A Union of Professionals

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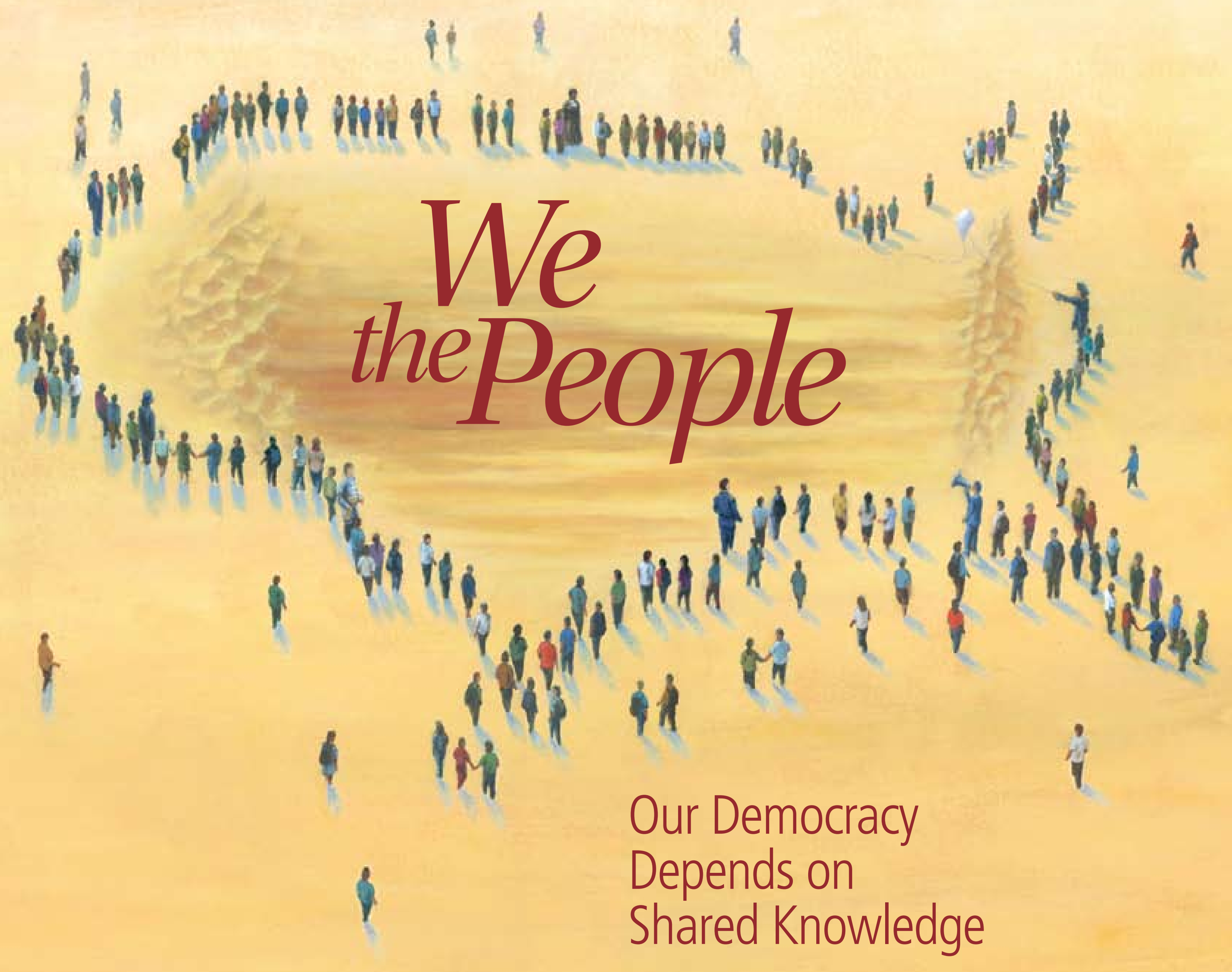

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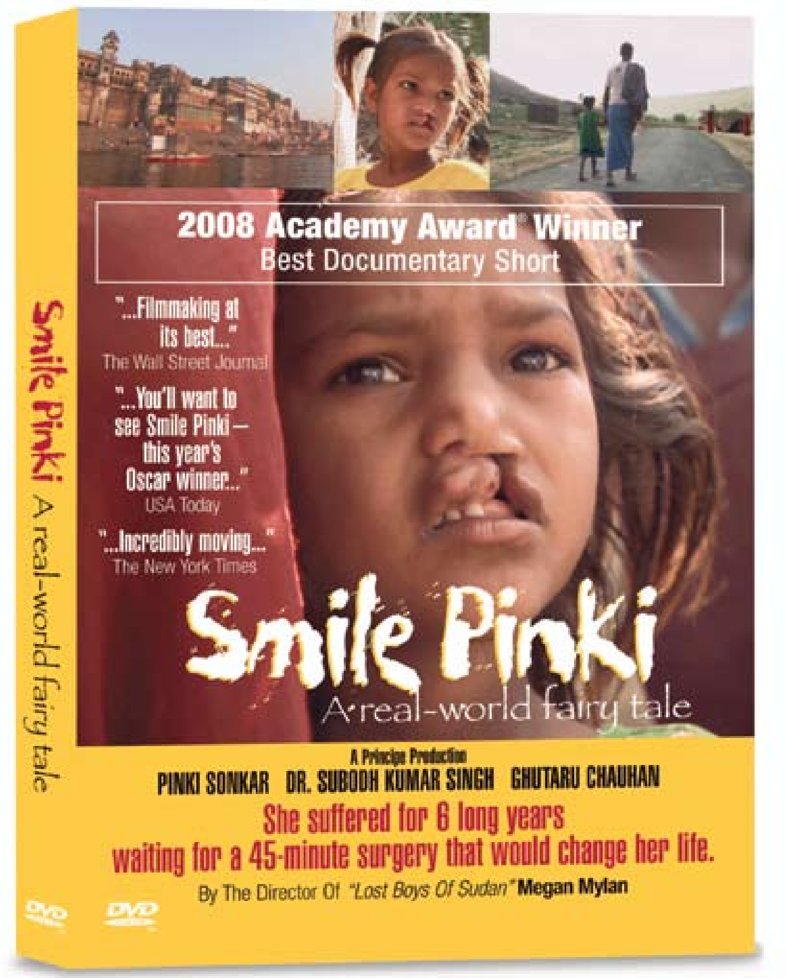

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Math Matchup

TO UNDERSTAND WHY Asian students often outperform their American peers in math, education researchers have studied many factors, such as classroom instruction, teacher training, and textbooks. A recent report, *Measuring Up: How the Highest Performing State (Massachusetts) Compares to the Highest Performing Country (Hong Kong) in Grade 3 Mathematics*, adds test questions to that list.

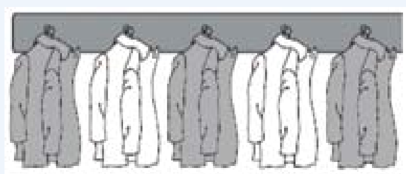
On the most recent fourth-grade math assessment of the Trends in International Mathematics and Science Study, Hong Kong ranked first, while Massachusetts (the highest achieving state in the United States according to the National Assessment of Educational Progress) ranked fourth. *Measuring Up*, published by the American Institutes for Research, compares the content and rigor of Massachusetts's and Hong Kong's third-grade mathematics assessments.

As the report's 36 exhibits (including the one shown here) demonstrate, on average, questions on Massachusetts's assessment are not as computationally challenging as those on Hong Kong's assessment. Also, Hong Kong's assessment often asks students to construct a response, not choose the correct answer from a list. According to the report, these differences reveal that math problems in Hong Kong "often require students to demonstrate deep conceptual understanding and the capacity to apply foundational mathematical concepts in multistep, real-world situations."

The report is available at **www.air.org/news/documents/AIR%20Measuring%20Up%20Report%20042709.pdf**.

Excerpt from Exhibit 10: Fractions
Hong Kong items involve understanding concepts from multiple perspectives

As shown in Exhibit 10, a Hong Kong item assesses the understanding of fractions from multiple perspectives. Specifically, students face four different pairs of fractions and must identify the correct order relationship between the two members within each pair. Together, the four items assess students' understanding of fractions with the same denominators, the same numerators, and equal numerators and denominators. The items also require students to apply their understanding of "less than," "equal to," or "greater than." By contrast, the Massachusetts item requires only that students understand the basic representation of the fraction as part of a set.

Massachusetts	Hong Kong
The coats shown below are hanging on coat hooks.  What fraction of the coats are white? Write your answer in the Answer Box below. ☐	Fill in the boxes with ">", "<" or "=". (a) $1 \ \square \ \frac{10}{10}$ (b) $\frac{1}{5} \ \square \ \frac{1}{8}$ (c) $\frac{3}{11} \ \square \ \frac{9}{11}$ (d) $\frac{2}{2} \ \square \ 2$

"Ask the Cognitive Scientist" Headed for Hollywood?

TEACHERS WHO WISH TO LEARN more from the researcher behind *American Educator*'s "Ask the Cognitive Scientist" column take note: Daniel T. Willingham has posted links to several short, thought-provoking videos on his Web site: **www.danielwillingham.com**. The videos—*Merit Pay, Teacher Pay, and Value Added Measures*; *Teaching Content* Is *Teaching Reading*; *Learning Styles Don't Exist*; and *Brain-Based Education: Fad or Breakthrough?*—tackle some of the most controversial topics in education. As in his articles, Willingham delivers the relevant research in an engaging, jargon-free way. Two thumbs up!

Elevating the Teaching Profession

By Arne Duncan

A little more than a half-century ago, in 1958, Senator John F. Kennedy penned a piece for the *NEA Journal*. In it, the future president urged a number of reforms to the teaching profession. As a longtime supporter of the NEA, Kennedy felt that higher pay and more classrooms were not enough—"more and better teachers are also needed." To strengthen the teaching profession, JFK wrote, "we must find better means for providing better rewards for our better teachers. We must make actual use of probationary periods to retain only those with satisfactory performance records, and we must demonstrate concretely to young beginners in the field that real opportunities for advancement await those whose contribution is of the highest caliber."

Flash forward a quarter century, and Al Shanker, the legendary head of the American Federation of Teachers, was echoing JFK's warning. In his 1984 address to the AFT Convention, Shanker suggested that "one possibility is that we will improve the profession ourselves and find ways of selecting and training teachers—and yes, even some ways of removing people who shouldn't be in the profession." Shanker recognized that change would not be easy or happen overnight. But he declared that "the professionalization of teaching in the next 10 or 20 years is life or death for the future of public education."

Unfortunately, JFK's and Al Shanker's calls to strengthen the teaching profession ring all too familiar today. Like President Kennedy and Al Shanker, President Obama and I believe deeply that good teachers are unsung heroes. We know exemplary teachers toil late into the night on lesson plans, shell out of their own pocket to pay for supplies, and wake up worrying when one of their students seems headed for trouble.

People remember their favorite teacher decades later because great teachers change the course of a student's life. They light a lifelong curiosity, teaching students to solve problems like a scientist, write like a novelist, listen like a poet, see like an artist, and observe like a journalist. It is no surprise that the single biggest influence on student growth is the quality of the teacher standing in the front of the classroom.

Teaching, in short, should be one of the nation's most revered professions. Teachers should be amply compensated, fairly evaluated, and supported by topnotch professional development. Yet teachers today are not accorded the respect they deserve—and teaching is still not treated as a profession on par with other highly skilled professions. The unavoidable question is, why? Why, 25 years after Al Shanker's admonition and 50 years after JFK's plea, are teachers still not treated like true professionals?

The answer, I believe, is that we have a broken system—a system of training, induction, evaluation, professional development, and promotion that is an artifact from an earlier era. As Al Shanker pointed out, schools today are still largely stuck in the factory model of the industrial age. Students, in classrooms that look uncannily like the classrooms of a century ago, move through 13 years of schooling beginning at age five, attending school 180 days a year, and taking five subjects a day in timed periods similar to what the Carnegie Foundation recommended in 1910.

Teacher promotion and compensation policies are based on equally outdated conceptions of K–12 education. This year marks the 100th anniversary of the first tenure law, passed by New Jersey in 1909. The single-salary pay schedule got its start in 1921, nearly 90 years ago, in Des Moines and Denver.

In the factory model of education, teachers are treated as interchangeable widgets who keep the educational assembly line moving. Teachers today are not paid based on their skill in the classroom or the difficulty of their teaching assignments. If two teachers have comparable experience and credentials, they are paid the same—even if one teacher is the Teacher of the Year and the other instructor

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Arne Duncan is the U.S. Secretary of Education.

ILLUSTRATIONS BY ERIC WESTBROOK

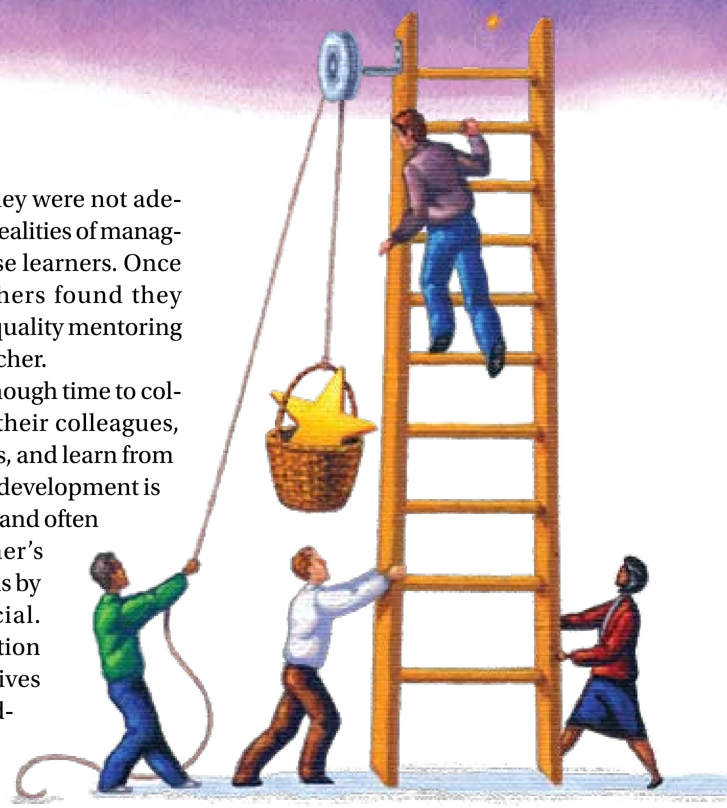
is the weakest teacher at her school. As Al Shanker summed up, teachers continue to be treated "as workers in an old fashioned factory who may not exercise judgment and discretion, [and] who are supervised and directed by everyone from the state legislature down to the school principal. Our schools are organized today exactly the way they were a century ago."

A century ago, when teachers could be fired willy-nilly, tenure protection and the single-salary schedule provided teachers with vital safeguards against arbitrary dismissals by principals and school boards. Yet in 2009, while teachers still need processes that assure fair treatment, it no longer makes sense to treat teachers as widgets. The teaching profession will never receive the respect it deserves, so long as teachers are perceived as indistinguishable components of the educational assembly line.

The Obama administration is committed to strengthening the teaching profession, from teacher preparation, to induction, professional development, and retention, especially in high-poverty schools and for high-needs students. In fact, much of our teacher quality agenda draws on what teachers and union leaders tell us needs to change to better support teachers and elevate the profession.

During the last year, I undertook a Listening and Learning Tour that took me to more than 30 states. During that tour, and in the seven preceding years when I was CEO of the Chicago Public Schools, I had hundreds of conversations with talented teachers. Virtually every teacher I spoke to told me the same thing, expressing a conviction borne out repeatedly in teacher surveys: Teachers want to challenge the status quo and they want to be treated as skilled professionals.

Most teachers are not content with their pre-service preparation. Novice teachers and veterans alike say they were not adequately prepared for the realities of managing a classroom of diverse learners. Once in the classroom, teachers found they lacked consistent, high-quality mentoring from an experienced teacher.



Nor do teachers get enough time to collaborate and plan with their colleagues, discuss problem students, and learn from their peers. Professional development is generally of poor quality, and often fails to develop a teacher's skills. Drop-by evaluations by principals are superficial. Single-salary compensation policies offer few incentives to teachers to take on leadership responsibilities in their schools—and almost no encouragement to attract, reward, and recognize effective teachers in high-needs schools.

Today, union leaders committed to challenging the status quo are courageously and candidly speaking out about the need to move beyond their comfort zones. For example, AFT president Randi Weingarten is an outspoken critic of current teacher evaluation systems. "For too long and in too many places," she says, "teacher evaluation has ranged from hollow to harmful. For most teachers, the process of evaluation is a ritual in which a principal spends 15 minutes in their classroom once a year checking off a grocery list of minimum competencies. This process does not improve teaching [or] learning."

NEA president Dennis Van Roekel testified recently that "we can all agree that our public schools need a wholesale transformation." Dennis concluded that "if states and/or the federal government are to make a serious commitment to ensuring a quality teacher for every child ... attention should be placed on how best to advance the professionalism of teaching."

So how does the administration plan to advance the teaching profession? As the President and I have stated, we start from the presumption that far-reaching reforms to the teaching profession can only take hold with the support and guidance of teachers and their unions. That is one reason why our teaching quality agenda adopts many of the policies that teachers themselves told us are essential to elevating the profession.

No area of the teaching profession is more plainly broken today than that of teacher evaluation and professional development. In district after district, more than 95 percent of teachers are rated as good or superior, even in schools that are chronically underperforming year after year. Worse yet, evaluations typically fail to take any account of a teacher's impact on student learning.

The truth is that students and teachers

don't live in mythic Lake Wobegon, where everyone is above average. Yet we have an evaluation system today that pretends otherwise. As a result, great teachers don't get recognized, don't get rewarded, and don't help their peers grow. The teachers in the middle of the skills spectrum don't get the support they need to improve. And the teachers at the bottom don't get the support they need either, and if they do and still don't improve, they need to be counseled out of the profession. It's not just students who suffer; as Al Shanker pointed out, "teachers have to live with the results of other people's bad teaching—the students who don't know anything." To continue tinkering around the edges of such a dysfunctional system is a waste.

All of the department's new or redesigned programs provide powerful incentives for states and districts to make far-reaching changes to teacher evaluation and professional development—from Race to the Top, to the 2009 School Improvement Grants, the Teacher Incentive Fund, and Title I and IDEA funds under the American Recovery and Reinvestment Act. Our guiding principle is simply that teachers should be treated as professionals: They should have the support, tools, and opportunities to perform at their full potential by having timely and accurate data about their students to inform instruction; they should have time to consult and collaborate with their peers; and they should be evaluated, compensated, and advanced based in part on student learning.

Student growth and gain, not absolute test scores, are what we are most interested in—how much are students improving each year, and what are teachers, schools, school districts, and states doing the most to accelerate student achievement?

The $4.3 billion Race to the Top program recognizes that strong teachers and leaders are the heart of educational improvement, and it places more weight on this factor than any other in its grant competition. The final Race to the Top application emphasizes that professional collaboration and planning time, individualized professional development plans, training and support to use assessment data, classroom observations with timely and constructive feedback, and other activities are critical to developing high-quality evaluation systems and professional development.

The Race to the Top competition also recognizes that teacher effectiveness cannot be assessed solely on student test scores. Instead, teacher effectiveness should be evaluated based on multiple measures, provided that student academic growth over the course of the year is a significant factor. I am pleased that both Dennis Van Roekel and Randi Weingarten recognized and applauded a number of these elements in the final Race to the Top guidelines.

