.

Designing future studies to address longitudinal questions will be very important for research going forward.

4. Teachers need coherent, actionable strategies for developing students as learners in the context of regular classroom instruction. If researchers strive for conceptual clarity and precise identification and measurement of individual noncognitive factors, this will help illuminate the mechanisms whereby each individual factor interacts with the others to affect student performance. However, where researchers need to pull everything apart and understand how it works, teachers need a coherent, integrated approach to build academic mindsets, learning strategies, social skills, academic behaviors, and academic perseverance as part of their everyday classroom practice. We cannot expect a teacher to implement separate interventions for all of the noncognitive factors that matter for their students' performance. Instead, they need guidance about how best to build classroom contexts and utilize pedagogical strategies that will leverage the body of research on noncognitive factors as they teach content and skills.

This is not to say that teachers are not an important audience for the research on noncognitive factors or that teaching as a profession does not need to take this research into account. But teachers should not be expected to focus on noncognitive factors as "another thing" to teach in isolation from the development of content knowledge and core academic skills. Fortunately, research from the learning sciences shows the tight interconnection between cognitive and noncognitive factors in shaping student learning and academic performance. For example, the evidence suggests that positive academic mindsets and learning strategies are developed through supporting students in engaging in challenging work. Teachers can design their classrooms so that they build mindsets, skills, behaviors, and strategies in pursuit of handling challenging content knowledge and developing core academic skills. Studies that seek to illuminate how this is all best pulled together in actual classrooms will provide an important step in bridging research and practice.

To the extent that we already have some knowledge base about how to develop positive mindsets and which learning strategies produce high learning gains, this knowledge needs to be much more accessible to teachers. Currently the vast majority of research on noncognitive factors is not written for a practitioner audience, and the literature is not available in places teachers are likely to go for professional learning. Bridging the gap between existing researcher knowledge and teacher practice is another important step.

There is also diffuse knowledge among practitioners that could inform practice broadly if it were systematically collected and disseminated. The most successful teachers may already have developed strategies that leverage noncognitive factors to engage students in learning. Researchers could gather evidence from practice to broaden our knowledge about how to do this. Such studies would need to be designed both to address unanswered questions and to incorporate what we already know. For example, we have strong evidence that noncognitive factors need to be understood along a developmental continuum. Separate studies of techniques and strategies used by effective instructors at the middle school, high school, and college levels would be helpful. Researchers should also consider gathering student-level data on mindsets, behaviors, skills, and strategies; any changes in these noncognitive factors should be measured over time for students in a given classroom as part of any study of effective classroom practices. In short, both empirical evidence and practice wisdom exists that could contribute to a broader understanding of the role and development of noncognitive factors in academic achievement, but this evidence and wisdom is too often isolated by disciplinary boundaries as well as the gulf between research and practice. Collectively, we still know too little about how teachers and school leaders can incorporate attention to noncognitive factors into the everyday work of schools and classrooms. Future research should aim to bridge this divide.

The Promise of Noncognitive Factors in Teaching Adolescents To Become Learners

As this review indicates, we know much about the role of noncognitive factors in academic performance. But there is still much to be learned about how to leverage noncognitive factors to transform educational practice from its current focus on content knowledge and testable academic skills to the broader development of adolescents as learners. Decades of research inform our understanding and point us towards promising practices in the classroom. Our conceptual framework organizes different categories of noncognitive factors and models how they fit together to affect student performance. This provides a foundation for future research and a framework for practice. Teaching adolescents to become learners requires more than improving test scores; it means transforming classrooms into places alive with ideas that engage students' natural curiosity and desire to learn in preparation for college, career, and meaningful adult lives. This requires schools to build not only students' skills and knowledge but also their sense of what is possible for themselves, as they develop the strategies, behaviors, and attitudes that allow them to bring their aspirations to fruition.

