9

Neglecting the Early Grades

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A *Nation at Risk*, the report published by the National Commission on Excellence in Education (Excellence Commission) in 1983, was mainly concerned with the high school years and ignored for most of its length the first eight grades of schooling. Then, in its last pages, the report finally alluded to the early curriculum:

> The curriculum in the crucial eight grades leading to the high school years should be specifically designed to provide a sound base for study in those and later years in such areas as English language development and writing, computational and problem solving skills, science, social studies, foreign language, and the arts. These years should foster an enthusiasm for learning and the development of the individual's gifts and talents. (72)

A *Nation at Risk* assumed that the first eight years are devoted mainly to foundational skills and considered high school the arena for decisive educational improvement.

It was natural for the writers of *A Nation at Risk* to seek reform where the most notable declines had appeared. But when we take a longer historical perspective on the declining test scores of high schoolers during the sixties and seventies, it seems probable that the watering down of high school was less a cause of its lower scores than a consequence of a gradual decline of learning in the early grades. *A Nation at Risk*'s attitude toward the early grades reminded me of the comment many years ago of a repair man who came to fix a leak in our washing machine. He asked my wife where the leak was, and she replied, "At the bottom." He looked at her knowingly and said, "Yeah, that's what they all say." Because the writers of *A Nation at Risk* saw the problems manifest in high school, they assumed that high school was the source of the problems.

With the passage of years and further empirical research on our current educational system (a notable example is the work conducted by Keith Stanovich and his colleagues), we now know that a student's academic achievement in first grade predicts his academic achievement in eleventh grade.[1] As a result, reformers and legislators have begun to emphasize early literacy—a promising advance in thinking and policy. But this welcome new emphasis on the early grades may not yield the hoped-for improvements in equity and overall achievement if, while correcting for an earlier neglect, we persist in the same formal, skills orientation to early education that guided the writers of *A Nation at Risk*.

Guiding ideas have great practical significance in educational affairs—greater than is sometimes assumed. The unexamined assumptions of teachers, administrators, and reformers can play just as large a role in determining the quality and equity of educational outcomes as money, organizational structure, accountability, and competition. Consider just one striking bit of evidence on that score. Some high-performing systems of early education, such as those in Japan, do not follow the advice of *A Nation at Risk* in stressing formal "higher-order skills" in early schooling. They pay much closer attention to the se-

quence and coherence of the content a child receives in the early grades. Nonetheless, the scores of their eighth-graders on the so-called higher-order skills, such as comprehension and problem solving, are not only higher than ours but are also more equitably distributed among social classes.

This is not intended as a dismissal of current efforts to introduce more competition into American schooling. It's possible that Japan would elicit even better results by experimenting with the market-oriented schemes currently being tested in the United States. But the superior outcomes of nationalized, bureaucratic, nonmarket education systems suggest that, at least in these instances, organizational schemes have been less critical to student outcomes than the ideas that have governed teaching and learning. The questionable ideas about the early curriculum that permeated *A Nation at Risk* continue to dominate discussion in the United States, while among research psychologists a consensus has formed that points to a set of more accurate ideas.

Higher-Order Skills

The writers of *A Nation at Risk* believed that the goal of early grades is to gain proficiency in the skills of reading, writing, thinking, and reckoning in order to "provide a sound basis" for high school study. With this assumption—that the aim of early education is skill building—it was natural for the writers of *A Nation at Risk* to pay little attention to the curricular content of the early grades. They assumed that any sensible content that develops the necessary foundational skills would do.

I have elsewhere called this concept—of skill building through arbitrary content—"educational formalism," the notion that a chief aim of early education is the attainment of formal skills.[2] The educational experts who were consulted by the writers of *A Nation at Risk* explicitly stated that the purpose of early schooling was the develop-

ment of "higher skills," and they cited with approval the consensus on this point that emerged from a hearing on Language and Literacy held in April 1982:

> A panel of five [Excellence] Commission members, chaired by Jay Sommer, foreign language teacher at New Rochelle High School in New York, and an audience of approximately 200 people heard testimony regarding the development of the higher-order language skills necessary for academic learning. Six invited speakers presented national perspectives on teaching reading, writing, and second languages and discussed related concerns with the [Excellence] Commission members. Sixteen other speakers presented their views on the hearing topics, predominantly from regional and local perspectives. The general theme provided by the witnesses was that the language skills that should be emphasized were the more sophisticated, integrated, concept-oriented skills of comprehension and composition. Each of the experts suggested that priority should be assigned to these high-level skills and that they can be taught through systematic instructional strategies requiring conscientious effort by teachers, administrators, and publishers. (55)

Throughout *A Nation at Risk*, the concern was expressed that comprehension and problem solving were being neglected in favor of merely basic skills such as number facts, phonics, and spelling. The writers implied that the battle for educational improvement in the early grades would be won when these grades went beyond the basics and emphasized higher skills. In that context, little needed to be said about the content of early schooling. The path to improvement was seen to lie not in the substance of what was taught in the first eight grades, but in the higher-order proficiencies that were systematically inculcated.

Two decades later, we can infer from the results of putting these formalistic ideas into practice that there was something wrong with that picture. For the past twenty years, our elementary schools have tried to follow the advice of the experts who contributed to *A Nation at Risk* by teaching such higher-order skills as critical thinking, prob-

lem solving, and looking for the main idea. Yet these turned out to be the very skills in which our students continued to decline compared with students in Asian and European countries that placed less emphasis on formal comprehension skills and more emphasis on coherent year-to-year subject matter. Cognitive psychology has long since reached a level of sophistication that enables it to explain why teaching higher-order skills explicitly as formal structures is highly ineffective.[3] This finding is the most plausible explanation for the historical paradox that national systems that stress content more than skills nonetheless inculcate these higher-order skills more effectively than systems that try to teach higher-order skills as such. To teach content *is* to teach higher-order skills; to teach higher skills as such is to pursue a phantom.