It defies common sense to bar all consideration of student learning from teacher evaluation. But it is time to move past the over-reliance on fill-in-the-bubble tests to richer assessments of successful teaching and learning—and the department will be pursuing such reforms in its $350 million competition for a new generation of assessments when it moves forward with reauthorizing the Elementary and Secondary Education Act in 2010. Those new assessments will be aligned to common college and career-ready standards being developed by states—which the NEA and AFT have endorsed, and which, eventually, should reduce curricular turmoil and instability for teachers.

Finally, teachers need high-quality, timely information about the progress of their students. Through the State Longitudinal Data Systems program and Race to the Top, we're providing hundreds of millions of dollars to states and districts to develop data systems that deliver this information in a timely and useful format. When teachers get better data on student growth, including results from interim assessments, they have the chance to tailor classroom instruction to the needs of their students and drive a cycle of continuous improvement.

Not all teachers have experience using data to improve instruction. But the department is asking states that apply for Race to the Top grants to develop plans for professional development to help teachers and principals get training in how to use data to inform instruction.

We want to continue working with teachers and unions to elevate the teaching profession. With that kind of collaboration, it is possible to turn battlegrounds into common ground. I am encouraged by the NEA's new $6 million initiative to recruit more topnotch teachers in high-needs schools and hard-to-staff subjects like science and mathematics, and specialties like special education and English language acquisition. I am heartened as well by the AFT's support of pay-for-performance initiatives in the AFT's Innovation Fund, and the AFT's innovative contract in New Haven, Connecticut.

As we move ahead to reform the teaching profession, we'll have disagreements and make mistakes along the way. But we cannot let the perfect become the enemy of the good. The need for reform, both for students and teachers, is urgent. Students cannot afford to wait another decade, while adults tinker with issues of teacher quality. It's time to stop tweaking the system. It's time, once and for all, to make teaching the revered profession it should be. ☐

Creating a Curriculum for the American People

Our Democracy Depends on Shared Knowledge

By E. D. Hirsch, Jr.

I was wrenched from my comfortable life as a conference-going literary theorist almost four decades ago. I was doing experiments on reading and writing, first with students at the University of Virginia and then with students at J. Sargeant Reynolds Community College, a predominantly African American institution in Richmond. What shocked me into school reform was the discovery that the community college students could comprehend written text just as well as the University of Virginia students when the topic was roommates or car traffic, but they could not understand passages about Robert E. Lee's surrender to Ulysses S. Grant. They had graduated from the schools of Richmond, the erstwhile capital of the Confederacy, and were ignorant of the most elementary facts of the Civil War and other basic information normally taken for granted in the United States. They had not been taught the things they needed to know to understand texts addressed to a general audience. What had the schools been doing? I decided to switch careers and devote myself to helping right the wrong being done to these students. It soon became clear that for most students, the primary determinant of whether they ended up at the community college or at the University of Virginia was not innate ability or family background—it was knowledge. More important, it was knowledge that could be learned at school.

America's three biggest educational problems are our low academic achievement relative to other nations, our lack of equality

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E. D. Hirsch, Jr., is a professor emeritus at the University of Virginia and the author of many articles and books, including the bestsellers Cultural Literacy *and* The Schools We Need. *He is a fellow of the American Academy of Arts and Sciences and the founder of the Core Knowledge Foundation. This article is drawn, with permission, from his most recent book,* The Making of Americans: Democracy and Our Schools *(New Haven: Yale University Press, 2009).*

ILLUSTRATIONS BY KENNETH McMILLAN

of educational opportunity, and our failure to perpetuate a strong sense of loyalty to the national community and its civic institutions. A single, radical reform will go far in solving all three: a content-rich core curriculum in the early grades.

A lack of knowledge, both civic and general, is the most significant deficit in most American students' education. For the most part, our students (and teachers) are bright, idealistic, well meaning, and good natured. Many students and teachers are working harder in school than their counterparts did a decade ago. Yet most students still lack basic information that high school and college teachers once took for granted. In this article, I'll explain why this lack of knowledge is even more important than most people realize and why a content-rich core curriculum is the *only* viable remedy.

Shared Knowledge Is Essential to Language Comprehension

Back in the 1970s, when I was doing research on reading and writing, the field of psycholinguistics was just beginning to emphasize that the chief factor in the comprehension of language is relevant knowledge about the topic at hand. That finding has since been replicated many times, in different ways and with varying constraints, both in the laboratory and in the classroom.

The specific knowledge dependence of reading comprehension becomes obvious when we take the time to reflect on what any given bit of text assumes the reader already knows. For a simple example, here is a passage from a sample 10th-grade Florida state test of reading comprehension:[1]

> The origin of cotton is something of a mystery. There is evidence that people in India and Central and South America domesticated separate species of the plant thousands of years ago. Archaeologists have discovered fragments of cotton cloth more than 4,000 years old in coastal Peru and at Mohenjo Daro in the Indus Valley. By A.D. 1500, cotton had spread across the warmer regions of the Americas, Eurasia, and Africa.
>
> Today cotton is the world's major nonfood crop, providing half of all textiles. In 1992, 80 countries produced a total of 83 million bales, or almost 40 billion pounds. The business revenue generated—some 50 billion dollars in the United States alone—is greater than that of any other field crop.

It would take many pages to indicate even a significant fraction of the tacit knowledge needed to understand this passage. The main subject, cotton, is not defined. The reader must already know what it is, a reasonable assumption. It also helps to have an idea of how it grows, and how it is harvested and then put into bales. (What's a bale?) Then consider the throwaway statement that different people "domesticated separate species of the plant thousands of years ago." To domesticate a species of a plant is not an action that is self-evident from everyday knowledge. Ask a group of 10th-graders what it means to domesticate a plant, and chances are that most will not know. Of course, they *should* know. Domestication of plants is fundamental to human history. But I suspect most do not, and so they will not understand that part of the passage. The writer of this passage (which was, the state of Florida informs us, taken from *National Geographic*) clearly expected his readers to know what cotton is and what plant domestication is. He expected them to know that the Indus Valley is many thousands of miles from Peru. (How many 10th-graders know *that*?)

This passage illustrates the way reading comprehension works in the real world of magazines, training manuals, textbooks, newspapers, Web sites, books, etc. Writers assume that readers know some things but not others. In this case, readers were expected to know some geography and history, and something about agriculture, but not how long human beings have used cotton—the new information supplied in the passage. That is exactly how new information is always offered: it is embedded in a mountain of knowledge that readers are expected to have already in their long-term memories. That is the way language *always* works. And it is

> For most students, the primary determinant of whether they ended up at the community college or at the university was not innate ability or family background—it was knowledge. Knowledge that could be learned at school.

the way language must work. Just imagine how cumbersome your newspaper would be if, in reporting on a baseball game, it did not assume you already knew what "pitching," "being at bat," and "hitting a home run" mean. Instead of a short synopsis of last night's game, you'd get paragraph after paragraph that (boringly) explained the basics of the game. Of course, if you didn't know anything about baseball, a short synopsis of the game wouldn't make any sense (no matter how many comprehension strategies you had mastered).

Not convinced? Give this passage on cricket, from the online site of the British newspaper the *Guardian*, a try:[2]

> Much depended on Ponting and the new wizard of Oz, Mike Hussey, the two overnight batsmen. But this duo perished either side of lunch—the latter a little unfortunate to be adjudged leg-before—and with Andrew Symonds, too, being shown the dreaded finger off an inside edge, the inevitable beckoned, bar the pyrotechnics of Michael Clarke and the ninth wicket.

This is perfectly understandable for virtually all British readers, but at the dim edge of comprehensibility for most American readers. Yet the words are familiar enough. There is not a single word except maybe "leg-before" that I could not use effectively in a sentence. Comprehension is not just a matter of knowing words—and it is certainly not a matter of mastering comprehension strategies. What makes the passage incomprehensible to me is that I don't know much about cricket.

In language use, there is always a great deal that is left unsaid and must be inferred. This means that communication depends on both sides, writer and reader, sharing a great deal of *unspoken* knowledge. This large body of tacit knowledge is precisely what our students are *not* being adequately taught in our schools. Specific subject-matter knowledge over a broad range of domains is the key to language comprehension—and, as a result, to a broad ability to learn new things. It is the cornerstone of competence and adaptability in the modern world. (Cognitive scientist Daniel T. Willingham thoroughly explained this in the Spring 2006 issue of *American Educator*. See "How Knowledge Helps: It Speeds and Strengthens Reading Comprehension, Learning—and Thinking," available online at **www.aft.org/pubs-reports/american_educator/issues/spring06/index.htm**.)

If we want students to read and write well, we cannot take a laissez-faire attitude to the content of their schooling. Rather, we must specify the content that adults are assumed to have (e.g., to comprehend a newspaper or serve on a jury), and be sure to teach it to our children.

The phrase "common school" meant rich and poor studying in the same classrooms with a common core curriculum that would foster patriotism, solidarity, and civic peace as well as enable effective commerce, rule of law, and politics.

But much more is at stake in ensuring that all students have access to this knowledge than just enabling our students to make higher scores on reading comprehension tests. Those scores do correlate with a student's ability to learn and to earn a good living,[3] but they also connect with something less tangible: a sense of belonging to a wider community and a feeling of solidarity with other Americans. When we acquire enough knowledge to become full members of the American speech community, we belong to a wider group toward which we feel a sense of loyalty.

Shared Knowledge Is Essential to Democracy

When Benjamin Franklin was leaving the Constitutional Convention of 1787, a lady asked him, "Well, Doctor, what have we got, a monarchy or a republic?" to which Franklin famously replied, "A republic, madam, if you can keep it." It's hard for us to recapture that state of mind, but it is instructive to do so. The causes of our Founders' concern for preserving the republic have not suddenly disappeared with the emergence of American economic and military power. We are still a nation of immigrants, social stratification, and disparate beliefs held together chiefly by a shared devotion to freedom and democracy.

Anxiety about maintaining the republic runs through the writings of all our earliest thinkers about American education. Thomas Jefferson, John Adams, James Madison, Franklin, and their colleagues consistently alluded to the fact that republics have been among the least stable forms of government, and were always collapsing from their internal antagonisms and self-seeking citizens.

The most famous example was the republic of ancient Rome, which was taken over by the unscrupulous Caesars and destroyed by what the American founders called "factions."[4] Internal conflicts were seen to be the chief danger we faced—Germans against English, state against state, region against region, local interests against national interests, party against party, personal ambition against personal ambition, religion against religion, poor against rich, uneducated against educated. If uncontrolled, these hostile factions would subvert the common good, breed demagogues, and finally turn the republic into a military dictatorship, just as in ancient Rome.

To keep that from happening, we would need far more than checks and balances in the structure of the national government. We would also need a special new brand of citizens who, unlike the citizens of Rome and other failed republics, would subordinate their local interests to the common good.

Our early thinkers about education believed the only way we could create such virtuous, civic-minded citizens was through common schooling. By the phrase "common school," our early educational thinkers meant several things: Elementary schools were to be universal and egalitarian. All children were to attend the same schools, with rich and poor studying in the same classrooms. The schools were to be supported by taxes and to have a common, statewide system of administration. And the early grades were to have a common core curriculum that would foster patriotism, solidarity, and civic peace as well as enable effective commerce, rule of law, and politics.[5]

For example, George Washington bequeathed a portion of his estate to education in order "to sprd systemactic ideas through all parts of this rising Empire, thereby to do away local attachments and State prejudices."[6] Thomas Jefferson's plan for the common school aimed to secure not only the peace and safety of the republic, but also social fairness and the best leaders. He outlined a system of elementary schooling that required all children, rich and poor, to go to the same schools so that they would get an equal chance regardless of who their parents happened to be.

Such notions about the civic necessity of the common school animated American thinkers far into the 19th century and had a profound effect on Abraham Lincoln. Lincoln believed that the center of children's upbringing and schooling in the United States should be instruction in a *religious* devotion to democracy. Like the Founders from whom he took his inspiration, Lincoln was sensitive to the fragility of peace and harmony in a country where people of different religious faiths and ethnic origins bound themselves into one federation. His tragic sense of how precarious that unity is brought him very early to the view that parents and schools must diligently teach a common creed in order to sustain the union. His great Lyceum speech on that subject, "The Perpetuation of Our Political Institutions," dates to 1838—long before he became the central figure in preserving the unity of a nation riven by the issue of slavery. The urgency conveyed in this speech came not from the single issue of slavery but more broadly from his perception of the need to put solidarity, equality, freedom, and civic peace above all other principles—a public "political religion" that transcended all sectarian religions.[7]

According to Thomas Jefferson, an educational system that offered equality of opportunity would "avail the commonwealth of those talents and virtues which nature has sown as liberally among the poor as rich."

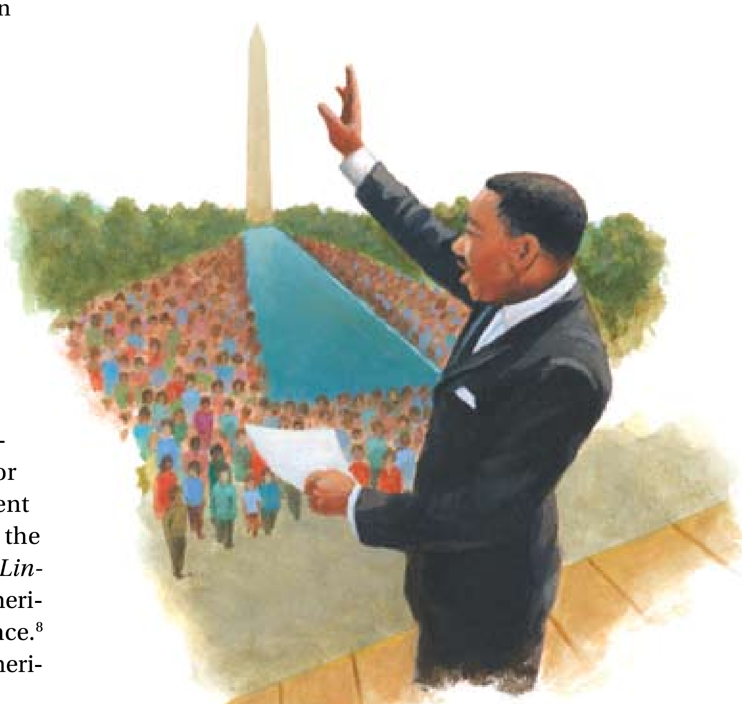
> Let reverence for the laws, be breathed by every American mother, to the lisping babe, that prattles on her lap—let it be taught in schools, in seminaries, and in colleges;—let it be written in Primmers, spelling books, and in Almanacs;—let it be preached from the pulpit, proclaimed in legislative halls, and enforced in courts of justice. And, in short, let it become the *political religion* of the nation; and let the old and the young, the rich and the poor, the grave and the gay, of all sexes and tongues, and colors and conditions, sacrifice unceasingly upon its altars.

Lincoln conceived that America needed to be held together by a secular religion called "Democracy" that would be taught in our schools and would supersede all other religions. This religious conception was not a mere analogy or rhetorical flourish. With his accustomed profundity, he went directly from the writings of the Founders to the center of the American idea. Garry Wills has shown in his dazzling book *Lincoln at Gettysburg* how concisely Lincoln reformulated the American creed as an extension of the Declaration of Independence.[8] In his Lyceum speech, he did no less for the basic theory of American schooling.

Fundamental to this idea of making democracy America's secular religion was the sharp distinction the Founders drew between the public and private spheres of life.[9] We operate in the public sphere whenever we vote, serve in the military, transact business, become a member of a jury or a defendant at a jury's mercy, write for a big unseen audience, or encounter any situation where we wish to be understood by strangers. This public sphere is where common laws and a common language are needed. The private sphere is a much broader realm, especially in tolerant America with its protections against intrusive government and its freedoms of association, speech, and action. It is neither literally private nor purely individual. "Private" associations are private only in the sense of being out of the reach of government and enjoyed peacefully apart from our legal, civic, and moral duties as members of the wider public community.

From the nation's founding to today, American schools have played a critical role in our attempt to accommodate different groups and ethnicities in a peaceful and harmonious unity without requiring them to abandon their private identities. The elementary school has a special place in this great political experiment because it is the institution that prepares children to participate effectively in the public sphere. Our ambition as a nation has been to give children from any and all origins a chance to participate in the pubic sphere as equals, no matter who their parents are, or what language or religion they practice in their homes.

Equality—both equality before the law and equality of opportunity—is not only a core American value but also a core requisite for a peaceable public sphere. In America, universal schooling has always been understood as critical to our ideal of equality. In the introduction to his 1817 bill for an Elementary School Act in Virginia, the aging Thomas Jefferson, the most consistent of the Founders in stressing the importance of public education, succinctly stated the grounds for equality of



opportunity. An educational system that offered it would "avail the commonwealth of those talents and virtues which nature has sown as liberally among the poor as rich."[10]

The early school curriculum needs to offer enough commonality of content to connect each American with the larger community of citizens. Students need to leave school with a good understanding of the civic principles under which the United States operates and with an emotional commitment to making this political experiment continue to work. They need to possess the specific, concrete knowledge that will enable them to communicate with one another in the standard language across time and space. That much substantial content is required for our civic life to function.

An initiation into this public sphere does *not* require students to reject the private sphere that nurtured them. Membership in this public sphere means mastery of the formal codes of speech and of the tacit knowledge that makes formal speech intelligible—shared information about football, civics, Shakespeare, Rosa Parks, Diego Rivera, and so on.

In the early grades of schooling in a democracy, the public sphere *should* take priority. No matter what special talents and interests we may encourage in a young child, all of us have to learn

The Anti-Curriculum Movement

Tragically and Unintentionally, It's Really an Anti-Equality Movement

It cannot be emphasized too strongly, nor repeated too often, that the most important cause of our educational shortcomings is not laziness, unionism, waywardness, stupidity, or any moral fault among the leaders of our educational enterprise. Rather, it is a system of attractive but unsound ideas. Known to educational historians as the progressive movement, these ideas took over in the United States during the latter half of the 20th century and remain very popular. The strength of the progressive movement—its lasting contribution—is its empathy with childhood. Its fatal flaw is its belief that the child-centered schooling it envisions can only be accomplished by resisting a rigorous academic curriculum and encouraging children to develop their skills using whatever content they find engaging.

Today, it is widely believed that schools need to focus on critical-thinking skills, not facts. This succinctly summarizes the dominant theory now taught in the majority of our schools of education—although *no knowledgeable cognitive scientist agrees with it*. (Cognitive scientist Daniel T. Willingham explains how and why thinking depends on knowledge in "Critical Thinking: Why Is It So Hard to Teach?" Go to **www.aft.org/pubs-reports/american_educator/issues/summer07/index.htm**.) The anti-curriculum, formal-skills approach to schooling has wasted enormous amounts of school time in endless, unproductive drills.

Apologists tend to view the educational decline that has occurred since the middle of the 20th century as having been caused by an influx of Hispanic and black students. Since the decline happened after the influx, they think the influx must have caused it. My alternative explanation is that the influx of Hispanic and black students in the postdesegregation era coincided tragically with the rise of the progressive movement and resulting decline of the academic curriculum in the public schools. The history of the contents of our textbooks supports this thesis.[1] Once the academic curriculum disappeared, no student, rich or poor, who grew up outside an enriched home environment (except for the odd voracious reader) could expect to become well educated. When a school ceases to offer a coherent academic curriculum, only a child who finds enrichment elsewhere can thrive academically.

The victory of the progressive, anti-curriculum movement has chiefly occurred in the crucial early grades, and the further down one goes in the grades, the more intense the resistance to academic subject matter, with the greatest wrath reserved for introducing academic knowledge in preschool. It does not seem to occur to the anti-curriculum advocates that the four-year-old children of rich, highly educated parents are gaining academic knowledge at home, while such knowledge is being unfairly withheld at school (albeit with noble intentions) from the children of the poor. For those who truly want equality, a common, content-rich core curriculum is the only option. It is the only way for our disadvantaged children to catch up to their more advantaged peers.