TABLE 9.1

Relationship to Academic Performance	
Academic Behaviors	All aspects of academic performance, cognitive and noncognitive, are expressed through academic behaviors. They have both a strong direct and indirect effect on grades.
Academic Perseverance	Research often conflates students' innate tendency to be perseverant with the actual behavior of doing work. While academic perseverance shows moderate relationships to student performance in cross-sectional designs, longitudinal studies find more modest relationships, making it difficult to establish evidence of a causal relationship between perseverance and performance.
Academic Mindsets	The effects of various school-based interventions suggest not only that mindsets are important but also that changing students' mindsets can result in improvements in academic performance.
Learning Strategies	Despite limitations, research shows that knowing how and when to use learning strategies is associated with higher overall learning and better academic success
Social Skills	Weakest evidence of direct relationship to grades. Much of the work done in the area of social skills training programs focuses on younger children, and there is only an indirect link between social skills and academic performance. A serious limitation of the studies showing a link between social skills and academic achievement is that almost all are correlational rather than causal. Studies tend to confound social skills with other variables, making it difficult to isolate the effect of social skills on academic performance.
Malleable	
Academic Behaviors	All types of human behavior are considered to be possible to change.
Academic Perseverance	The malleability of academic perseverance depends on how one defines perseverance. Evidence suggests that grit is fairly stable as an individual trait. However, students are more likely to display academic perseverance when they have positive academic mindsets or strategies to successfully manage tasks.
Academic Mindsets	The apparent success of many of the mindsets interventions suggests that mindsets are malleable, that is, they can be changed intentionally.
Learning Strategies	Research strongly supports the idea that learning strategies are malleable and can be directly taught. But many of the studies reviewed measured strategy use and performance concurrently. While these studies showed strong relationships between the two, they left open the question of whether learning strategies can be effectively taught, and if so, if teaching such strategies would result in improved performance.
Social Skills	Research on social skills training programs has found that they are generally effective, although the methodological strengths of these studies vary.

TABLE 9.1

Role of Classroom Context	
Academic Behaviors	Clear evidence that classroom context matters. Context shapes academic behaviors indirectly through its effect on other noncognitive factors, as well as directly through behavioral expectations and strategies.
Academic Perseverance	Classroom contexts that are structured to support students' success at assigned tasks and that provide students with strategies to make the tasks easier, make it more likely for students to persevere at those tasks.
Academic Mindsets	There is a theoretical and empirical basis for the importance of context in shaping mindsets. The effect of classrooms on student mindsets is particularly salient for racial/ethnic minority students.
Learning Strategies	Classrooms are important both as sites for the explicit teaching of subject-specific learning strategies and as contexts that set motivational conditions for learning strategy use.
Social Skills	Schools and classrooms play an important role in shaping students' social behaviors. Student behaviors are responsive to interpersonal, instructional, and environmental factors in the classroom.
Clear Strategies	
Academic Behaviors	While there are a wide range of classroom-based and school-wide strategies, few strategies have been evaluated on large scale basis. Academic behaviors such as attendance and assignment completion can be affected by close monitoring and support. Whole school reform shows some effects, but it is unclear what is responsible for changing behavior.
Academic Perseverance	There are numerous instructional practices which have been shown to improve students' perseverance in their coursework by changing students' mindsets. There is little research on whether and how teachers might structure classes to develop students' perseverance in the long run.
Academic Mindsets	There are a variety of short-term interventions that have evidence of success—from programs focused on envisioning "future possible selves" to "developing a sense of belonging." But while each individual study points to a relationship between mindsets and school performance, educational attainment, or other life-course outcomes, the broad array of findings across studies is confusing, and the directions for practice are unclear. There are few resources available currently that would translate social-psychological theory into classroom-based instructional practices that could be readily employed by teachers in a variety of school settings.
Learning Strategies	There are numerous short-term studies that provide evidence for the effectiveness of the teaching of specific strategies. Teacher feedback can provide ongoing formal and informal assessments so students can understand which strategies worked for them and where they need to improve. Student self-assessments can also provide opportunity for students to critique their strategies. Students can talk about their thinking with their teachers when planning out an academic task.
Social Skills	There is little direction for classroom teachers wanting to support the positive development of social skills in their students outside of a formal program.