Teacher Preparation: It's More Indoctrination Than Education

Faith in the failed ideas of the progressive movement is sustained, unfortunately, by an intellectual monopoly within the majority of our teacher training institutions. Because of this monopoly, most of our new teachers are unaware of the large body of cognitive science research that does not support the central tenets of the progressive, anti-curriculum movement. I can illustrate this national problem with a personal anecdote. About 12 years ago, I began teaching in the

the same base-10 system of arithmetic; the same 26-letter alphabet; the same grammar, spelling, and connotations of words; and the same basic facts about the wider community to which we belong. Most modern nations impose that kind of compulsory early education because neither a democracy nor a modern economy can function properly without citizens who have enough shared knowledge to be loyal, competent, and able to communicate with one another.

Under this founding conception, the early curriculum can be viewed as a set of concentric circles. At the core are the knowledge and skills all citizens should have. Beyond that is the knowledge, such as state history, that each state wants children to possess. Beyond that may be the knowledge and values agreed on by the locality. And finally, beyond that, are the activities and studies that fulfill the needs, talents, and interests of each individual student. From the standpoint of the public good, what must be imparted most clearly and explicitly are the central core elements common to all citizens of the republic. These need to be set forth specifically, grade by

School of Education at the University of Virginia. It was the twilight of my university career. My teaching reputation at the university was pretty high. I had taught for many years in the College of Arts and Sciences, in the English department, where my courses on literary theory and the Romantic period continued to be oversubscribed and to get top ratings from students. I had arranged with the dean of the education school to teach a course on the causes of and cure for the achievement gap between, on one hand, blacks and Hispanics, and, on the other, whites and Asians—a hot topic.

I expected to attract a lot of curious students and expose them to heterodox (i.e., pro-curriculum) views in the literature. I had by then written two books on K–12 education. One of them, *Cultural Literacy* (1987), was a bestseller, and the other, *The Schools We Need*, was placed by the *New York Times* on its rarified "Notable Books of the Year" list for 1996. Given the normal curiosity of students to take a course from the author of a bestseller, I expected to draw quite a few students even though my work was critical of the dominant ideas in American education schools. I was surprised when I drew just a handful—10 or so students, and no auditors. The next year the story was the same, as it was the year after that. In the third year, one of my students mentioned to me privately that I should be proud of the courage shown by my students; they were all in my class despite having been explicitly warned by members of the education faculty not to take the course.

I was astonished. This would not normally have happened over in Arts and Sciences, where professors, instead of shunning and shunting dissent, tended to exploit it. The controversialists would have held a big symposium and tried to create as many intellectual fireworks as possible. In the history department, even Thomas Jefferson, the university's revered founder, was the subject of various symposia in which anti-Jeffersonians were encouraged to have their say.

I am still stunned when I think about how students are being shielded from heterodox ideas in education schools. Subject-matter-oriented people are considered authoritarian, undemocratic, and right-wing. Their writings must not be assigned, and if their ideas are mentioned, it must be in the controlled environment of a properly decontaminated textbook.* (This totalitarian feature of present-day education schools was demonstrated in a data-rich article by David Steiner and Susan Rozen analyzing the syllabi of education courses.)[2]

*In fairness, I was invited to speak once at the Harvard School of Education and once at Teachers College at Columbia University. But those gestures of openness should be balanced by the hysterical reviews of my books in the *Harvard Educational Review* and the *Teachers College Record*, the upshot of which was in every case: "Don't read this awful book." The *Teachers College Record* honored *Cultural Literacy* with two fiercely hostile reviews in one issue, which was, I am told, a first. The review in the *Teachers College Record* of my 2006 book, *The Knowledge Deficit*, calls it an "infomercial" designed to sell my Core Knowledge books. That particular ad hominem "he's just-doing-it-for-the-money" dismissal is the current response in lieu of a counterargument. In fact, I get no money from the Core Knowledge books, having from the start assigned all royalties to the foundation, from which I also receive no money.

Anyone interested in the schooling of our children should be aware of the ideological indoctrinations that our prospective teachers are required to undergo. Currently, teachers are being taught that progressivism is motivational and inculcates general skills, independent thought, love of learning, and critical thinking. By contrast, an academic curriculum is portrayed as anti-motivational, requiring rote learning of mere facts, and antipathetic to independent-mindedness, love of learning, and critical thinking. In truth, there is no inherent connection between establishing a definite curriculum and any particular form of instruction or classroom management. This is an absolutely critical point that is universally glossed over in teacher indoctrination. A dishonest trick is being played on our prospective teachers. There is no reason why a highly explicit multiyear academic curriculum cannot be taught in lively ways.

–E.D.H.

Endnotes

1. Carl F. Kaestle et al., *Literacy in the United States: Readers and Reading since 1880* (New Haven and London: Yale University Press, 1991).

2. David Steiner and Susan Rozen, "Preparing Tomorrow's Teachers: An Analysis of Syllabi from a Sample of America's Schools of Education," in *A Qualified Teacher in Every Classroom? Appraising Old Answers and New Ideas*, ed. Frederick M. Hess, Andrew J. Rotherman, and Kate Walsh (Cambridge, MA: Harvard Education Press, 2004), 119–148.

grade, so that one grade can build cumulatively on the prior one, allowing school time to be used effectively and putting all students in a given grade level on an equal footing.

We *all* have a stake in promoting an effective public sphere and a vibrant economy through our schools. The distinction between the private and public spheres is a founding conception that has made the United States a haven for freedom and an outstanding political success. But the public sphere cannot exist as a democratic vehicle for everyone unless everyone is schooled to participate in it. That goal requires a common core curriculum in the early grades. There is no practical way around that necessity.

All of our earliest educational thinkers agreed that precisely because we were a big, diverse country, our schools should offer many common topics to bring us together; if schools did so, they felt, we would be able to communicate with one another, act as a unified republic, and form bonds of loyalty and patriotism among our citizens.

The kind of education that will enable all our young people to access the public sphere and develop a sense of national solidarity is precisely the kind that will narrow the achievement gaps among demographic groups and raise the nation's average level of achievement.

Shared Knowledge Should Be Taught Using a Shared Curriculum

The policy implications of this article and my new book, *The Making of Americans*, can be boiled down to this: institute in your district or state an explicit, knowledge-rich, grade-by-grade core curriculum in grades K–8 that takes up at least 50 percent of school time. There are no good educational arguments against a coherent, content-specific core curriculum that could possibly outweigh its superior efficacy and fairness. Nevertheless, prejudices against commonality, and indeed against any set curriculum, continue to dominate American education. (See "The Anti-Curriculum Movement" on page 10.)

In discussions of a common curriculum, the main question is always the conversation stopper, "Who will decide?" The problem has been solved in other multicultural liberal democracies. In fact, no high-performing and fair educational system has failed to solve it. If an American core curriculum can meet two criteria—*acceptability* and *effectiveness*—then the political problem can be solved, and there will be a real chance to reverse decades of American educational decline.*

The kind of education that will enable all young people to develop a sense of national solidarity is precisely the kind that will narrow the achievement gaps and raise the nation's average level of achievement.

Acceptability: We know from surveys that the public generally likes the idea of a common core and wants the schools to teach the traditions that hold the country together—traditions such as respect for those laws, institutions, and ideals of freedom and equality that Abraham Lincoln exhorted American schools to promote in order to preserve the union as the "last best hope of earth." Lincoln's view is seconded by most citizens. In the Public Agenda report *A Lot to Be Thankful For*, 84 percent of parents said they wanted their children to learn about America's political institutions, history, and ideals of freedom and equality. Concerning civics, then, the American public has clearly decided the core-curriculum question. Moreover, few sensible people will wish to launch a campaign against a core curriculum in math and science, which are the same in China as in Chattanooga. But there is a lot more to elementary education than civics, math, and science. We also need agreement on a common core for history, art, music, and literature—a more daunting task that leads to the second characteristic a common core must exhibit: effectiveness.

Effectiveness: An explicit curriculum would be accepted in the United States if it were shown to be highly effective in imparting an ability to read, write, and learn at a high level. Hence the answer to the question "Who decides?" is "The community that makes up the public sphere has already largely decided." A core curriculum that systematically imparts this content will be optimally effective

*Other, more technical attributes are that the early core curriculum must be highly specific and outlined grade by grade. Without specificity there can be no commonality, and then we fall into the vagueness trap of current state standards. Grade-by-grade definiteness is needed because the school year is the key time unit for the student, who usually moves to a new teacher at each new grade level.

in developing reading, writing, and learning ability, and in giving all children equal access to the public sphere.

In 1987, I ventured to set down an index to some of the knowledge students needed to possess to be proficient in the American standard language and full participants in the public sphere.[11] In the two decades since then, my colleagues and I at the Core Knowledge Foundation have transformed that list into a coherent core curriculum that is now being followed by hundreds of schools. Unsurprisingly, reading comprehension scores at these schools have soared.[12]

Other sequences that put the same basic knowledge in a different order could be equally effective.† But the substance of any such curriculum would need to be very similar to the Core Knowledge curriculum, because the taken-for-granted knowledge in the American public sphere is finite and definable. Core Knowledge did not decide what students should learn—it inventoried and then organized the knowledge that the public sphere assumes adults know.

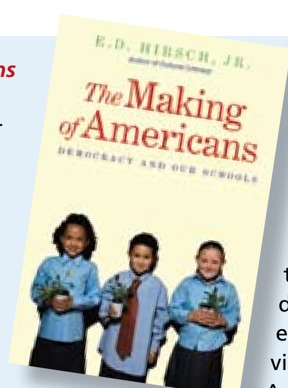
Any effective curriculum would also need to be, like ours, grade-specific. This is a critical point for the following reasons:

Without a common core curriculum, the disparity in student readiness increases with each successive grade, slowing down progress and making the teacher's task ever more difficult.

1. Specifying core content by year enables the teacher at each grade level to know what students already know, making it possible to communicate with the whole class and bring the group forward together. As Harold Stevenson and James Stigler pointed out in their pathbreaking book *The Learning Gap*, the American

(Continued on page 38)

†An alternative example with excellent results is the Roxbury Preparatory Charter School, a public school for grades 6–8 (see www.roxburyprep.org). The school has developed a highly specific, grade-by-grade curriculum based on an analysis of the Massachusetts state standards (among the best in the country) and the kinds of knowledge probed by the state tests. It is a tremendous credit to this school that it has undertaken the immense labor required to create this curriculum.



The Making of Americans departs from and supplements my earlier books on education. It concerns itself, like them, with overcoming low literacy rates and narrowing the achievement gaps between demographic groups, but places those themes within the broader context of the founding ideals of the American experiment, which have been a beacon to us and the world.

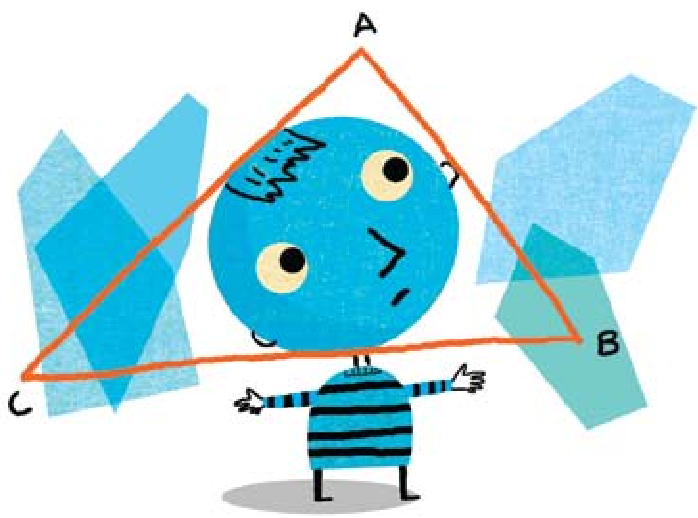
If my arguments are accepted, it will mean repudiating ideas and slogans that have dominated early schooling for at least 70 years, and replacing them with different and more fundamental ideas. Only a grasp of the accidents of history can enable such change to prevail. The apparently benign idea of natural, child-centered education that took hold at the beginning of the 20th century came by gradual degrees to weaken our country's competence and competitiveness, diminish our solidarity, and reduce equality of opportunity. It has almost nullified two of the most precious founding ideas of the United States: the idea of unity despite our differences and the idea of equality. The Founders viewed the making of Americans as *the* dominant purpose of the public school, and that purpose must be made dominant once again, enriched by the humane traditions of pedagogical practice that the child-centered movement introduced.

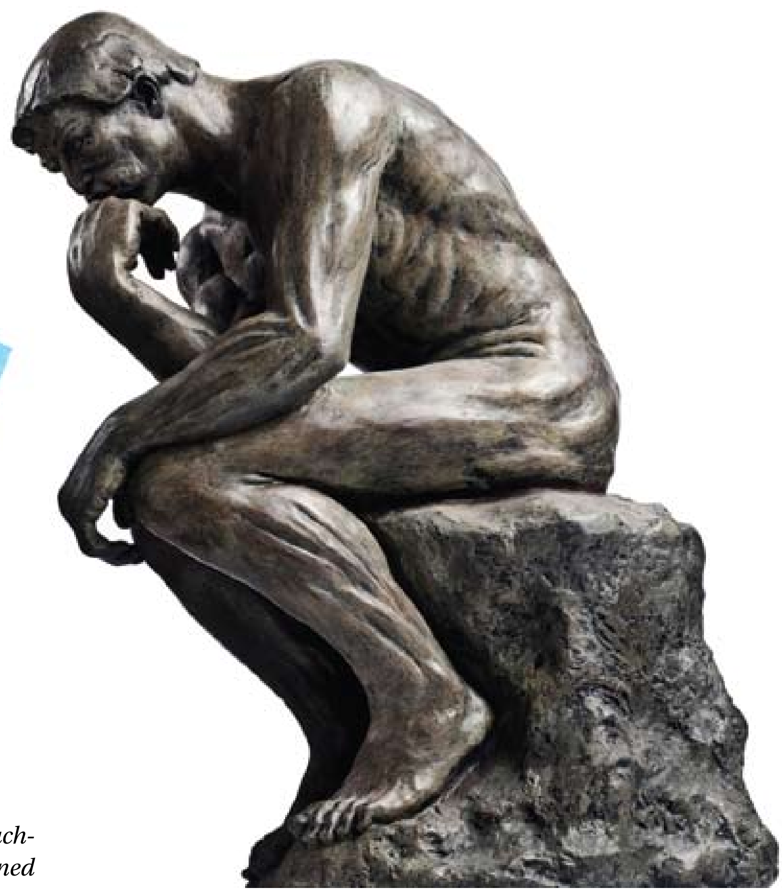
I dedicate this book to the memory of my late friend Albert Shanker, who was president of the American Federation of Teachers. I decided to write it while reading *Tough Liberal*, Richard Kahlenberg's fine biography of Shanker. Al's premature death 12 years ago was a setback to American educational improvement. His unique combination of ideals, courage, and acumen was just what we needed—and still need—to reinstate the grand Enlightenment goals of the American school. His intellectual and political toughness and strong influence are irreplaceable. Al's intellectual biography is the very image of what American schooling was instituted to accomplish. When he started as a student in the schools of New York City, he did not speak English. No wonder he defended the great aim of assimilation at a time when it was unfashionable to do so. His adversaries liked to advert to the militancy of his earlier days as a union leader. But those of us who knew the statesmanlike Al of the 1980s and 1990s were drawn to his unique ability to overcome the left-right polarization of educational issues. I was especially grateful to Al for championing my ideas when it took great courage to do so.

–E.D.H.

ASK THE COGNITIVE SCIENTIST

Is It True That Some People Just Can't Do Math?





How does the mind work—and especially how does it learn? Teachers' instructional decisions are based on a mix of theories learned in teacher education, trial and error, craft knowledge, and gut instinct. Such knowledge often serves us well, but is there anything sturdier to rely on?

Cognitive science is an interdisciplinary field of researchers from psychology, neuroscience, linguistics, philosophy, computer science, and anthropology who seek to understand the mind. In this regular American Educator *column, we consider findings from this field that are strong and clear enough to merit classroom application.*

By Daniel T. Willingham

Question: "I'm just no good at math." Every year, I hear this from at least a few of my students. In fact, I've heard it from plenty of adults too. Is there any truth to this notion that some people just can't learn mathematics?

Daniel T. Willingham is a professor of cognitive psychology at the University of Virginia. His most recent book, Why Don't Students Like School?, *is designed to help teachers apply research on the mind to the classroom setting. For his articles on education, go to* **www.danielwillingham.com**. *Readers can pose specific questions to "Ask the Cognitive Scientist," American Educator, 555 New Jersey Ave. N.W., Washington, DC 20001, or to* **amered@aft.org**. *Future columns will try to address readers' questions.*

ILLUSTRATIONS BY JAMES YANG

Answer: While it is true that some people are better at math than others—just like some are better than others at writing or building cabinets or anything else—it is also true that the vast majority of people are fully capable of learning K–12 mathematics. Learning mathematics does not come as naturally as learning to speak, but our brains do have the necessary equipment. So, learning math is somewhat like learning to read: we can do it, but it takes time and effort, and requires mastering increasingly complex skills and content. Just about everyone will get to the point where they can read a serious newspaper, and just about everyone will get to the point where they can do high school–level algebra and geometry—even if not everyone wants to reach the point of comprehending James Joyce's *Ulysses* or solving partial differential equations.

* * *

"I'm just no good at math" is said so often—and with so little embarrassment (at least in the United States)—that it seems as though our society has accepted the "fact" that math is not for most of us. The problem is that this notion is a myth. Virtually everyone is fully capable of learning the numeracy content and skills required for good citizenship: an understanding of arithmetic procedures, algebra, geometry, and probability deep enough to allow application to problems in our daily lives.

What Does Nature Provide?

Humans have a clear proclivity to learn some types of information. The most notable example is language; given normal linguistic input, virtually all children learn their native language without effort or explicit instruction. In fact, we seem to have some innate knowledge of grammatical structures; our minds are so biased to learn language, we will *improve* on imperfect linguistic input. Deaf children exposed only to crude signs have been observed modifying what they see to give it *more* linguistic structure.[1] Is something comparable true of mathematics? Just how "naturally" do children learn mathematics? Two important findings from the last 20 years are relevant: (1) humans are born with the ability to appreciate the concept of number, and (2) humans seem to be born with a sense that numbers and space are related. Let's discuss each of these briefly.

First, humans are born with two ways to appreciate number. One is an approximate number sense. This sense cannot support precise enumeration, but it does enable us to compare two sets of objects and immediately know which set is larger. For example, if you saw 50 beans scattered on one table and 100 beans on another table, you would know at a glance, without counting, which table had more beans on it. Carefully conducted laboratory tests confirm that people can use their natural sense of numerosity to make these judgments, and are not making judgments by the area taken up by the beans, the density, or other cues.[2]

Although infants cannot give verbal replies, we know that they can make these judgments as well. Infants look at a novel object until they grow bored with it. If a new object is presented, they will look at it; but if the same object is presented, they will look at it for a much shorter time. By measuring looking time, an experimenter can determine whether the infant perceives a difference between the first and second objects. Using this methodology, studies have determined that infants have this approximate number sense,[3] although it is not as fine-grained as that seen in older children or adults. Six-month-olds can appreciate differences in numerosity in a ratio of 2:1 or larger, whereas adults can appreciate 8:7 (e.g., without counting, infants can tell that there is a difference between a group of four dots and a group of eight dots, while adults can tell that there is a difference between a group of seven dots and a group of eight dots). There is good evidence that nonhuman primates[4] and rats[5] also have approximate number sense.

The other way in which humans are born with an appreciation of number is that we have a way of representing precise values in our minds, but only up to a value of three. For example, if 10-month-old infants watch as one cracker is put into one bucket and then two crackers are put into another bucket, they crawl to the bucket with two crackers. They also choose three crackers over two, but fail when comparing two versus four.[6] A comparable experiment testing untrained rhesus monkeys showed similar performance; in fact, they performed slightly better than human infants, with an ability to mentally represent quantities of four.[7] Adults can perceive numerosities of up to four more or less instantly and virtually error free. Errors and response times increase sharply as the number of objects increases beyond four.[8]

The other important finding from the last 20 years of research is that humans seem to be born with a sense that numbers and space are related. There is a variety of evidence for this relationship; we'll review just a handful of it. First, many cultures make use of a spatial representation of numbers, for example, via a number line. Second, numbers and space are represented in overlapping areas of the brain. Damage to a particular region of the brain (the intraparietal sulcus, which is on the upper part of the brain, toward the back) leads to difficulties with directing spatial attention *and* difficulties with processing numbers.[9] In one of the more interesting demonstrations of the overlap of

> Virtually everyone is fully capable of understanding arithmetic procedures, algebra, geometry, and probability deeply enough to allow application to problems in our daily lives.

mathematics and space, a group of researchers wrote a computer program that analyzed brain imaging data to classify whether subjects were moving their eyes rightward or leftward during a brain scan.[10] The researchers then applied the classification program to brain data from subjects who performed two utterly different tasks: addition and subtraction. The theory was that, given the relationship between numbers and space, subtraction is like leftward eye movements because it decreases number size, and addition is like rightward eye movements because it increases number size. Remarkably, the computer program (created with just the brain data from eye movements) was successful 70 percent of the time in predicting whether subjects were adding or subtracting numbers.

Still, how we express our inborn sense that numbers and space are related is clearly affected by culture, as revealed in the following experiment. Subjects are seated in front of a computer screen and have two buttons. On each trial, a digit appears on the screen, and subjects are told to push the button on the left if the digit is even and the button on the right if it is odd. When an even digit appears, subjects are faster to push the left button for small numbers (two or four) than larger numbers (six or eight). When an odd digit appears, they are faster to push the right button for larger numbers (seven or nine) than smaller ones (one or three). In other words, small numbers "belong" on the left side, and large numbers "belong" on the right. This widely replicated effect is not observed until children are about 9 years old,[11] and it is reversed in Iranian adults who read from right to left.[12] Thus, it seems quite likely that, even if it is natural to associate space with number, the manner in which this happens is learned, and is specific to cultural convention.

The ability to enumerate precisely *beyond* about four depends on another, culture-specific system that is learned, and that is supported by language. In short, we learn to count. One of the most dramatic sources of evidence to help researchers understand counting as a culture-specific system comes from tests of the Mundurucú, an Amazonian indigen group. Their language has words for numbers only up to five. Beyond five, they simply refer to "many." They can use their innate approximate-number system to estimate and to roughly perform addition, but they cannot perform precise arithmetic with numbers larger than five.[13]

The Mundurucú have a sense of numbers corresponding to space, but this correspondence is not linear. That is, unlike on a ruler or number line, each increase of one number is not matched by a uniform increase in space. If asked to point to a location on a line to indicate where 1 to 10 dots should be represented, the Mundurucú will place the quantities 1 through 5 relatively spread out, and the quantities 6 through 10 more crowded together: the difference between 2 and 3 will be bigger than the difference between 7 and 8.* American adults, in contrast, do have a linear sense of number and space: they space the quantities 1 through 10 equally, as on a number line. But, American adults' linear sense is limited to situations where they are counting. When asked to perform the same task with quantities of dots between 10 and 100, Mundurucú and American participants perform comparably.

Automatic retrieval of basic math facts is critical to solving complex problems because complex problems have simpler problems embedded in them.

*The relationship between number and space is actually logarithmic.

They both allocate more space on the line to smaller quantities and less space to larger quantities, with crowding increasing as they get closer to 100.[14]

So it appears that humans are born with a sense of number as spatial, but the space is not linear. Indeed, until they have had sufficient experience (mostly in school) with the linear one-to-one correspondence between number and space that characterizes the number line, American children perform the place-the-dots-on-the-line task as the Mundurucú do. While American first-graders crowd higher numbers together, third-graders space higher numbers more evenly, and second-graders will do one or the other, depending on the task, the day of testing, and other incidental factors.[15]

So what comes naturally to children in mathematics? They have a natural number sense that allows them to understand and manipulate very small quantities with precision, and much larger quantities in approximation. Those abilities are, of course, a far cry from the abilities teachers hope to develop in their students, but they are the base upon which teachers must build. Just as reading does not come naturally, but uses visual and language representations that *are* natural,[16] it's a good bet that mathematics uses mental representations that are natural, but that did not evolve to support mathematics in the way our advanced society now needs them to.[17] For educators, that means we should not expect students will learn mathematics with ease. Rather, we should expect that mathematical proficiency will require careful cultivation and will develop slowly. At the same time, we should keep in mind that students are born with the ability to learn math, and we should not let students give up by concluding that they're just no good at math.

What Do Students Need to Be Successful in Math?

In its recent report,† the National Mathematics Advisory Panel argued that learning mathematics requires three types of knowledge: factual, procedural, and conceptual. Let's take a close look at each.

Factual knowledge refers to having ready *in memory* the answers to a relatively small set of problems of addition, subtraction, multiplication, and division.‡ The answers must be well learned so that when a simple arithmetic problem is encountered (e.g., 2 + 2), the answer is not calculated but simply retrieved from memory. Moreover, retrieval must be automatic (i.e., rapid and virtually attention free). This automatic retrieval of basic math facts is critical to solving complex problems because complex problems have simpler problems embedded in them. For example, long division problems have simpler subtraction problems embedded in them. Students who automatically retrieve the answers to the simple subtraction problems keep their working memory (i.e., the mental "space" in which thought occurs) free to focus on the bigger long division problem.[18] The less working memory a student must devote to the subtraction subproblems, the more likely that student is to solve

‡Addition and multiplication facts are easier to memorize because they are commutative; that is, 3 + 4 is the same as 4 + 3, and the same is true for 3 x 4 and 4 x 3. That is not the case for subtraction and division. Even well-educated adults from countries with excellent math education will sometimes calculate subtraction and division facts, rather than retrieve them from memory.

†The National Mathematics Advisory Panel's report is available at **www.ed.gov/about/bdscomm/list/mathpanel/report/final-report.pdf**.

the long division problem.

This interpretation of the importance of memorizing math facts is supported by several sources of evidence. First, it is clear that before they are learned to automaticity, calculating simple arithmetic facts does indeed require working memory. With enough practice, however, the answers can be pulled from memory (rather than calculated), thereby incurring virtually no cost to working memory.[19] Second, students who do not have math facts committed to memory must instead calculate the answers, and calculation is more subject to error than memory retrieval.[20] Third, knowledge of math facts is associated with better performance on more complex math tasks.[21] Fourth, when children have difficulty learning arithmetic, it is often due, in part, to difficulty in learning or retrieving basic math facts.[22] One would expect that interventions to improve automatic recall of math facts would also improve proficiency in more complex mathematics. Evidence on this point is positive[23] but limited, perhaps because automatizing factual knowledge poses a more persistent problem than difficulties related to learning mathematics procedures.[24]

What of procedural and conceptual knowledge, also deemed necessary by the National Mathematics Advisory Panel? A procedure is a sequence of steps by which a frequently encountered problem may be solved. For example, many children learn a routine of "borrow and regroup" for multidigit subtraction problems. Conceptual knowledge refers to an understanding of meaning; knowing *that* multiplying two negative numbers yields a positive result is not the same thing as understanding *why* it is true.

The "math wars" that have been waged among math educators and researchers in the United States have largely revolved around the procedures-versus-concepts axis and, like most heated debates, have included a fair amount of caricature. At the extremes, progressives claim that traditionalists would be happy for students to execute procedures without understanding what they are doing, and traditionalists claim that progressives care only that students understand concepts and are unconcerned about whether they can actually solve math problems. Most observers of the math wars understand that, even though some children with conceptual understanding may invent appropriate calculation procedures,[25] this process of invention cannot be relied on for all children.[26] Then too, knowledge of procedures is no guarantee of conceptual understanding; for example, many children can execute a procedure to divide fractions without understanding why the procedure works.[27] Most observers agree that knowledge of procedures *and* concepts is desirable.[28]

Somewhat more controversial is the relative emphasis that should be given to these two types of knowledge, and the order in which students should learn them. Perhaps with sufficient practice and automaticity of algorithms, students will, with just a little support, gain a conceptual understanding of the procedures they have been executing. Or perhaps with a solid conceptual understanding, the procedures necessary to solve a problem will seem self-evident.

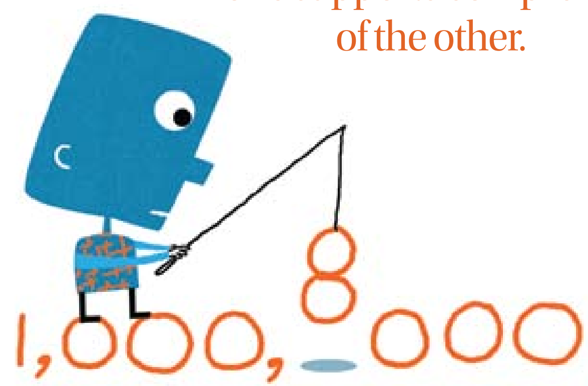
There is some evidence to support both views. Conceptual knowledge sometimes seems to precede procedural knowledge or to influence its development.[29] Then too, procedural knowledge can precede conceptual knowledge. For example, children can often count successfully before they understand all of counting's properties, such as the irrelevance of order.[30]

A third point of view (and today perhaps the most commonly accepted) is that for most topics, it does not make sense to teach concepts first or to teach procedures first; both should be taught in concert. As students incrementally gain knowledge and understanding of one, that knowledge supports comprehension of the other.[31] Indeed, this stance seems like common sense. Since neither procedures nor concepts arise quickly and reliably in most students' minds without significant prompting, why *wouldn't* one teach them in concert?

The Problem of Conceptual Knowledge

How well are American students doing on these three types of knowledge? The National Mathematics Advisory Panel concluded that American students have reasonable, though incomplete, factual and procedural knowledge, and poor conceptual knowledge. These conclusions seem sound, but they ought to be considered tentative because there are not up-to-date, comprehensive assessments designed to provide this sort of data. Still, studies from the last 20 years indicate that American students, even college students, have not completely automatized fact retrieval[32] or achieved fluency with procedures.[33]

> For most topics, it does not make sense to teach concepts first or to teach procedures first; both should be taught in concert. Gaining knowledge and understanding of one supports comprehension of the other.



More troubling is American students' lack of conceptual understanding. Several studies have found that many students don't fully understand the base-10 number system.[34] A colleague recently brought this to my attention with a vivid anecdote. She mentioned that one of her students (a freshman at a competitive university) argued that 0.015 was a larger number than 0.05 because "15 is more than 5." The student could not be persuaded otherwise.

Another common conceptual problem is understanding that an equal sign (=) refers to equality—that is, mathematical equivalence. By some estimates, as few as 25 percent of American sixth-graders have a deep understanding of this concept.[35] Students often think it signifies "put the answer here." It has been argued that student textbooks and textbooks for future mathematics teachers do not make the meaning of the equal sign clear enough, nor do they offer examples of its use that would help readers understand the meaning.[36]

The cost of poor conceptual understanding should be clear. If you think an equal sign means "put the answer here," you'll be confused the first time you see an equation with terms on *both* sides of the equal sign. When a student first encounters factoring, he ought to see how it relates to division, but he probably won't without a deep conceptual understanding of division. (And, just to emphasize that factual, procedural, and conceptual knowledge all go together, he also will be slowed in factoring if he hasn't memorized the multiplication table.)

Unfortunately, of the three varieties of knowledge that students need, conceptual knowledge is the most difficult to acquire. It's difficult because knowledge is never acquired *de novo*; a teacher cannot pour concepts directly into students' heads. Rather, new concepts must build upon something that students already know. That's why examples are so useful when introducing a new concept.[37] Indeed, when someone provides an abstract definition (e.g., "The standard deviation is a measure of the dispersion of a distribution."), we usually ask for an example (such as, "Two groups of people might have the same average height, but one group has many tall and many short people, and thus has a large standard deviation, whereas the other group mostly has people right around the average, and thus has a small standard deviation.").

Manipulatives don't always help learning—they sometimes impede it. It's familiarity that helps, because it allows students to think in new ways about things they already know.

This is also why conceptual knowledge is so important as students advance. Learning new concepts depends on what you already know, and as students advance, new concepts will increasingly depend on old conceptual knowledge. For example, understanding algebraic equations depends on the right conceptual understanding of the equal sign. If students fail to gain conceptual understanding, it will become harder and harder to catch up, as new conceptual knowledge depends on the old. Students will become more and more likely to simply memorize algorithms and apply them without understanding.

So how can students learn concepts? In the United States, much is made of the use of manipulatives to help children understand abstract concepts in mathematics, but of course manipulatives themselves are abstract (the student is to treat them as a symbol for something else[38]) and manipulatives don't always help learning—they sometimes impede it.[39] This is most likely when manipulatives are so visually interesting that they distract from their purpose, or when their relationship to the concept to be represented is obscure.

Manipulatives seem helpful because they are concrete. To illustrate the idea of a fraction, one might divide a cookie in two for the purpose of sharing it with a student. But the *concreteness* of this example is likely less important than its *familiarity*.[40] Suppose I tore a book into two pieces, and said "See? Now there are two equal pieces. Each one is half a book." That example is concrete, but less effective because it is unfamiliar; the student has no experience with divided books, and the purpose of sharing is also missing. Concreteness is not a magical property that allows teachers to pour content into students' minds. It's familiarity that helps, because it allows the teacher to prompt students to think in new ways about things they already know.

Familiarity is not the only ingredient necessary for successful examples. Students are more likely to understand abstract ideas when they see many examples,[41] so that they can learn which properties are important to the concept (division of the object into equal parts) and which properties are incidental (that the resulting parts can be shared). Crucially, students frequently fail to understand the concept if they are not explicitly told to look for the commonalities among examples, or are not given hints as to what the commonalities are.[42]

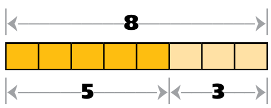
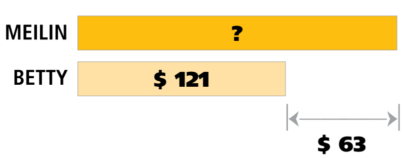
As concepts become more complex, familiar examples from the students' lives become harder to generate, and teachers may use analogies more often; a familiar situation is offered as analogous to the concept, not as an example of the concept. Thus, a teacher might tell students that algebraic equations may be thought of like a balance scale: the two sides are equivalent, and you maintain their equivalence so long as you perform the same operation on both sides. Laboratory studies have revealed several principles that make analogies especially effective: familiarity (e.g., students know what a balance scale is), vividness (actually having the balance scale for students to see), making the alignment plain (e.g., writing the two sides of the equation over the two sides of a drawing of a balance scale), and continuing to reinforce the analogy (e.g., by referring to the scale at appropriate times as the equation is solved). Some data indicate that math teachers in Hong Kong and Japan (where mathematics achievement is consistently high) are especially effective in using analogies according to these principles.[43]

What Does All This Mean for Teaching?

1. *Think carefully about how to cultivate conceptual knowledge, and find an analogy that can be used across topics.* Of the three types of knowledge mentioned, conceptual knowledge is the most difficult for students to learn. Seeing and hearing many different examples of a concept are useful for abstracting the core idea and learning which features of the examples are irrelevant. It is also useful for students to learn a single analogy to which they return

again and again. Using the same analogy across topics makes it much clearer to students how those topics relate to one another.

Drawing connections among mathematical topics deepens conceptual knowledge, but it is one of the desired outcomes that is seldom met in the United States. In contrast, drawing connections by building systematically upon simple models is the centerpiece of the Singapore method,[44] which appears to be quite successful given the high performance of Singapore's students. Teachers in the United States may not be free to adopt a curriculum wholesale, but the cognitive advantages of the model approach (see box below) are impressive.

> The Singapore Model Method uses graphical models to help students understand mathematical concepts. These models are introduced in early grades starting with real objects, but quickly transition to bars, as shown in the two examples below. Both models can represent the same function, in this case addition.
>
> 1. The part-whole model emphasizes that two parts of a bar, such as the 5 sections and 3 sections shown here, can also be considered together as a whole with 8 sections.
>
> 
>
>
> 2. The comparison model emphasizes comparison of two bars. For example, students might use this model to represent the following problem:*
>
> *Betty saved $121. She saved $63 less than Meilin. How much did Meilin save?*
>
> 
>
>
> In higher grades, these bars easily transition to number lines. The two models can be used for many of the fundamental concepts through algebra: the four operations, fractions, ratios, and percentages.
>
> ---
>
> *Kho Tek Hong, Yeo Shu Mei, and James Lim, *The Singapore Model Method for Learning Mathematics* (Singapore: PanPac, 2009), 20.

2. *In cultivating greater conceptual knowledge, don't sacrifice procedural or factual knowledge.* Procedural or factual knowledge without conceptual knowledge is shallow and is unlikely to transfer to new contexts, but conceptual knowledge without procedural or factual knowledge is ineffectual. Tie conceptual knowledge to procedures that students are learning so that the "how" has a meaningful "why" associated with it; one will reinforce the other.†

Increased conceptual knowledge may help the average American student move from bare competence with facts and procedures to the automaticity needed to be a good problem solver. But if we reduce work on facts and procedures, the result is likely to be disastrous.

3. *In teaching procedural and factual knowledge, ensure that students get to automaticity*. Explain to students that automaticity with procedures and facts is important because it frees their minds to think about concepts. For automaticity with procedural knowledge, ensure that students are fluent with the standard algorithms. This requires some memorization and ample practice. For factual knowledge, ensure that students have memorized basic math facts, such as the multiplication table up to 12 x 12.

Increased conceptual knowledge may help students move from bare competence with facts and procedures to the automaticity they need to be good problem solvers.