TABLE 9.1

Would Changing This Factor Narrow the Achievement Gap?	
Academic Behaviors	There is evidence that academic behaviors explain part, but not all, of the gender gap in grades. There is little consistent evidence that academic behaviors explain differences in grades by race/ethnicity, particularly when controlling for test scores and economic status.
Academic Perseverance	Despite the fact that differences in perseverance by race or gender have been suggested as an explanation for race/ethnicity or gender differences in student academic performance, there is no research that has examined this directly.
Academic Mindsets	A number of interventions targeting mindsets have been shown to reduce gender and racial/ethnic achievement gaps. Ultimately, whether a focus on mindsets can narrow current gaps in performance and degree attainment depends on how much of the gap is caused by stereotype threat or other forces that differentially harm minority students in the first place.
Learning Strategies	Little evidence across studies about measured differences in learning strategies by race/ethnicity or gender.
Social Skills	Research gives little indication as to whether changes in students' social skills would narrow racial and/or gender achievement gaps.

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Endnotes

Chapter 1

1 This is not to suggest that the academic content of a course does not matter. Challenging academic work is an essential ingredient in preparing students for college. However, mere exposure to rigorous content does not increase learning. Students' performance in their classes—how well they are doing the work that is assigned to them—is a much better indicator of their future success than is the course title or their test scores.

2 A one standard deviation increase in high school GPA was associated with a 0.34 standard deviation increase in college GPA. The SAT II writing test, the SAT component that has the strongest association with grades in college, was correlated with only a 0.19 standard deviation increase in college GPA.

Chapter 3

3 Both studying time and senior grades were self-reported, which may account for the relatively high average course grades reported. The authors suggest that truncated measures from self-reports are likely to attenuate the size of the effects. In other words, if study time were measured directly and course grades were taken from transcripts, the effect of homework time on grades would likely be larger.

Chapter 6

4 Self-regulated learning is a very specific form of self-regulation, and should be considered as distinct from behavioral self-regulation more broadly, which is largely about impulse control. Self-regulated learning shares with self-regulation a focus on the ability to make conscious choices to direct the self and the ability to alter one's responses or one's behavior to align or conform to particular ideals, standards, norms, rules, agreements, or plans. However, self-regulated learning deals primarily with mental processes and metacognition rather than behavioral control.

5 Winne and Hadwin (1998) note that the learner's goals are not necessarily aligned with the teacher's goals. The teacher might assign a task that involves reading a chapter from a physics textbook and then completing a set of questions, while a student's goal might be to find someone from whom he can copy the homework and thus avoid reading the chapter.

6 This becomes a challenge in measuring students' use of learning strategies when those measures rely on student self-report of strategy use.

7 Sample items include: "I ask myself questions to make sure I know the material I have been studying," "I find that when the teacher is talking I think of other things and don't really listen to what is being said," and "I often find that I have been reading for class but don't know what it is all about. "

Chapter 7

8 Note that in this review we do not examine the broader work on social-emotional learning. An adolescent's demonstration of social skills can be understood as the physical manifestation of underlying social-emotional factors such as emotional awareness or emotional "intelligence" and emotional self-regulation. This is an area worthy of further study which could well contribute to a deeper understanding of the role of noncognitive factors in school performance.

9 Suspension is defined as "temporarily removed from regular school activities either in or out of school...due to a behavior problem."

Chapter 8: Case Study 2

10 The Ninth Grade Success Academy is part of the Talent Development High School model. The Success Academy is designed to increase structure and support for freshmen by combining three approaches: 1) keeping groups of ninth-graders together who share the same classes and same teachers in a school-within-a-school model; 2) using blocked scheduling to reduce the number of classes freshmen take and providing specialized courses for ninth-graders to transition them to high-school-level work, and 3) providing professional development supports and structures for teachers to work together (Kemple, Herlihy, & Smith, 2005).