4. *Choose a curriculum that supports conceptual knowledge.* If conceptual knowledge is indeed so difficult to learn, it makes sense to (1) study just a few concepts each year, but study them in depth so there is sufficient time to comprehend one concept before the next one is introduced, and (2) sequence topics so, as much as is possible, the mental distance between concepts is small and the previously learned concept will help in learning each new one. These two sensible precepts (along with a third, rigor) are exactly those that William Schmidt has advocated, based on his analysis of the curricula of countries that excel in mathematics.‡

5. *Don't let it pass when a student says "I'm just no good at math."* We hear it a lot, but it's very seldom true. It may be true that the student finds math more difficult than other subjects, but with some persistence and hard work, the student can learn math—and as he learns more, it will get easier. By attributing the diffi-

(Continued on page 39)

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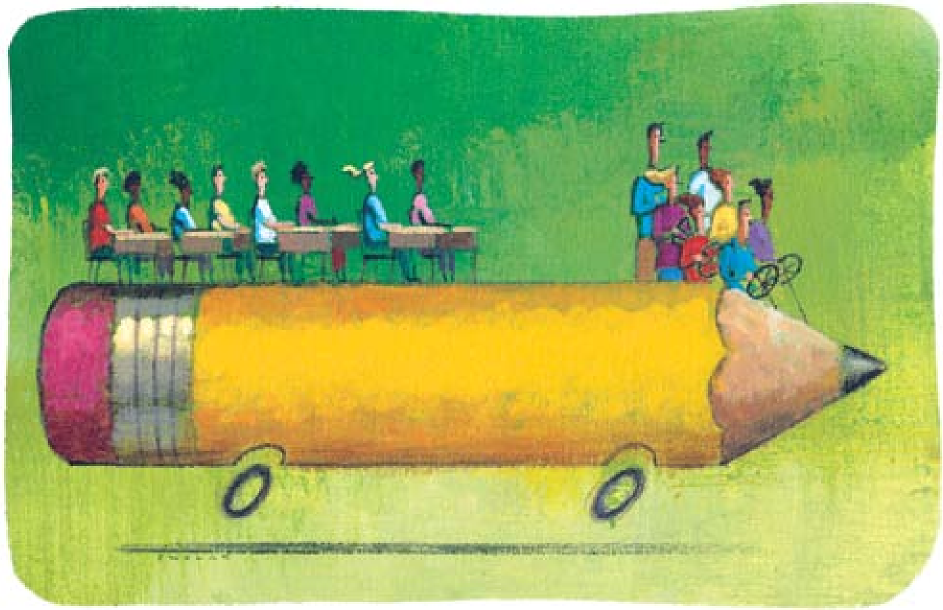
†For an in-depth look at how to teach so that conceptual, factual, and procedural knowledge reinforce each other, see "Basic Skills versus Conceptual Understanding: A Bogus Dichotomy in Mathematics Education" by Hung-Hsi Wu in the Fall 1999 issue of *American Educator*, available online at www.aft.org/pubs-reports/american_educator/fall99/wu.pdf.

‡To learn more about William Schmidt's research and the need for focus, coherence, and rigor in mathematics curricula, see "What's Missing from Math Standards?" in the Spring 2008 issue of *American Educator*, available online at www.aft.org/pubs-reports/american_educator/issues/spring2008/schmidt.htm.

Want to Improve Children's Writing?

Don't Neglect Their Handwriting

By Steve Graham



The famed playwright Harold Pinter, having just been introduced as a very good writer, was once asked by a six-year-old boy if he could do a *w*.[1] I suspect that *w* was a difficult letter for this young man, and he judged the writing capability of others accordingly.

This student's assumption—that being a "good writer" means having good handwriting—is not as off base as you might think. In dozens of studies, researchers (including, but certainly not limited to, myself and my colleagues) have found that, done right, early handwriting instruction improves students' writing. Not just its legibility, but its *quantity and quality*.

Of all the knowledge and skills that are required to write, handwriting is the one that places the earliest constraints on writing development. If children cannot form letters—or cannot form them with reasonable legibility and speed—they cannot translate the language in their minds into written text. Struggling with handwriting can lead to a self-fulfilling prophecy in which students avoid writing, come to think of themselves as not being able to write, and fall further and further behind their peers. Just as young readers must learn to decode fluently so they can focus on comprehension, young writers must develop fluent, legible handwriting (and must master other transcription skills like spelling*) so they can focus on generating and organizing ideas.

Handwriting and the Developing Writer

Imagine you have been asked to write something using a Chinese typewriter. This is a very complicated machine, containing about 6,000 characters. Top typing speeds are 11 characters per minute, so you'll have no hope of typing fast enough to keep up with your thoughts. As you write your masterpiece, some of your ideas are likely to slip from memory. Any time you have to hunt for the next character, your memory will be taxed further, resulting in even more of your ideas being forgotten. The act of typing is so demanding, cognitive resources that could be devoted to planning, evaluating, and sharpening text are diverted to simply transcribing it.

For young children, the act of writing is almost this demanding. The thought they must put into how to form letters interferes with other writing processes.[2] Eventually, most people's handwriting becomes fluent and automatic, minimizing that interference.[3] Researchers do not yet know when most youngsters reach this point, but it does not appear to be during the elementary years. In grades 4 to 6, handwriting fluency still accounts for 42 percent of the variability in the quality of children's writing,[4] and students' handwriting speed continues to increase at least until grade 9.[5]

Legibility is also a serious problem that, unfortunately, is inversely related to fluency.

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*For an in-depth article on spelling instruction, see "How Words Cast Their Spell" in the Winter 2008–2009 issue of *American Educator*: www.aft.org/pubs-reports/american_educator/issues/winter08_09/joshi.pdf.

ILLUSTRATIONS BY PAUL ZWOLAK

If students have to write more quickly, when taking notes or working on a timed test, for example, the legibility of their text declines.[6] Estimates of handwriting legibility difficulties in the elementary grades range from 12 percent of children to as high as 44 percent of children in urban schools.[7] And, as all teachers no doubt know, boys are at greater risk for such difficulties than girls.[8]

Legibility obviously causes problems for these students' teachers, but it causes problems for the students too. Studying for a test is quite difficult when students can't read their own notes. Furthermore, readers form judgments, positive or negative, about the quality of text based on its legibility. When teachers are asked to rate multiple versions of the same paper differing only in legibility, neatly written versions of the paper are assigned higher marks for overall quality of writing than are versions with poorer penmanship.[9]

All beginning writers struggle with fluency and legibility to some extent, and that inevitably affects their approach to composing. Young writers typically cope with the multiple demands of handwriting and composing by minimizing the composing process (planning, organizing, etc.). Because so much of their thinking must be devoted to forming legible letters, they turn composing into a knowledge-telling process in which writing is treated as a forward-moving idea-generation activity. A relevant idea is generated and written down, with each new phrase or idea serving as the stimulus for the next one. Mostly absent from this approach to writing are more reflective and demanding thinking activities such as considering the constraints imposed by the topic, the needs of the reader, or the most coherent way to organize the text.[10] As handwriting skills become more automatic and less cognitively demanding, attention and resources for carrying out other writing processes, including those involving more reflection and careful composing, become available. It is important that this occurs early, as the longer the knowledge-telling approach to writing is in place, the more difficult it is to get children to change their writing habits.

Early attention to handwriting is especially important for children who experience difficulty. They often avoid writing whenever possible, and develop a mindset that they cannot write.[11] This, of course, increases the likelihood that they will become poor writers.

Teaching Handwriting

There is considerable scientific evidence, collected over a span of almost 100 years, demonstrating that directly teaching handwriting enhances legibility and fluency.[12] This is not to say less formal teaching methods, such as capitalizing on teachable moments, should be avoided. But the available research does clearly indicate that children—especially those who struggle with handwriting—benefit from carefully planned, explicit handwriting instruction.

Effective handwriting instruction does not require a large investment of school time. During kindergarten and grades 1–3, it should be taught in short sessions several times a week or even daily, with 50 to 100 minutes a week devoted to its mastery.[13] There are considerable returns for such a small investment of time, as students' sentence-writing skills, the amount they write, and the quality of their writing all improve along with their handwriting.[14]

Just last year, my colleagues and I conducted a national survey of first- through third-grade teachers' beliefs about and instructional strategies for handwriting.[15] We were heartened to find that 90 percent reported that they taught handwriting, devoting an average of 70 minutes a week to it. In addition, more than half agreed that handwriting has important consequences for students, indicating that it influences their grades, the quantity and quality of their writing, and time needed to complete writing assignments.

Only 39 percent of teachers said that their students' handwriting was adequate, however, and just 46 percent indicated their students' handwriting was fast enough to keep up with classroom demands. Even more disconcerting, a mere 12 percent reported that they received adequate preparation to teach handwriting in their college education courses. With these results in mind, the rest of this article is devoted to describing effective handwriting instruction—everything from which script to teach to tackling difficult letters to increasing speed. As you'll see, effective handwriting instruction involves many components. To make it more manageable, my colleagues and I have developed and tested a handwriting program for first-grade teachers. I describe it in the sidebar on page 24 and have posted it online at **www.peabody.vanderbilt.edu/casl.xml** for teachers to use free of charge.

Students' sentence-writing skills, the amount they write, and the quality of their writing all improve along with their handwriting.

Manuscript, Cursive, D'Nealian, or Italics?

One of the most fundamental issues in explicitly teaching handwriting to students involves the script(s) students are to be taught. In the United States, children are typically taught both manuscript and cursive, as the former is usually introduced in kindergarten or grade 1 and the latter in grade 2 or 3. One relatively common variation on this theme is to teach slanted manuscript letters (the D'Nealian alphabet) that more closely resemble their cursive counterparts than the more traditional manuscript alphabet, which is characterized by round upright letters that resemble type.[16] The supposed purpose of this modified, slanted manuscript alphabet is to make the transition between manuscript and cursive writing easier and more efficient. Despite the generally agreed-upon practice of teaching both manuscript and cursive writing, some educators have challenged the desirability of teaching both manuscript and cursive, recommending that only manuscript be taught[17] or that cursive be emphasized from the start.[18] Still others have advocated the exclusive use of italics.[19]

Unfortunately, research does not provide a definitive answer on the relative effectiveness of different scripts.[20] Even so, I would like to proffer the following recommendation: instruction should start with traditional manuscript letters for the following four reasons. One, most children come to kindergarten and first grade already knowing how to write some letters. These are typically traditional manuscript letters taught by parents or preschool teachers.[21] Learning a special alphabet, such as D'Nealian, means that children will have to relearn many of the letters they can already write. Two, there is some evidence (although it is dated) that traditional manuscript is easier to learn than cursive writing.[22] Three, once traditional manuscript is mastered, it can be written as fast as cursive, and possibly even more legibly.[23] Four, the use of traditional manuscript in the early grades may actually facilitate reading development.[24] This is likely due to the fact that the material students read is written in manuscript, not cursive.

Students need to be able to quickly and easily name the letters, match each name to its appropriate letter, and write letters when named.

Regardless of which script(s) a child is taught, it is important to realize that children will inevitably develop their own style. This may involve using slightly more curved lines, eliminating clockwise movements, combining letters from different scripts, and eliminating or modifying some connecting strokes.[25] Such modifications appear to be aimed at increasing handwriting efficiency, as they are commonly associated with faster handwriting. Thus, teachers who insist on a strict adherence to a particular model are likely to frustrate not only themselves, but their students as well.

Letter Names

Several years ago, a teacher told me that a young child asked how to write "elemeno," thinking that *l*, *m*, *n*, and *o* were all one letter (the child probably inferred this from the alphabet song where the

Scribble, Scribble, Eh, Mr. Toad?

Whether sending a note to a friend or pushing through the most difficult part of an essay, there's something about putting pen to paper that is more thought provoking and revealing than pecking away at a keyboard. Professor and journalist Lance Morrow noted as much more than 20 years ago—just as personal computers were becoming widespread. He published this piece in Time *on February 24, 1986. We think it's worth revisiting, so we bring it to you just before National Handwriting Day, which is January 23.*

–EDITORS

BY LANCE MORROW

National Handwriting Day passed last month without parades. But the occasion may deserve to be celebrated, belatedly, with an updating of a part of *The Wind in the Willows*, a new chapter in the life of Toad of Toad Hall:

Toad gave up pen and pencil years ago, when he discovered the Smith-Corona manual portable typewriter. Toad loved his Smith-Corona. He played upon it like a flamboyant pianist. Now he massaged the keyboard tenderly through a quiet phrase, now he banged it operatically, thundering along to the chinging bell at the end of the line, where his left arm would abruptly fire into midair with a flourish and fling home the carriage return.

If Toad ever put pen to paper, it was reluctantly, to scribble in the margin of a college textbook ("Hmmmmm" or "Sez who?" or "Ha!"), or to write a check. Over the years, Toad's handwriting atrophied, until it was almost illegible. Who cared? Sonatas of language, symphonies, flowed from the Smith-Corona.

At length, Toad moved on to an electric model, an IBM Selectric, and grew more rapturous still. Toad said the machine was like a small private printing press: the thoughts shot from his brain through his fingers and directly into flawless print.

Then one winter afternoon, Toad came upon the marvel that changed his life forever. Toad found the word processor. It was to his Selectric as a Ferrari to a gypsy's cart. Toad now thought that his old writing machines were clattering relics of the Industrial Revolution.

Toad processed words like a demon. His fingers flew across the keys, and the words arrayed themselves on a magic screen before him. Here was a miracle that imitated the very motions of his brain, that teleported paragraphs here and there—no, there!—as quickly as a mind flicking through alternatives. Prose with the speed of light, and lighter than air! Toad could lift 10 lbs. of verbiage, at a whim, from his first page and transport it to the last, and then (hmmm), back again.

A happy life, until one day, Toad, when riding his bicycle in the park, took a disastrous spill. Left thumb broken, arm turned to fossil in a cast, out of which his fingers twiddled uselessly, Toad faced the future. He tried one-handing his word processor, his hand jerking over the keyboard like a chicken in a barnyard.

It was no use. There is no going back in pleasure. "Bother!" said Toad. He picked up a No. 1 Eberhard Faber pencil. He eyed it with the despair of a suddenly toothless gourmand confronting a life of strained carrots and peas. He found a schoolboy's lined notebook and started to write.

The words came haltingly, in misshapen clusters. Toad's fingers lunged and jabbed and oversteered. When he paused to reread a sentence, he found that he could not decipher it. The language came out Etruscan.

Yet Toad perforce persisted. It had been years since he had formally and respectfully addressed blank paper with only pen or pencil in hand. He felt unarmed, vulnerable. He thought of final exams long years ago—the fields of rustling blue-book pages, the universal low, frantic scratching of pens, the smell of sour collegiate anguish.

Toad drove his pencil onward. Grudgingly, he thought, This is rather interesting. His handwriting, spasmodic at first, began to settle after a time into rhythmic, regular strokes, growing stronger, like an

Lance Morrow has written more than 150 Time *cover stories, as well as several books, including* Evil: An Investigation*;* Second Drafts of History: Essays*; and* The Best Year of Their Lives: Kennedy, Johnson and Nixon in 1948*. Before retiring, he was a university professor at Boston University.*

cadence speeds up for these four letters). Because the name of a letter is likely to serve as a cue for retrieving from memory the motor program for writing it,[26] students need to be able to quickly and easily name the letters of the alphabet, match each name to its appropriate letter, and write letters when named. Two examples of procedures designed to strengthen these links include (1) naming each letter as it is initially practiced and, (2) the alphabet practice game in which the student writes the letter that comes after a series of five designated letters (e.g., *c*, *d*, *e*, *f*, *g*) and then writes the letter that comes before them.[27] (For more on these instructional strategies, see the handwriting program described on page 24.)

Letter Forms

The basic goal of handwriting instruction is to help students develop legible writing that can be produced quickly with little conscious attention. A critical ingredient in achieving this goal is teaching students an efficient pattern for forming individual letters. Research has found that examining a model of the letter marked with numbered arrows (indicating the nature, order, and direction of component strokes), combined with reproducing the letter from memory, produced the best handwriting performance in a study with first-grade students at risk for handwriting problems.[28] In contrast, one strategy that is not effective is asking students to overtly verbalize the steps for forming a letter while learning it.[29] Most likely, this strategy does not work well because it uses up children's limited working-memory resources.[30]

Some teachers are not sure how much time students should spend practicing individual letters. It is not a good idea to apply "massed practice" procedures, where

(Continued on page 26)

oarsman on a long haul.

Words come differently this way, thought Toad. To write a word is to make a thought an object. A thought flying around like electrons in the atmosphere of the brain suddenly coalesces into an object on the page (or computer screen). But when written in longhand, the word is a differently and more personally styled object than when it is arrayed in linear file, each R like every other R. It is not an art form, God knows, in Toad script, not Japanese calligraphy. Printed (typed) words march in uniform, standardized, cloned shapes done by assembly line. But now, thought Toad, as I write this down in pencil, the words look like ragtag militia, irregulars shambling across the page, out of step, slovenly but distinctive.

Toad reflected. What he saw on the penciled page was himself, all right, not just the content of the words but the physical shape and flow of thought. Some writers do not like to see so much of themselves on the page and prefer to objectify the words through a writing machine. Toad for a moment accused himself of sentimentalizing handwriting, as if it were home-baked bread or hand-cranked ice cream. He accused himself of erecting a cathedral of enthusiasm around his handicap.

At length Toad could see his own changes of mood in the handwriting. He could read haste when he had hurried. He thought that handwriting would make a fine lie-detector test, or a foolproof drunkometer. Handwriting is civilization's casual encephalogram.

Writing in longhand does change one's style, Toad came to believe, a subtle change, of pace, of rhythm. Sentences in longhand seemed to take on some of the sinuosities of script. As he read his pages, Toad considered: the whole toad is captured here. *L'ecriture, c'est l'homme* (Handwriting is the man). Or, *L'ecriture c'est le crapaud* (Handwriting is the toad). What collectors pay for is the great writer's manuscript, the relic of his actual touch, like a saint's bone or lock of hair. What will we pay in future years for a great writer's computer printouts? All the evidence of his emendations, his confusions and moods, will have vanished into hyperspace, shot there by the Delete key.

Toad found himself seduced, in love, scribbling away in the transports of a new passion. Toad was always a fanatic, of course, an absolutist. He bought the fanciest fountain pen. His word processor went first into a corner, then into a closet with the old IBM.

Toad thought of Henry James. For decades, James wandered Europe and the U.S., staying in hotels or in friends' houses. He was completely mobile. He needed only pen and paper to write his usual six hours a day. Then in middle age, he got writer's cramp. He bought a typewriter, and, of course, needed a servant to operate the thing. So now James was more and more confined to his home in Sussex, pacing the room, dictating to the typist and the clacking machine. James became a prisoner of progress.

Toad, liberated, bounded off in the other direction. Light of heart, he took to the open road, encumbered by nothing heavier than a notebook and a pen. Pausing on a hilltop now and then, he wrote long letters to Ratty and Mole, and folded them into the shape of paper airplanes, and sent them sailing off on the breeze. ☐

Pencil on Paper, Let's Go

Effective—and Efficient—Handwriting Instruction

The negative consequences (for both the writer and the reader) of poorly developed handwriting led my colleague, Karen Harris, and me to develop a supplemental instructional program designed to accelerate the handwriting development of the slowest handwriters, including children with disabilities, in first grade. The program's 27 lessons take just 15 minutes each and could be used with the whole class—especially if the teacher is careful to give extra attention to the students with the slowest and least legible handwriting. While we created the program for first-graders, it could also be used with a whole class of kindergartners or as an intervention for second-graders whose handwriting is too slow or illegible. (See the main article for handwriting speed norms by grade and gender.)

In developing the program, we conducted a study with 39 children and found, on average, that children made greater gains in their handwriting and writing than their control-group counterparts, both immediately after completing the program and six months later.[1] These gains included faster and more correctly formed handwriting, greater facility in constructing sentences, and greater output when writing stories. We calculated effect sizes to gauge the statistical and practical significance of our results. The effect size for handwriting was 1.46, for constructing sentences it was .76, and for length of stories it was 1.21. These are large effects, as an effect size of .25 is considered practically significant, whereas an effect size above 1.00 is rare.

Having developed this program under the auspices of the Center to Accelerate Student Learning (CASL), we call it the CASL handwriting program and are pleased to share it with teachers for free. Just go to **www.peabody.vanderbilt.edu/casl.xml**. The program's goals—to teach first-graders how to write letters accurately and fluently—are accomplished by teaching children to name and identify the letters of the alphabet; correctly write lowercase manuscript letters in isolation, in words, and in sentences; and copy connected text more quickly.

The program contains 27 lessons that are divided into nine units (three lessons per unit). In each unit, three lowercase manuscript letters are introduced and practiced. The only exception involves the ninth unit, in which just two letters are taught.

Letters were grouped for instruction based on four criteria. First, the letters in each unit are formed in similar ways or share common formational characteristics (e.g., slanting line letters *v*, *w*, and *y* are grouped together in unit 7). Second, letters that occur more frequently in children's writing are introduced before less frequently occurring ones. Third, letters that are easier for young children to produce are introduced before more difficult ones. Fourth, easily confusable or reversible letters, such as *u* and *n* or *d* and *b*, are not included in the same unit. It was sometimes necessary to emphasize one criterion over another when assigning letters to a unit. For instance, when assigning letters to unit 1, we included the letters that were easiest to produce, but ranked second in terms of frequency of occurrence. The letters for each unit are:

- unit 1 – l, i, t
- unit 2 – o, e, a
- unit 3 – n, s, r
- unit 4 – p, h, f
- unit 5 – c, d, g
- unit 6 – b, u, m
- unit 7 – v, w, y
- unit 8 – x, k, z, and
- unit 9 – j and q.

All lessons were designed to be 15 minutes long and follow a common format, consisting of four activities: Alphabet Warm-Up (two minutes), Alphabet Practice (six minutes), Alphabet Rockets (five minutes), and Alphabet Fun (two minutes). The style of manuscript letters used in the program is Zaner-Bloser continuous script. This script uses traditional upright manuscript letters (as opposed to slanted ones), and most letters are formed using a continuous stroke (in contrast to lifting the pencil from the paper one or more times to form a letter).

Alphabet Warm-Up

Each lesson begins with Alphabet Warm-Up, a series of tasks designed to teach students to name each letter of the alphabet, match letter names with their corresponding symbol, and identify where each letter is placed in the alphabet. Because the name of a letter is likely to serve as a cue for retrieving the motor memory for writing it, children need to be fluent in naming, identifying, and accessing alphabet knowledge.

During the first lesson, when Alphabet Warm-Up is introduced, children are told that "just as an athlete needs to warm up before a game, we are going to warm up by saying letters before writing." The first Alphabet Warm-Up task involves students singing the alphabet song, while pointing to the corresponding letters on an alphabet chart. Once this task is mastered, it is replaced with a second task, where the teacher says the name of a letter and children point to it on the alphabet chart. When children can do this task accurately and fluently for all alphabet letters, it is modified so that the teacher points to a letter and students name it. With the final task, the teacher says a letter and then asks what letter comes before or after it in the alphabet. Initially, children are encouraged to consult the alphabet chart, but its use is faded as it is no longer needed. For each of these tasks, the teacher provides feedback and assistance as needed.

Alphabet Practice

The second activity in each lesson is Alphabet Practice, in which children are taught how to form lowercase manuscript letters and receive practice writing them in isolation and in words. The format for Alphabet Practice is identical across all nine units of the program.

During the first lesson of all units, the teacher models how to form each letter in that unit (e.g., *l*, *i*, and *t*). Using cards with numbered arrows that show the order and direction of strokes for each letter, the teacher traces and describes aloud how the target letters are formed. Next, children imitate the teacher, tracing each letter, while describing how to write it. The teacher and students then discuss how these letters are similar and different. This is followed by practice tracing, copying, and writing each letter. With a pencil, children trace a copy of the letter that has numbered arrows showing how to form it, trace three copies of the letter without numbered arrows, write the letter three times within the confines of an outline of the letter, and write the letter three times on regular lined paper. While completing these tasks, children say the name of the letter as it is traced, copied, or written (but they do not describe how to write the letter, as that may take up their limited working-memory resources). For each letter, children are also asked to circle their best-formed letter.

The Alphabet Practice tasks for the second and third lessons of each unit are similar to the ones used in the first lesson with the following differences. One, the teacher and students do not discuss similarities and differences in how the target letters are formed. Two, practice tracing, copying, and writing letters is modified so that children trace each target letter and then write it on regular lined paper, circling their best-formed letter. Additional practice is provided during the second lesson by having students copy words containing the target letters (e.g., *till*, *it*, *lit*, *ill*, and *little* for unit 1). During the third lesson, the children copy three hinky-pinkys (e.g., *tutti-frutti*, *willy-nilly*, and *palsy-walsy*). For both of these lessons, students are asked to circle their best-formed word or hinky-pinky, respectively. Last, during the second and third lessons, the teacher uses a highlighter to correct one or more miscues children make while copying a word or hinky-pinky. This might include highlighting difficulties involving letter formation (e.g., breaks, extra lines, and so forth), slant, alignment, spacing, and size. For instance, if a student fails to cross a *t*, the teacher adds the cross using the highlighter, and the child then corrects the miscue by tracing the highlighter mark with a pencil.

Children in the program made greater gains in handwriting and writing than their control-group counterparts, both immediately after the program and six months later.

Alphabet Rockets

The primary purpose of the third activity, Alphabet Rockets, is to increase students' handwriting fluency or speed of copying text. During the first lesson of each unit, children copy a sentence (26 to 34 letters long) that contains multiple instances of the target letters (e.g., *Little kids like to get letters* for unit 1 on *l*, *i*, and *t*). Students are directed to spend three minutes copying the sentence quickly and without making mistakes. The number of letters copied is then graphed on a performance chart containing three rockets (one for each lesson in the unit).

During the second lesson, students are encouraged to beat, by three letters, their previous performance copying the sentence. A gradual increase in fluency is emphasized, as rapid increases can be accompanied by declines in legibility.[2] After rewriting the sentence for three minutes, the number of letters copied is recorded on the second rocket. If a child's performance increases by three or more letters, the teacher or child draws a big star above the rocket to reinforce the child for achieving the goal. Identical procedures are followed during the third lesson, except the goal increases by three more letters if it was met during the second lesson.

Alphabet Fun

During the final activity of each lesson, students are shown how to write one letter from the unit in an unusual way (e.g., tall and skinny) or use it as part of a picture. Alphabet Fun was included as part of the instructional package so that each lesson ended with an enjoyable activity. When describing this activity, however, teachers are asked not to use the label, Alphabet Fun, as this might imply that other activities are not enjoyable.

–S.G.

Endnotes

1. Steve Graham, Karen R. Harris, and Barbara Fink, "Is Handwriting Causally Related to Learning to Write? Treatment of Handwriting Problems in Beginning Writers," *Journal of Educational Psychology* 92, no. 4 (2000): 620–633.

2. Steve Graham and Naomi Weintraub, "A Review of Handwriting Research: Progress and Prospects from 1980 to 1994," *Educational Psychology Review* 8, no. 1 (1996): 7–87.

(Continued from page 23)
students practice the same letter over and over again in a single session. Instead, once a letter is introduced, students should spend a short time carefully practicing it under the teacher's direction and then evaluate the quality of their efforts (e.g., by circling their two best-formed letters). The letter should then be reviewed and practiced in subsequent sessions as needed.*

Difficult Letters

Although *w* was apparently the most difficult letter for the youngster who quizzed Harold Pinter, it is not among the most difficult letters for most students. In a study involving 300 children,[31] my colleagues and I identified letters that were particularly difficult for children in grades 1 through 3: *q*, *j*, *z*, *u*, *n*, and *k*. These six letters accounted for 48 percent of the omissions, miscues, and illegible attempts students made when writing the lowercase letters of the alphabet. When only illegible responses were considered, the following five letters accounted for 54 percent of miscues: *q*, *z*, *u*, *a*, and *j*. Teachers should pay special attention to these letters during instruction, as they may pose special problems for young writers.

The most effective method for facilitating handwriting fluency is to have children write frequently.

Pencil Grip and Paper Position

When asked about the hardest part of being a writer, one child responded, "That's easy; your hands always hurt from writing so much."[32] While pencil grip need not be perfect, it is important. A child who has a two-fingered death-grip on the tip of the pencil is likely to complain of fatigue or discomfort when asked to write for a sustained period of time. To help ensure that children do not develop such a grip (which can be very hard to change), it is essential that students be encouraged and prompted to use a reasonably comfortable grip, such as the tripod method (in which the pencil is held between the thumb and index finger, resting on the distal phalanx of the middle finger, about an inch from the point), as soon as they start school. And yet, regardless of the type of grip initially taught and reinforced, 50 to 75 percent of children will make some modifications in how they hold the writing instrument as they mature,[33] and such modifications do not appear related to how legibly or quickly most children write.[34]

In addition to pencil grip, teachers need to attend to how children position their paper when writing. Paper position influences the degree and direction of slant in letters. When children are taught traditional manuscript letters, right-handed students should be encouraged to place the page squarely in front of them with the left side at about the center of the body.[35] When the transition to cursive is made, the paper should be rotated about 45 degrees counterclockwise.

Left-handed writers, in contrast, should be encouraged to rotate their paper somewhat clockwise and hold their pencil slightly farther back (about one and a half inches from the tip) than right-handers do.[36] Left-handers who position their papers like right-handers are likely to develop an inverted grip, and this may decrease both the speed and legibility of their writing.

Handwriting Speed

To collect normative data on handwriting speeds, my colleagues and I conducted a study[37] with children in grades 1 through 9. We established the norms by asking children to copy the paragraph from the copying subtest of the Group Diagnostic Reading Aptitude and Achievements Tests[38] as quickly as possible without any mistakes. Students copied the paragraph for one and a half minutes. The results are shown in the table below. Because handwriting speed was influenced by gender, the data are reported separately for girls and boys.

To assess your students' handwriting speed, simply select a short paragraph from a grade-level book and have students spend one and a half minutes legibly copying as much as they can. Extra handwriting instruction may be advisable for students

Mean Handwriting Speeds: Letters per Minute

	Girls	Boys
Grade 1	21	17
Grade 2	36	32
Grade 3	50	45
Grade 4	66	61
Grade 5	75	71
Grade 6	91	78
Grade 7	109	91
Grade 8	118	112
Grade 9	121	114

*To learn more about the benefits of spreading practice out over time, see "Allocating Student Study Time: 'Massed' versus 'Distributed' Practice" in the Summer 2002 issue of *American Educator*: www.aft.org/pubs-reports/american_educator/summer2002/askcognitivescientist.html.

in first, second, and third grades who score 7, 13, and 14 letters, respectively, below the mean. Older students who score 20 letters below the mean are also good candidates for extra assistance.

The most effective method for facilitating handwriting fluency is to have children write frequently. Handwriting speed develops gradually as a consequence of writing connected text. A method that has been used to improve the handwriting speed of especially slow handwriters is self-competition on timed copying exercises. For example, students count the number of letters they copied from a passage during a three-minute period, and in subsequent sessions set goals to gradually increase their fluency as they copy the text.[39] Attempts to increase handwriting speed, however, must be balanced against possible decreases in legibility.[40]

Neatness

Teachers need to be sure that students know when neat and legible handwriting is most important. For example, sloppy first drafts are just fine, but this does not work well for final drafts. Likewise, test and homework answers must be readable. It may be necessary to teach some students how to make handwritten papers neater (e.g., demonstrate how to make good erasures), and then have them systematically check their final drafts to be sure they applied taught skills.[41]

In order to maximize handwriting development, teachers need to explicitly teach it while simultaneously capitalizing on incidental and less formal methods of instruction, such as frequent writing, taking advantage of teachable moments, teacher modeling of correct handwriting, and so forth. With all the competing demands that teachers must juggle each day, it can be difficult to consistently deliver high-quality handwriting instruction. To help, my colleagues and I have developed the checklist of best practices shown here and a handwriting program for first-graders (which we offer at no cost and have posted online at **www.peabody.vanderbilt.edu/casl.xml**). For a thorough description of the program, see "Pencil on Paper, Let's Go" on page 24.

* * *

With the advent of affordable and more

(Continued on page 40)

Checklist of Best Practices

I Teach Children How to Write Each Letter by...

___ Showing them how it is formed.
___ Describing how it is similar to and different from other letters.
___ Using visual cues, such as numbered arrows, as a guide to letter formation.
___ Providing practice tracing, copying, and writing the letter from memory.
___ Keeping instructional sessions short, with frequent reviews and practice.
___ Asking them to identify or circle their best-formed letter or letters.
___ Encouraging them to correct or rewrite poorly formed letters.
___ Monitoring their practice to ensure that letters are formed correctly.
___ Reinforcing their successful efforts and providing corrective feedback as needed.

I Help Children Become More Fluent in Handwriting by...

___ Providing them with plenty of opportunities to write.
___ Eliminating interfering habits that may reduce handwriting fluency.
___ Having them copy a short passage several times, trying to write it a little faster each time.

I Promote Handwriting Development by...

___ Making sure that each child develops a comfortable and efficient pencil grip.
___ Encouraging children to sit in an upright position, leaning slightly forward, as they write.
___ Showing them how to place or position their paper when writing.
___ Teaching children to identify and name the letters of the alphabet.
___ Teaching them how to write both uppercase and lowercase letters.
___ Allotting 75 to 100 minutes per week to handwriting instruction (in grades 1 through 4).
___ Providing children with plenty of opportunities to use different types of writing instruments and paper.
___ Asking children to set goals for improving specific aspects of their handwriting.
___ Implementing appropriate procedures for left-handed writers, such as how to properly place or position their paper when writing.
___ Monitoring students' handwriting, paying special attention to their instructional needs in letter formation, spacing, slant, alignment, size, and line quality.
___ Dramatizing children's progress in handwriting through the use of charts or graphs, praise, or posting neatly written papers.

I Assist Students Who Are Experiencing Difficulty by...

___ Organizing my class so that I can provide additional handwriting instruction to children who need it.
___ Coordinating my handwriting instruction with the efforts of other professionals, such as an occupational therapist.
___ Placing special emphasis on teaching difficult letters, such as *a, j, k, n, q, u,* and *z,* as well as reversals.
___ Ensuring that they master one style of handwriting before a second style is introduced.
___ Considering if an alternative to handwriting, such as word processing or using a speech recognition program, is warranted.
___ Helping them develop positive attitudes about handwriting.
___ Talking with their parents about my handwriting program and soliciting advice.

I Make Sure That I...

___ Encourage students to make all final drafts of papers neat and legible.
___ Maintain a balanced perspective on the role of handwriting in learning to write.

SOURCE: STEVE GRAHAM AND KAREN R. HARRIS, "PREVENTION AND INTERVENTION FOR STRUGGLING WRITERS," IN *INTERVENTIONS FOR ACADEMIC AND BEHAVIOR PROBLEMS II: PREVENTIVE AND REMEDIAL APPROACHES*, ED. MARK R. SHINN, HILL M. WALKER, AND GARY STONER (BETHESDA, MD: NATIONAL ASSOCIATION OF SCHOOL PSYCHOLOGISTS, 2002), 599.

Beyond Singapore's Mathematics Textbooks

Focused and Flexible Supports for Teaching and Learning

ILLUSTRATIONS BY NENAD JAKESEVIC

BY PATSY WANG-IVERSON, PERLA MYERS, AND EDMUND LIM W.K.

It has been over 10 years since schools in the United States began looking to Singapore to learn from its approach to mathematics education. This interest can be traced to Singapore students' consistently high performance on all four of the Trends in International Mathematics and Science Studies (TIMSS), which were conducted in 1995, 1999, 2003, and 2007.[1] Even more important, Singapore has been pursuing excellence and equity, having shown in TIMSS 2003 and 2007 a relatively smaller performance gap than the United States among students from differing socioeconomic backgrounds.[2]

As part of TIMSS 1995, a group of researchers conducted an in-depth analysis of curricula from the participating countries.[3] When they summarized the grades 1–8 mathematics scopes and sequences from the six top-performing countries (Singapore, Korea, Japan, Hong Kong, Belgium [Flemish-speaking], and the Czech Republic), their findings revealed a common, coherent curriculum sequence.[4] The coherence, focus, and rigor found in the top-performing countries stood in sharp contrast to the results for the United States. Examining mathematics standards from 21 states, the researchers found too many mathematics topics per grade and characterized the hodgepodge of standards as "a mile wide and an inch deep."[5]

For many educators, researchers, and policymakers, the results ignited great interest in the top-performing countries' mathematics curricula and teaching. Of the six top performers, only Singapore conducts classroom instruction and writes its textbooks in English, a pragmatic decision made at the time of its independence in 1965.

Today, Singapore's mathematics textbooks are available in the United States,* so it is tempting to think that there is an easy solution to increasing mathematics achievement here—just adopt the textbooks.† But the textbooks are not solely responsible for Singapore's success; these written resources are just one part of a multifaceted approach. Singapore's academic strength lies in its national commitment to high-quality education and the overall

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coherence of its educational system. Singapore's goals for its students are fully supported by a systematic plan that includes a realistic timeline and ample funding. The investment in education is all-encompassing—it includes all levels of the education community, from the schools, to the National Institute of Education (Singapore's sole teacher-training institution) to the Ministry of Education (MOE). Singapore's commitment to education—which is derived from its ongoing desire to improve by learning from the strengths of other countries—begins with a first-class curriculum *and* the nurturing of educators at all levels.

Singapore's national mathematics syllabus provides the foundation for teaching and learning mathematics. The syllabus is comprehensive, yet concise and coherent. Curriculum, teaching, learning, and assessments (both school-based and national) are closely aligned with the syllabus, and are regularly reviewed and updated to ensure that they remain relevant to the needs and interests of students and teachers.

Having a cogent curriculum and well-written textbooks can improve instruction to a certain extent. At the same time, preparing, hiring, nurturing, and retaining knowledgeable, caring, and skilled educators are essential to successful learning and teaching in the classroom. In particular, Singapore's pre-service teacher-education programs play a vital role in Singapore's success in education. Unlike in the United States, prospective teachers, who are selected from among the top one-third of high school graduates, receive free tuition and a stipend during their teacher preparation program. Once they become teachers, they receive competitive pay and support throughout their careers.

In this paper, we explore the preparation and support of mathematics teachers in Singapore. Explaining the entire teacher-preparation program is beyond what we can accomplish in a single article. Instead, we have chosen to take a careful look at two ways in which teacher preparation and support are dramatically different in Singapore and the United States: the flexibility in pathways and the focus on goals.

Singapore's educational system—from primary school through teacher preparation and support—is characterized by flexibility. In particular, Singapore offers high performers various opportunities to become teachers. Formal teacher preparation can begin at different stages: right after students complete post-secondary school (equivalent to the end of 12th grade in the United States), after completion of a university degree, or as a midcareer change.

At the same time, Singapore's whole educational system—including its teacher preparation and support—is focused on the goal of having all students master the national curriculum. Teachers are encouraged to teach as they see fit, but the content and skills that students must master in each subject and at each grade are clearly specified in the national curriculum; they are also well reinforced through the approved textbooks, aligned assessments, and carefully constructed teacher preparation and professional development.

Assuming most readers are not well acquainted with Singapore's education system, and believing teacher preparation (just like preparation for any other career) formally begins when children start school, let us start with a brief look at how flexibility and focus play out in the primary and secondary schools. We will begin with the focus provided by the national curriculum.

Prospective teachers, who are selected from among the top one-third of high school graduates, receive free tuition and a stipend during their teacher preparation program.

I. A Focused National Curriculum

Singapore's primary (grades 1–6) and secondary (grades 7–10) schools follow the national curriculum[‡] developed by the Curriculum Planning and Development Division of the MOE. In mathematics, a pentagonal framework designed to develop students' problem-solving abilities sets the direction for learning, teaching, and assessment. The syllabus provides details that guide teachers in planning, preparing, and implementing mathematics programs in their schools. Teachers are encouraged to be flexible and creative in implementing the syllabus in the classroom, but they must be careful to maintain its scope and sequence so as to prepare students for high-stakes national exams at the end of primary and secondary school. (See the sidebar on page 32 for a description of the framework and an excerpt from the syllabus.)