11 A student is considered on-track if he or she has accumulated five full credits (10 semester credits) and has no more than one semester F in a core subject (English, math, science, or social science) by the end of the first year in high school. This is an indicator of the minimal expected level of performance. Students in CPS need 24 credits to graduate from high school, so a student with only five credits at the end of freshman year will need to pass courses at a faster rate in later years (Miller, Allensworth, & Kochanek, 2002).

12 Allensworth & Easton (2007) estimate that, even after controlling for the demographic characteristics and entering test scores of freshmen, the predicted probability of graduation was 55 percentage points higher (81 versus 26 percent) for a student who was on- versus off-track at the end of freshman year.

Appendix

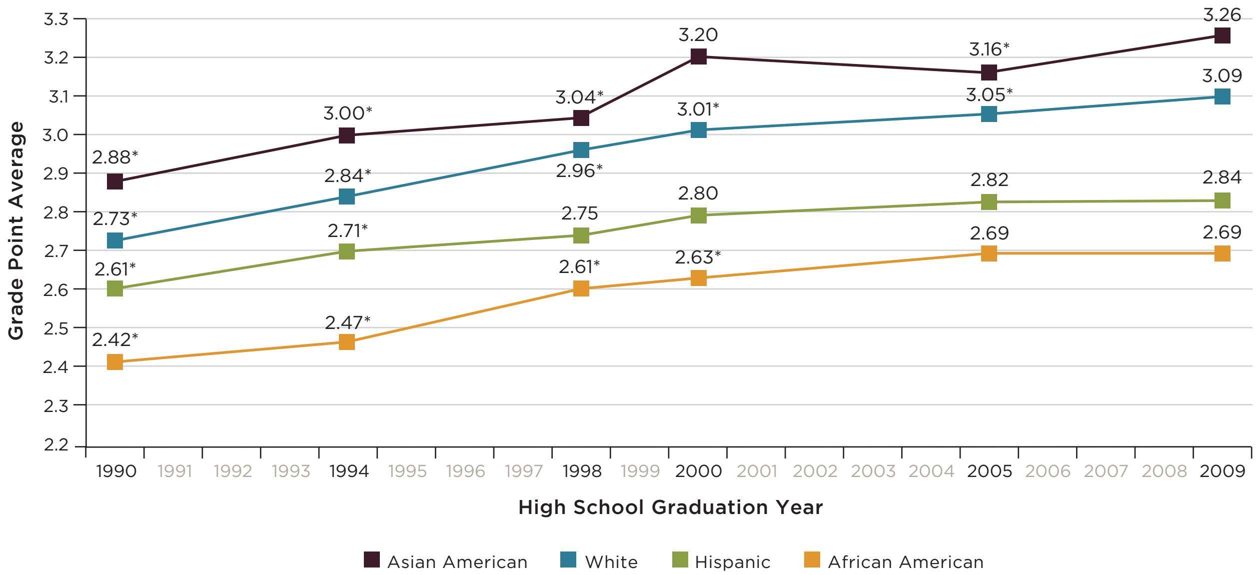
Educational Attainment by Gender, Race, and Ethnicity is Driven by Differences in GPA

There are large and persistent gaps in educational attainment by students' race, ethnicity, and gender. Asian American and White students graduate from high school and attend college at much higher rates than African American and Latino students. Girls graduate from high school and attend college at higher rates than boys. Much of the conversation around college readiness focuses on students' college entrance exams—scores on the ACT and the SAT. However, it is not low test scores that explain gaps in educational attainment. What really drives the differences in educational attainment by gender and race/ethnicity are differences in students' course grades, or GPA.