Textbooks in Singapore closely follow the national syllabus. Until 2001, they were written by a unit of the MOE. Now textbooks and activity books are developed by private publishers, subject to MOE approval. In mathematics, the majority of primary schools in Singapore currently use either the *My Pals Are Here* series or the *Shaping Mathematics* series. An extraordinary amount of thought has gone into these slim and focused textbooks. They present the mathematics content in a way that helps students grasp the concepts, yet they are slim enough that teachers can provide additional lessons on topics, as needed, without pressure to "cover" an excessive amount of material. Furthermore, they are written in simple English to accommodate the more than 40 percent[§] of Singapore students who most frequently speak a language other than English at home.

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[*]The Singapore textbook series used most commonly in the United States at present is *Primary Mathematics* (grades 1–6), U.S. edition, published in 2003 and based on the 1983 curriculum framework (see www.singaporemath.com). Notably, these books have been integrated into some courses for pre-service American teachers. The college textbooks *Elementary Mathematics for Teachers*[6] and *Elementary Geometry for Teachers*[7] incorporate the U.S. edition of *Primary Mathematics* and Singapore's *New Elementary Mathematics 1* for supplementary reading and homework assignments. Another pre-service mathematics textbook, *Mathematics for Elementary Teachers*,[8] also was influenced (especially chapters 3, 7, and 13) by the *Primary Mathematics* series.

[†]Some states have approved modified versions of Singapore textbooks that do not preserve Singapore's concise and coherent curriculum. For example, in the California version, variables, which are not taught until grade 7 in Singapore, are introduced in grade 5. *Math in Focus*, a U.S. version of a Singapore mathematics textbook series, *My Pals Are Here*, has been approved for use in Indiana, Kentucky, and Oklahoma.

[‡]International and private schools are not bound by the national syllabi.

[§]When the curriculum was developed in the early 1980s, 77 percent of Singapore's students did not speak English at home.

The clarity and detail of the curriculum offer many benefits. For example, when teachers develop lesson plans either individually or in a group, since *what* will be taught is already determined, teachers can focus on *how* to teach it. Teachers are then able to make sure the content for each grade is clear to the students, and they can provide students with the support needed to stay at grade level. Consistency of content also helps with student mobility—if students change schools, they do not fall behind or end up with gaps in their learning. Additionally, teacher preparation and professional development can be more effective since they are based on the content teachers are expected to teach.

II. A Flexible Educational Structure

Singapore's educational system is notable for its flexibility and efforts to accommodate the needs of individual students. The MOE acknowledges that people are different—they have different abilities, interests, and motivations; they require different support systems; and they develop at different rates. Singapore provides flexibility throughout the educational system in order to accommodate its different learners while maintaining a firm commitment to each student mastering the core content in the curriculum. Some examples of how Singapore achieves quality through flexibility follow.

Student support begins in grade 1 for students with inadequate prior academic exposure. The goal is to have them at grade level when they enter grade 2.

1) *Different tracks lead to the same end goal in primary school.* A Singapore education for most students begins with two years of private kindergarten, followed by six years of primary school (elementary school) in the national education system. Schools provide differentiated learning experiences for students with different needs. Student support begins in grade 1 with a learning support system for students with inadequate prior academic exposure. They are placed in small classes of up to 12 students, and the goal is to have them at grade level when they enter grade 2. Starting in grade 4, students are separated according to their performance in specific subjects such as mathematics and their mother tongue language (Mandarin, Malay, or Tamil). Lessons in each track are conducted at different rates of speed and levels of difficulty in order to accommodate the abilities of the students and to optimize their learning potential. As in the United States, tracking students engenders ongoing debate. Yet, it allows teachers to proceed at a pace and depth suitable for each group of students. Slower children receive extra instruction to help them achieve the high standards set by the national curriculum. Since Singapore's educational goals are clear, the system is able to achieve high quality while providing flexibility. At the end of the sixth year of primary school, students in the national school system take high-stakes national examinations, called the Primary School Leaving Examinations (PSLE), in English, mathematics, science, and their mother tongue language.*

2) *Paths have different lengths, but the same core content, in secondary school.* Based on their performance on the PSLE overall and in each subject, students follow one of three secondary education paths† beginning in grade 7:

i) four years in the Normal (Technical) course,
ii) four years in the Express course, or
iii) five years in the Normal (Academic) course.

The less academically inclined students (about 12 percent of the population) are assigned to the Normal (Technical) stream. Although their curriculum is less demanding academically than that of the other streams, they learn the core content set forth in the national curriculum. In mathematics, that includes topics such as graphs of quadratic functions and their properties, rotational symmetry, and the volume and surface area of pyramids, cones, and spheres.[9]

The curricula for students in the Express and Normal (Academic) streams are similar to each other, with the main difference being that Express students (about 64 percent of the population) complete their course of study in four years while the curriculum for the Normal (Academic) students (about 22 percent of the population) is spread over five years.[10]

3) *Students have opportunities to move between paths.* Once students are placed along a certain path, they have several opportunities to move to a different path based on their performance. For instance, if a child in primary school shows more growth and readiness in a certain subject, he or she may be moved to a higher achievement track in that subject. Also, Normal (Technical) stream students who excel in the first or second year of secondary school can be transferred to the Normal (Academic) stream. Similarly, students who do very well in the Normal (Academic) stream in the first or second year can transfer to the Express stream. Conversely, students in the Express stream who perform poorly may be transferred to the Normal (Academic) stream.

4) *Students take different paths after secondary school.* After successful completion of secondary school (which is the equivalent of 10th grade in the United States), there are various educational routes for graduates. Further education is not mandatory, but the vast majority of students continue their education. The academic options are plentiful, ranging from vocational and industry-related courses offered by the Institute of Technical Education[11] to university-preparatory courses offered by two-year junior colleges. Importantly, all of the options leave open the door to a

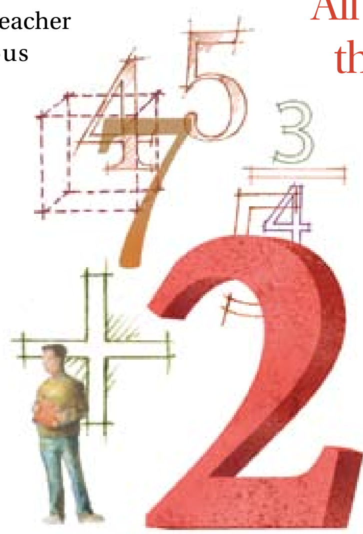
*Severely retarded children are usually educated in special schools and do not take the PSLE. Students with learning difficulties (e.g., dyslexia or ADHD) or hearing impairments are mainstreamed and take the PSLE, though a minority may be exempted from certain subjects. The bottom range of students (about 15 percent) may take a different version of the PSLE, a Foundation PSLE, in certain subjects, and the regular PSLE in other subjects.

†Based on the 2007 PSLE results, 98 percent of students qualified for mainstream secondary-school education. The remaining 2 percent were considered not ready for mainstream secondary schools and better suited for the two secondary schools that provide vocational training. These students can still progress on to vocational higher education if they perform well.

university education. Students who complete the Normal (Technical) course in secondary school and then attend the Institute of Technical Education could, if they perform well, go to a polytechnic institute (which offers a mix of academic and industry-related courses) and then a university. This route is several years longer than the fastest route (which entails studying in the Express stream, attending a junior college, and then going to a university), but for some students, that slower pace is exactly what they need. Unlike in the United States, however, there are no nonselective universities. At each juncture, students must perform well on rigorous exams in order to proceed to the next institution.

III. Flexibility and Focus in Teacher Preparation

Flexibility and focus also are key characteristics of Singapore's approach to teacher preparation. Teachers[‡] at public and government-aided schools undergo teacher preparation, education, and certification at the National Institute of Education (NIE), the sole provider of the country's teacher education. Although there are various degree programs that prospective (and in-service) teachers can pursue, there is also tight quality control since all teacher preparation is overseen by the MOE and delivered by the NIE, and exactly what teachers must accomplish is specified by the national curriculum.



Primary school teacher candidates may be offered or assigned one of several program options. They may pursue a two-year Diploma in Education[§] or a four-year Bachelor of Arts in education or Bachelor of Science in education. Candidates who already have a university degree in another field can earn a one-year Post Graduate Diploma in Education. As in the United States, most lower-grade primary school teachers are generalists who teach English, mathematics, science, and social studies. However, some teachers in the upper elementary grades specialize in teaching mathematics.

Secondary school teachers usually are content specialists. Mathematics teacher candidates may pursue a humanities-based bachelor's degree in education by specializing in mathematics and one liberal arts subject,[**] or a science-based degree by specializing in mathematics, a liberal art, and one or two science subjects. Those who already hold a university degree have to earn a Post Graduate Diploma in Education for primary and secondary school teachers.

[‡]There are a small number of teachers from other countries who have not attended the NIE.

[§]As recently as 1993, the Diploma in Education was the highest level of education attained by most primary school teachers. The MOE's goal is for all teachers to eventually pursue a minimum of a bachelor's degree. This goal comes with financial incentives, as there is a significant difference between the starting salaries of the teachers who have a bachelor's degree and of those who do not. A number of teachers with a Diploma in Education have gone back to the NIE to study for another two years to earn a Bachelor of Education degree.

[**]Options include art, drama, English language, English literature, geography, history, Malay language, and music.

Recruitment of Teacher Candidates

The teaching profession is highly respected and well compensated in Singapore, and teacher quality is a top priority. This serious commitment to education is reflected in the financial support[††] provided to attract, retain, and develop high-quality candidates.[12] More than 95 percent of the students accepted by the NIE simultaneously become contracted employees of the MOE; the MOE pays their tuition and provides a monthly stipend. As teachers (in public or government-aided schools), they are employees of the MOE, so beginning teacher preparation is very much like beginning work. In exchange for this financial support, teachers must commit to teaching at a school selected by the MOE for three to six years, depending on the degree program. If they do not fulfill their obligation, whether they choose to leave or are deemed inadequate, they must repay the money with interest.

All teacher preparation is overseen by the National Institute of Education, and exactly what teachers must accomplish is specified by the national curriculum.

Candidates for teacher-education programs are selected from the top one-third of each graduating cohort from universities, polytechnics, junior colleges, and the Millennia Institute (which offers the same pre-university curriculum as the junior colleges, but at a slower pace).[‡‡] As a result, teacher candidates begin their teacher training with a solid foundation in mathematics and all other subjects covered by the national curriculum. But entrance is not based exclusively on academic achievement. Candidates also are interviewed by NIE academic staff and MOE staff to determine their suitability to work with children and youth. For individuals making a transition from another career to teaching, prior work experience is also taken into consideration.

Pre-Service Programs

The objective of the pre-service program is to help individuals begin their journey to become reflective teachers with an evidence-based practice. As such, teacher preparation in mathematics ensures teachers have six key characteristics: (1) mathematical knowledge (e.g., school-related mathematics content and mathematical reasoning); (2) knowledge of curriculum (e.g., lesson plans aligned with recent reforms); (3) knowledge of pupils (e.g., their common errors and misconceptions, as well as their abilities

[††]Teachers' starting salaries, which depend on if they have a degree, a degree with merit, an honors degree, and/or relevant work experience, are quite attractive. Their salaries are comparable to the starting salaries of professionals such as engineers.

[‡‡]In the past, most teachers came from the Express stream and completed a junior college education. Now, a small number of teachers come from the polytechnics.

and interests); (4) mathematics-based pedagogy (e.g., effective questioning and discussion, and classroom management); (5) knowledge of assessment (e.g., various types of formative and summative assessments); and (6) lifelong learning and values (e.g., professional development and professional communities).

Since the national curriculum is clearly defined, teacher candidates can study the content that they will be responsible for teaching in depth and from different viewpoints. Quite purposefully, NIE academic staff members have varied backgrounds. The mathematics department includes both mathematicians and mathematics educators specializing in different fields: mathematics content, teaching and learning mathematics, or curriculum and pedagogy. There are also experienced mathematics schoolteachers (usually former mathematics department heads) as well as former MOE mathematics curriculum officers who work with teacher candidates. Selected mathematics classroom teachers can spend up to four years as staff at the NIE and may conduct postgraduate research while they teach, guide, and mentor teacher candidates.

NIE teacher candidates take a range of core and elective courses. For instance, teacher candidates in the four-year Bachelor of Arts (BA) in education or Bachelor of Science (BSc) in education programs take courses in education studies, curriculum studies, and subject knowledge, as well as other courses and practica (in which they are assigned to schools).

In the first year, BA/BSc candidates for teaching in the primary grades

Shared Structure, Common Content

In Singapore, the foundation for learning, teaching, and assessing mathematics is a pentagonal framework that shows how the following five interrelated components are all essential to developing students' ability to solve problems (including nonroutine, open-ended, and real-world problems):*

1. *Concepts*: Students must attain conceptual understanding of mathematical concepts—numerical, algebraic, geometrical, statistical, probabilistic, and analytical—in order to learn mathematics successfully. Conceptual understanding allows students to see mathematical ideas as interconnected, apply mathematics in various contexts, develop mathematical proficiency, and gain confidence in their abilities and appreciation for mathematics.
2. *Skills*: Students must develop procedural skills that are needed for problem solving—numerical written and mental calculation, algebraic manipulation, spatial visualization, data analysis, measurement, use of mathematical tools and technology, and estimation. Students should master these skills, but they should do so mindfully—with conceptual understanding of the procedures.
3. *Processes*: Students must combine the knowledge and skills that are necessary to learning and applying mathematical concepts—mathematical reasoning, communication, making connections, thinking skills and strategies, and application and modeling.
4. *Attitudes*: Students' attitudes in mathematics include their beliefs about mathematics and its usefulness, their interest and enjoyment in learning mathematics, their appreciation of the beauty and power of mathematics, their confidence in using mathematics, and their perseverance in solving a problem. Since attitudes are shaped by learning experiences, teachers are encouraged to create positive learning experiences that children of all abilities will find challenging and rewarding.
5. *Metacognition*: Students should be able to monitor and control their thinking in order to progress as problem solvers. They should be able to analyze the selection of particular strategies for learning or for problem solving, and understand why certain methods are unsuccessful.

According to Singapore's mathematics syllabus,[†] the primary purpose of the framework is to explain "the philosophy of the syllabus and the spirit in which it should be implemented." That done, the portion of the syllabus devoted to grade-by-grade content is concise, coherent, and uncluttered. As an example, here is the *complete* mathematics syllabus for primary 1 (first grade). Compared with most standards in the United States, it has clear content and is a reasonable length.

–P.W.I., P.M., E.L.W.K.

1. Whole Numbers

Numbers up to 100

Include:

- counting to tell the number of objects in a given set,
- comparing the number of objects in two or more sets,
- use of ordinal numbers (first, second, up to tenth) and symbols (1st, 2nd, 3rd, etc.),
- number notation and place values (tens, ones),
- reading and writing numbers in numerals and in words,
- comparing and ordering numbers,
- number patterns.

Exclude:

- use of the terms 'cardinal number' and 'ordinal number',
- use of the symbols > and <.

Addition and subtraction

Include:

- concepts of addition and subtraction,
- use of the addition symbol (+) or subtraction symbol (–) to write a mathematical statement for a given situation,
- comparing two numbers within 20 to tell how much one number is greater (or smaller) than the other,
- recognising the relationship between

*To read more about the pentagonal framework, see Lee Peng Yee and Lee Ngan Hoe, eds., *Teaching Primary School Mathematics: A Resource Book*, 2nd ed. (Singapore: McGraw-Hill, 2009).

†The mathematics syllabus is separated into primary and secondary levels; both include the framework. See **www.moe.gov.sg/education/syllabuses/sciences**.

enroll in basic courses, including three education courses such as educational psychology, critical perspectives on education, and information and communication technology. In the second year, they take mathematics courses, including numbers and operations, and fundamental principles of primary mathematics, as well as a curriculum course that provides an overview of the Singapore Primary Mathematics Curriculum. Teacher candidates also learn how to prepare lesson plans, which include teaching objectives, learning outcomes, teaching and learning processes, and resources. They explore pedagogical strategies and psychological theories related to mathematics education and how to teach topics such as whole numbers, fractions, decimals, percentages, ratios, direct proportion, rate, and speed.

In the third year, BA/BSc teacher candidates enroll in a more advanced curriculum course, along with two more subject-knowledge courses in which they learn about teaching problem solving, conducting mathematical investigations, and facilitating mathematical communication. In addition, they learn how to teach algebra, geometry and measurement, data analysis, and statistics. Throughout the curriculum courses, while covering the various topics, teacher candidates explore the use of technology and the common errors made by primary school students.

In the fourth and final year, BA/BSc teacher candidates take another mathematics curriculum course, in which they learn about various traditional assessment strategies, including details about planning and constructing test items. Another major area of study is the practice of teaching skills, which includes catering to students of mixed abilities. BA/BSc teacher candidates who wish to teach upper primary mathematics* may take additional courses on pedagogical skills and content knowledge, as well as advanced use of technology, and challenging problems and games.

*Teachers who do not take these optional courses may still be assigned to teach upper primary levels. Similarly, teacher candidates who take the optional courses may be assigned to teach lower primary classes if there is a need.

addition and subtraction,
- building up the addition bonds up to 9 + 9 and committing to memory,
- solving 1-step word problems involving addition and subtraction within 20,
- addition of more than two 1-digit numbers,
- addition and subtraction within 100 involving
  - a 2-digit number and ones,
  - a 2-digit number and tens,
  - two 2-digit numbers,
- addition and subtraction using formal algorithms.

Mental calculation
Include:
- addition and subtraction within 20,
- addition and subtraction involving
  - a 2-digit number and ones without renaming,
  - a 2-digit number and tens.

Multiplication and division
Include:
- multiplication as repeated addition (within 40),
- use of the multiplication symbol (×) to write a mathematical statement for a given situation,
- division of a quantity (not greater than 20) into equal sets:
  - given the number of objects in each set,
  - given the number of sets,
- solving 1-step word problems with pictorial representation.

Exclude:
- use of multiplication tables,
- use of the division symbol (÷).

2. Measurement

Length and mass
Include:
- measurement and comparison of the lengths/masses of two or more objects in non-standard units,
- use of the following terms:
  long, longer, longest
  short, shorter, shortest
  tall, taller, tallest
  high, higher, highest
  heavy, heavier, heaviest
  light, lighter, lightest

Exclude finding the difference in length/mass.

Time
Include telling and writing time to the hour/half hour.
Exclude 24-hour clock.

Money
Include:
- identifying coins and notes of different denomination,
- matching a coin/note of one denomination to an equivalent set of coins/notes of another denomination,
- telling the amount of money
  - in cents up to $1,
  - in dollars up to $100.
- use of the symbols $ and ¢,
- solving word problems involving addition and subtraction of money in dollars only (or in cents only).

Exclude combinations of dollars and cents.

3. Geometry

Basic shapes:
- **rectangle**
- **square**
- **circle**
- **triangle**

Include:
- identifying and naming the 4 basic shapes from 2-D and 3-D objects,
- describing and classifying shapes.

Patterns
Include:
- making/completing patterns with 2-D cut-outs according to one or two of the following attributes
  - shape
  - size
  - colour
- making/completing patterns with 3-D models:
  - cube
  - cuboid (rectangular block)
  - cone
  - cylinder

4. Data Analysis

Picture graphs
Include:
- collecting and organising data,
- making picture graphs,
- use of a symbol/picture to represent one object,
- reading and interpreting picture graphs in both horizontal and vertical forms.

Exclude picture graphs with scales.

All BA/BSc in education candidates who are planning to teach upper primary grades also can pursue optional independent-study topics to strengthen their mathematical content knowledge, and expand and improve their range of teaching skills. Through these courses, teacher candidates are nurtured and equipped with the necessary skills and knowledge to teach mathematics effectively.

Experiential Education

Experiential education opportunities in local schools are an important part of teacher preparation. In Singapore, teacher candidates have multiple opportunities to apply and hone their knowledge and skills while gaining practical experience under the tutelage of their assigned mentors (who are teachers) and their NIE supervisor.

> Teacher candidates are assigned to schools in each of their four years of undergraduate studies. In the fourth year, performance during the 10-week teaching practicum is evaluated.

For example, in the bachelor's degree programs, teacher candidates are assigned to schools in each of their four years of undergraduate studies.* At the end of their first year at the NIE, they have two weeks of school experience. At the end of the second year, they have a five-week school experience akin to a teaching assistantship in which they observe and learn from their "cooperating" teachers (teachers of the classes to which they have been assigned), who coach them in specific subjects, as well as help them reflect on teachers' responsibilities and roles. At the end of the third year, there is a five-week teaching practicum in which teacher candidates begin to become independent and responsible for teaching—they plan and teach their own lessons. They learn from observing their cooperating teachers and working with them on lesson preparation and delivery, as well as classroom management. Mentors, cooperating teachers, and staff from the NIE observe teacher candidates during select lessons and provide feedback, guidance, and support. In the fourth and final year, teacher candidates teach their designated grade level or subject during a 10-week period in which they are assigned to the same school where they were apprentices. They become actively involved in school life as they plan, teach, and learn through guiding and assessing their students, while still under the tutelage of their NIE supervisor and mentors. Some teacher candidates also become involved in afterschool activities such as enrichment, remedial, and supplementary classes.

In the fourth year, performance during the teaching practicum is evaluated. In order to successfully graduate from the NIE and qualify as trained teachers, teacher candidates must attain at least a passing grade. Teacher candidates who do not perform as expected or who are at risk of failing their practicum receive additional counseling and support from the school and the NIE. If they still fail, they may be offered a second chance to redo their teaching practicum at another school, which then delays their graduation. Teacher candidates who are deemed unsuitable or lacking the integrity necessary to be teachers, even after help and counseling, are asked to leave the teaching service (and, as noted above, must repay the MOE their tuition fees and stipend, with interest). Most student teachers successfully complete their teaching practicum and proceed to become full-fledged teachers in schools.

IV. Flexibility and Focus Throughout the Teaching Career

In Singapore, successfully completing a teacher-preparation program in no way signifies that a person has finished learning how to teach. Teachers continue upgrading their knowledge and skills throughout their careers. They are entitled to take 100 hours of professional development annually, paid for by the MOE. In fact, all educators, including teachers, department heads, vice principals, and principals, are strongly encouraged to develop their professional capabilities and competencies. The NIE and MOE regularly organize workshops, courses, and conferences. NIE staff members also provide customized school-based professional development, as well as lesson-planning input and individualized feedback based on lesson observations. Although the bulk of the 100 hours is dedicated to improving teachers' practice, teachers also can enroll in some courses to promote personal well-being. For instance, some may take a health-related course, subject to approval.

Professional Development Continuum Model

The MOE supports teachers who wish to pursue additional undergraduate (e.g., by upgrading from a Diploma in Education to a bachelor's degree) and postgraduate studies. As part of the Professional Development Continuum Model (PDCM)—a collaboration between the MOE and NIE—some NIE courses that are taken as professional development also provide credits that contribute to the pursuit of postgraduate degrees. Through the PDCM, teachers can attain advanced certification or pursue one of the 18 PDCM master's degree programs, including one Master of Education (MEd) degree focusing on mathematics education for primary and secondary teachers. PDCM postgraduate courses are fully paid for or largely subsidized† by the MOE.

The MEd in mathematics education consists of 10 courses taken over three years. The courses are designed to help teachers develop deeper knowledge of mathematics curriculum, content, and pedagogy, and greater expertise in the mathematical topics

(Continued on page 36)

*In the U.S., student teachers do not typically begin practica their first year.

†For MOE sponsorship, applicants must be Singapore citizens or permanent residents, have good evaluations at work during the year preceding the application, have at least an overall C grade for their university degree, have at least two years of teaching experience, and be employed by the MOE on a permanent basis.

Career Development

How Singapore Merges Teacher Professional Development and Evaluation

BY SUSAN SCLAFANI WITH EDMUND LIM W.K.

From their first year on the job, all teachers in Singapore are planning their careers and using self-assessment, coaching, and evaluation to achieve their next steps as professionals. To manage the process, in 2003, Singapore began implementing a comprehensive system, the Enhanced Performance Management System (EPMS). While the EPMS culminates in a final annual evaluation (which contributes to performance bonuses and promotions), it is actually a yearlong process that consists of setting goals, seeking out professional development courses and other learning opportunities, collaborating with colleagues, and assessing one's progress. Everyone takes the entire process very seriously. Teachers and reporting officers (a department head or vice principal) work together to enhance the teachers' performance and the performance of their colleagues through observations and coaching. But more important, teachers believe that the EPMS will help them become better teachers.

Through the EPMS process, teachers are encouraged to expand their teaching repertoire, improve their knowledge and skills in their selected career track,* and take those developmental actions that lead to greater competence—and higher levels on the career ladder. Teachers start the year with a self-assessment and develop their goals for (1) teaching, (2) instructional innovations and improvements at the school, (3) professional training, and (4) personal development. They discuss their goals and performance benchmarks with their reporting officer to ensure they are aligned with the department, school, and national goals and benchmarks. These meetings are opportunities to discuss where the teacher ended the previous year and what needs to be done next to reach his or her career goals. Reporting officers encourage teachers to improve and to reach their full potential. Together they decide on additional training or identify which teachers or department heads can best help with coaching. It is a collegial process focused on ensuring that teachers have the competencies to improve their capabilities as teachers as well as their students' learning and achievement. During the year, there are informal meetings, a more formal midyear evaluation, and then the final evaluation.

The EPMS is not an evaluation as we in U.S. education usually do it. The resulting document is a narrative that summarizes, at midyear and at the end of the year, the activities engaged in, progress made toward the goals set, and data on the agreed-upon performance benchmarks. It resembles our portfolio assessments, although it adds summaries of relevant discussions between the teacher and the reporting officer as well as evaluative narratives from both. These evaluations are based on the experience and current position of the teacher, since the level of competence expected of a new teacher is much lower than that expected of senior and master teachers.

The final annual evaluation includes not just an assessment of current performance, but also an assessment that is the reporting officer's view of the teacher's "Current Estimated Potential."

The decision on potential is made in consultation with senior teachers who have worked with the teacher, department and grade chairs, the vice principal, and the principal. While it is a subjective decision, it is based on their observations, discussions with the teacher, evidence in the portfolio, and knowledge of the teacher's contributions to the school and community. The estimate of potential is used to help the teacher grow and develop that potential.

Ultimately, teachers' annual evaluations determine their performance grade. The performance grade for the year affects the size of their performance bonus (which can range from one month's salary for performance that exceeds expectations in some areas, to more than two and a half months' salary for outstanding performance), as well as their progression in salary and position. The expectation is that all teachers are striving to be the best they can be. Because teachers understand and respect the evaluation system, they honor and endeavor to learn from the teachers who move up. At the same time, those who achieve the higher grades and eventually become subject, department, and grade chairs or senior teachers are expected to help their colleagues improve. □

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*See the main article for brief descriptions of the career tracks.

(Continued from page 34)

they are responsible for helping students master. About half the courses address issues related to mathematics education, including qualitative and quantitative research methods so teachers can engage in mathematics education research. The remaining courses are devoted to deepening teachers' knowledge of mathematics. Some of the courses include:

- How the Internet and multimedia can be used effectively as aids in teaching and learning mathematics.
- Current mathematics education issues from both overseas and local perspectives. Teachers examine and evaluate research studies and methodologies on effective mathematics curriculum, learning and teaching, and explore in depth multiple assessment practices, diagnostic assessment, and integrating assessment with instruction.
- Recent developments in curriculum models, design, and evaluation in relation to mathematics education, and their implications for the curriculum.

With regard to mathematics content, MEd mathematics education candidates learn in greater depth and breadth about selected topics such as algebra, geometry, and statistics, and about teaching these topics. There are also courses on discrete mathematics, number theory, and teaching arithmetic. In addition, teachers pursue an independent critical inquiry module in which they identify a problem, examine the relevant literature, and undertake data collection and analysis to address the problem. MEd candidates also gain an understanding of research and interpretation of research data.

Teachers sponsored through the PDCM pay a one-time fee of $1,500 upon registration, and the MOE pays for the minimum number of courses necessary to satisfy the degree requirements. However, if sponsored teachers fail or withdraw from the courses, they assume responsibility for the full cost. After completion of the master's program, graduates must remain employed with the MOE as teachers for one year.

V. Focus and Flexibility Are Important, but Effective Teaching Requires Ongoing Leadership and Support

The MOE works with schools and partners such as the NIE to boost the quality of education for teachers and students. It oversees education policies, and provides leadership and resources. It also provides autonomy to support the implementation of policies and programs in the schools and to empower leaders and teachers to make decisions that will help them teach more effectively. It supervises the management and development of the government and government-aided primary schools, secondary schools, junior colleges, and the Millennia Institute.[*] In addition, the MOE is involved in the administration of the nine polytechnics and the Institute of Technical Education, as well as the three universities and the NIE.

Over the past 10 years, the MOE has engaged in major initiatives to improve teachers' career paths, and to promote creative thinking, collaborative learning, and the use of information technology in schools. It has also provided schools with more autonomy and resources.

In order to attract and retain caring and capable teachers, the ministry periodically revises their salaries[†] and advancement prospects. For example, in April 2001, a comprehensive pay and career system was introduced to ensure that the teaching profession remains competitive with other careers. It includes new career and recognition structures, and refinements to the performance-management systems. There are now three career tracks: (1) the teaching track, which keeps teachers in the classroom[‡] but also recognizes growth and accomplishments by identifying senior and master teachers and giving them responsibility for assisting their peers; (2) the senior specialist track, which encourages teachers to become subject or curriculum specialists and conduct education research; and (3) the leadership track, which offers opportunities to take leadership positions in schools and in the MOE. Within each of these tracks are positions at various levels such that all educators have clear goals and opportunities for advancing.[13] The means to accomplish those advancement goals are also clear: Singapore has an elaborate professional development and evaluation system (see "Career Development" on page 35).

> Since 2000, most first-year teachers have been assigned 80 percent of the normal workload to provide additional time to learn from colleagues.

There are other efforts that help boost teachers' morale and performance. For example, since 2000, most first-year teachers have been assigned 80 percent of the normal workload to ease their adjustment to the teaching environment and provide additional time to learn from colleagues. Also, in an effort to continue the purposeful exchange and cross-fertilization of ideas between schools and the NIE, an educational exchange system was established. Selected school teachers have an opportunity to work at the NIE, where they teach, conduct courses, and share their school-based experiences, while some NIE staff members conduct research and immerse themselves in the school environment.

[*] Private schools also have to be registered so that the MOE can keep track of them.

[†] The starting salary of beginning teachers in Singapore is comparable to the starting salaries of accounting and engineering graduates.

[‡] In the U.S., competent teachers frequently are promoted out of the classroom.

Another recent change is that in 2004, the MOE enlarged the pool of teachers by implementing an Adjunct Teacher Program so that schools could rehire experienced and capable teachers who had retired or left the teaching service. In 2005, the MOE began employing more teachers, reducing the sizes of primary 1 (i.e., first grade) classes from 40 to 30 students. By 2010, the MOE plans to have 10 additional teachers in each primary and secondary school. The deployment of these extra teachers is left to the schools. For example, one school assigned a teacher to help small groups of students evaluated as being weak in mathematics. These groups of students leave the regular mathematics class in order to receive focused attention and support by the designated mathematics remediation teacher, who has deep knowledge of mathematics. When these children's understanding of mathematics improves, they rejoin their classmates for regular mathematics.

* * *

Some people may argue that lessons from Singapore cannot be applied in the United States, given the vast differences in size, policies, and culture between the two countries. For example, Singapore has one syllabus, while the United States has thousands of state and district mathematics standards. Singapore has one teacher-preparation institution; the United States has more than 1,400,[14] and their course requirements can range from no mathematics-content requirement (for those planning to teach grades 1–4) to requirements of several mathematics courses, with no consistency in content across institutions. In short, Singapore focuses on specific high standards (for teachers and students) and provides flexibility in attaining them. In the United States, curricular incoherence (in both K–12 education and in teacher preparation) means that only some teachers and students are held to high standards. As a result, the flexibility the United States offers leaves some students without a decent education and some teachers without decent preparation.

When it comes to mathematics content, differences between countries should play no role in determining what mathematics is learned. Mathematical coherence and rigor transcend national boundaries, as revealed by the similarity in the grades 1–8 mathematics taught in the six top-performing countries.[15] Interestingly, some of the effective educational strategies used in Singapore that are currently being adopted by other countries actually originated in these countries, including the United States. For example, Singapore's mathematics curriculum strategy of moving students carefully from the concrete to the pictorial to the abstract (thus offering a smooth, progressive transition from arithmetic to algebra[16] that is accessible to most students, rather than to a minority of students, as in the United States), was drawn from the work of the American psychologist Jerome Bruner.[17]

In the United States, there has been ongoing debate on what mathematics should be taught, but some positive news has emerged in the last few years. In 2006, the National Council of Teachers of Mathematics called for a more coherent and concise mathematics curriculum and suggested three big ideas for each grade level, from prekindergarten to grade 8.[18] Then, in 2008, the National Mathematics Advisory Panel reinforced the call for a coherent mathematics curriculum.[19]

In conjunction with a common, coherent curriculum, greater teacher knowledge of mathematics is also needed.[20] As recognized by a U.S. elementary school teacher, "one is only as effective as one's own level of understanding."[21] But most of our teacher-preparation programs are falling short. Last year, when the National Council on Teacher Quality studied dozens of mathematics education programs, it found overall low quality and enormous variability in course requirements.[22] Might it make sense for teacher-preparation institutions, at least in each state, to come together to review Singapore's required mathematics coursework for pre-service teachers, as guidelines for conversations about developing common, coherent mathematics courses?

Before one dismisses the content of this paper as unrealistic for consideration in the United States, let's examine what has been happening in Massachusetts. Since 2000, the state has made a concerted effort to align its standards, curriculum frameworks, and assessments. It has also begun to assess more seriously the content knowledge of those who aspire to be teachers, with a specific requirement that individuals must pass the mathematics portion of the state's certification test in order to be certified.[§] Since 2000, both the National Assessment of Educational Progress (NAEP) and the TIMSS mathematics results have documented Massachusetts's continuous improvement. Its students recorded the highest scores in the nation on the most recent NAEP. In addition, Massachusetts's students performed near the top internationally on TIMSS 2007.

Singapore continues to improve its educational system by learning from the strengths of other countries, including the United States. Singapore sends many leaders and talented students to earn degrees in the United States and also benefits from partnerships with American universities. For instance, the Singapore University of Technology and Design (opening in 2011) recently appointed Thomas Magnanti, former dean of the School of Engineering at the Massachusetts Institute of Technology, as its founding president.

As we in the United States move toward more coherence in our overall mathematics education system, we need better alignment of what students learn and what teachers know. In addition to content and pedagogy, we need to identify ways to attract and keep competent teachers in the classroom, and to develop a systematic and systemic infrastructure that is sustainable. In this process, there is much we may learn from Singapore's common, coherent curriculum and its dedication to teacher preparation, development, and retention. ☐

Endnotes

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Shared Knowledge

(Continued from page 13)

classroom's lack of productivity is not chiefly caused by diversity of ethnic and family background but by diversity of academic preparation. Without a common core curriculum, the disparity in student readiness increases with each successive grade, slowing down progress and making the teacher's task ever more difficult. In core-curriculum nations such as Finland and France, the disparity in students' knowledge, skills, and readiness to learn new material decreases over time.[13]

2. When critical knowledge gaps (for some students) and boring repetitions (for others) are avoided, student interest and motivation are enhanced and progress in learning speeds up. Many American teachers say that they spend several weeks at the start of each year in review. That is, they offer a minicourse in the things students need to know to go forward. To students who already know those things, the review is an occasion to start shooting spitballs. To students who are so far behind that they lack the knowledge needed to make sense of the review, it is an occasion for spitballs, too, because they are lost.

3. Instituting a common core curriculum is especially helpful for disadvantaged students who change schools. By third grade, some 50 to 60 percent of low-income students have changed schools, many in the middle of the year.[14]

4. Specific, grade-by-grade planning allows the entire curriculum to be integrated. The history of a period can be integrated with its literature, art, and music. Such integration leads to better retention and fuller understanding.

I have not encountered any cogent arguments against these reasons for greater commonality and specificity in the curriculum.

The need for a common core curriculum in the early grades is far greater in the United States than in other nations that actually have one. Americans move from one place to another in greater numbers than do residents of any other country. As a transethnic nation, we have a greater need for an *invented* common public sphere that is determined not by blood and soil, or hearth and home, but by transethnic traditions concerning our history, laws, and freedoms. The medium of this public sphere is language, which cannot be disentangled from specific, commonly shared knowledge. Such a curriculum is critical to the United States continuing to be, in Lincoln's words, "the last best hope of earth."[15] ☐

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Ask the Cognitive Scientist

(Continued from page 19)

culty to an unchanging quality within himself, the student is saying that he's powerless to succeed. ☐

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Handwriting

(Continued from page 27)

sophisticated personal computers and newer writing tools, it seems that the death of handwriting draws closer every year. Lance Morrow did a great job of capturing this sentiment in his tongue-and-cheek article (see page 22), in which the pursuer of all things shiny and new, Toad, of Toad Hall, from *The Wind in the Willows*, enthusiastically gives up pencil and paper for, in rapid succession, a Smith-Corona portable typewriter, then an electric typewriter, and finally an even more spectacular marvel—a word processor. In the end, of course, he rediscovers the unique power of handwriting, its ability to reveal "changes of mood" and to result in sentences that "take on some of the sinuosities of script."

Sinuosities aside, it's unlikely that anything will ever be as inexpensive as pen and paper, and yet, a typed note could never be as valuable as a handwritten card from a friend. As Toad found, only handwriting puts "the physical shape and flow" of the author's thoughts on the page.

Nonetheless, it is important to use good common sense when thinking about handwriting. Legible and fluent handwriting is the desired norm, but a small percentage of youngsters will not achieve this goal for a variety of reasons, ranging from physical impairments to learning disabilities. (Fortunately, there are a number of viable alternatives for these students, including traditional word processing, word processing with word prediction capabilities, and speech-to-text synthesis word processing programs.)*

Handwriting has bedeviled more than one professional writer. The handwriting of some of the most successful writers of all time, including the likes of Victor Hugo, James Joyce, and Lord Byron, was almost an illegible scrawl.[42] Difficulty mastering handwriting does not mean the game is lost, it just means writing is more challenging. ☐

Teachers need to explicitly teach handwriting and capitalize on incidental instruction, such as frequent writing and modeling correct handwriting.

*See, for example, Renaissance Learning's keyboard for students with special needs (www.renlearn.com/neo/NEO2/specialneeds/default.aspx), Don Johnston's word prediction program (www.donjohnston.com/products/cowriter/index.html), and Dragon NaturallySpeaking, a speech recognition program (www.nuance.com/naturallyspeaking).

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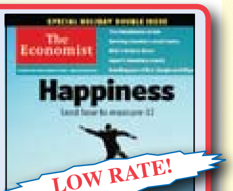

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