While African American and Latino CPS students have lower average ACT scores than White and Asian American CPS students, it is actually course failures and low GPAs that create significant barriers to high school graduation, college access, and college graduation for African American and Latino students. Differences in course grades by race and ethnicity explain most of the gaps in educational attainment (Allensworth & Easton, 2007; Roderick, Nagaoka, & Allensworth, 2006). Differences in high school GPA also explain all of the gender gap in college attendance and college graduation among Chicago high school graduates. Boys do not have lower ACT scores than girls, on average, but their grades are considerably lower; almost half of boys (47 percent) graduate with less than a C average, compared to about a quarter of girls (27 percent) (Roderick, Nagaoka, & Allensworth, 2006). These patterns are mirrored in national data. Using a nationally representative sample, Jacob (2002) found that students' course grades explained a large proportion of the gender gap in college enrollment. Despite similar test score performance, males were less likely to attend college because of lower grades.

In order to address racial, ethnic, and gender differences in educational attainment, it becomes crucial to focus on the GPA gaps as an important lever to explain high school graduation and college enrollment. Yet, the 2009 National Assessment of Educational Progress (NAEP) transcript study shows that from 1990 to 2009 gaps in GPAs by race/ethnicity and gender were persistent and showed no sign of improving (see **Figures A.1 and A.2**).

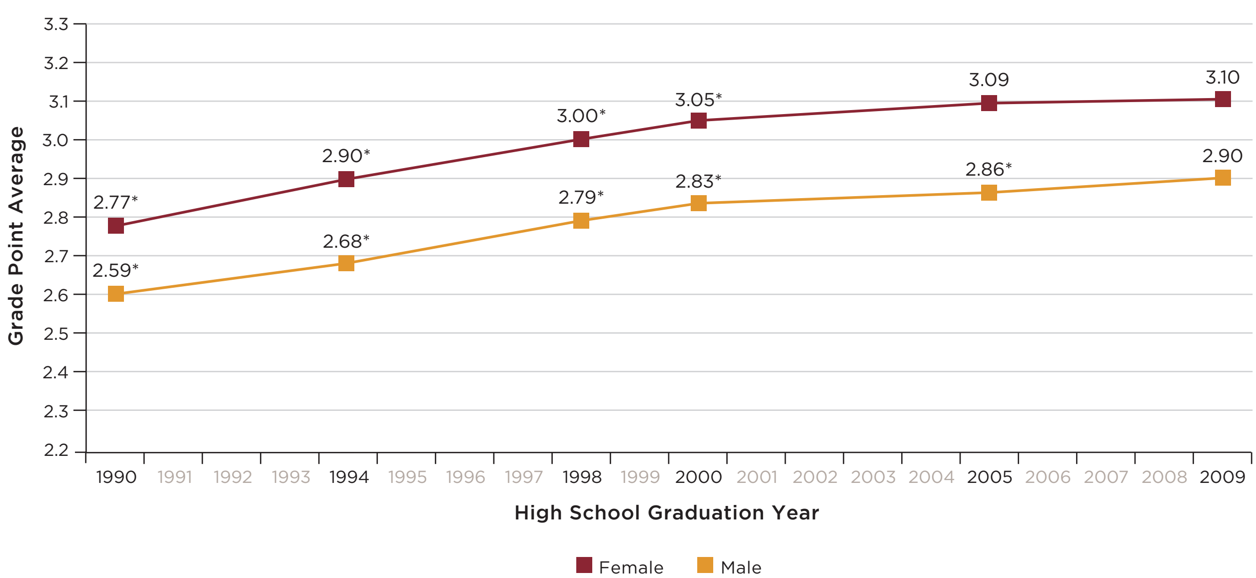
Figure A.1
National Trend in Average GPAs by Race/Ethnicity: 1990–2009



SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Transcript Study (HSTS), various years, 1990-2009.

* Significantly different (p<.05) from 2009.

Figure A.2
National Trend in Average GPAs by Gender: 1990–2009



SOURCE: U.S. Department of Education, Institute of Education Sciences, National Center for Education Statistics, High School Transcript Study (HSTS), various years, 1990-2009.

* Significantly different (p<.05) from 2009.

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