Content Is Skill, Skill Content

Literate adults already possess the reading skills that *A Nation at Risk* thought could be taught divorced from content. We can read the words of this chapter with comprehension, think critically about them, analyze their main import, and ultimately judge whether the argument contributes to solving an educational problem. We can congratulate ourselves that our schooling has done the foundational job that *A Nation at Risk* called for. But it is unlikely that we gained these proficiencies by being taught them directly as formal skills. Few of us learned to find the main idea by being taught explicitly to look for it (a favorite with the formalistic approach to comprehension skill). Few of us learned the skill of thinking critically about what we read by taking formal lessons in critical thinking. How then did we gain these complex skills, and what is their nature? These are questions that educational experts and policy makers need to be able to answer if we are to achieve better results in the next twenty years than we did in the post–*A Nation at Risk* period.

By the time *A Nation at Risk* was published in 1983, cognitive

psychology had achieved a degree of consensus about the fundamental nature of academic skills. Yet the science of psychology was not often alluded to in *A Nation at Risk*. Even today, twenty years later, there is little crossover between cognitive science and educational policy. *A Nation at Risk* simply assumed that gaining an academic skill such as reading or reckoning is independent of the specific curricular content through which the skill is taught. This formalistic conception continues to dominate American educational circles. It is a misleading oversimplification that will have to be corrected if our schools are to teach higher skills successfully.

Five propositions neatly summarize the scientific consensus on the nature of academic skills:

1. The character of an academic skill is predetermined by the narrow limitations of working memory.[4]
2. Academic skills have two components: procedures and contents.[5]
3. Procedural skills such as turning letters into sounds must initially be learned as content along with other content necessary to higher-order skills.[6]
4. An advance in skill, whether in procedure or content, is correlated with an advance in speed of processing.[7]
5. A higher-order academic skill such as reading comprehension requires prior knowledge of domain-specific content; the higher-order skill for that domain does not readily transfer to other content domains.[8]

Understanding the Five Principles

These well-established principles, taken together, constitute a refutation of the formalistic conception of academic skills. They explain why national systems of early education that stress a coherent approach to content succeed in teaching higher-order skills such as prob-

lem solving in mathematics more effectively than does our system, which although it explicitly stresses higher-order skills, it does so on the incorrect assumption that they are formal procedures that can be learned through arbitrary contents and transferred to new content domains. This is a mistake of historic proportions. Let's take each principle in turn, and see how they each support the idea that the learning of higher-order skills is dependent on the coherence and content of an academic program.

1. The character of an academic skill is predetermined by the narrow limitations of working memory.

The conscious activity of the mind occurs within a narrow window of time, lasting a very few seconds, in which we can manipulate a very small number of mental objects before they disappear into forgetfulness. These limitations cannot be overcome directly. Acquiring a skill means acquiring ways of indirectly circumventing the limitations of working memory for the purposes at hand. This is the most fundamental and important principle for understanding the nature of academic skills.[9]

Consider the difference in mental capacity between a practiced reader and a beginning first-grader who is painstakingly parsing out T-H-E-C-A-T-I-S-O-N-T-H-E-M-A-T (we'll use the example of reading skills here, but the principles apply just as well to mathematics, and indeed to any subject). What is the difference in raw mental capacity between that child and practiced readers? We find that the child's functional mental operations are equal to or even exceed our own. For example, the child's ability to remember a set of unfamiliar sounds or shapes is equal to ours, and the child's reaction time may be even faster than ours. The child's basic operational machinery—the hardware, so to speak—is as good as or better than our own.

It follows that our ability to read "the cat is on the mat" is not a consequence of an enhanced raw ability that has made our mental muscles bigger and stronger or has given us a more powerful central

processing unit. Our ability is the consequence of our acquiring some specific software that allows us to transform an arduous task for the child into a task that is as easy for us as falling off a log. Our ability to effortlessly convert visual symbols into words is an acquired system by means of which we are able to cleverly circumvent the still-unyielding constraints of working memory.

On this basic fact hang all the law and the prophets of educational doctrine relative to skills. The conscious mind, where higher-order skills mostly take place, is limited by a universal, highly democratic constraint called working memory whose narrow limits are on average the same for child and adult, rich and poor. It is the small window of present-tense consciousness and attention. It is the "place" where we put things together and create meaning, where we solve problems and process language. Within its small temporal extent, which lasts just a few seconds, we are able to manipulate only a very small number of sensations, sounds, or symbols.

In the fifties, George Miller wrote "The Magical Number Seven Plus or Minus Two," a famous article about the limitations of working memory. Miller pointed out that the number of chunks we can handle in the brief span of working memory is extremely limited—five to nine items at most.[10] (Some now believe that the true limit of working memory varies according to the temporal constraints of the number of syllables required to name the items.)[11] The enlargement of academic skills, including, notably, acquiring a big vocabulary, consists of building efficient mental systems that enable us, despite the very constrained bottleneck imposed by limited memory, to perform huge feats of analysis and synthesis.

A famous experiment conducted by Dutch psychologist Adrian de Groot illustrated this universal bottleneck in human processing skills.[12] He noticed that chess grand masters have a remarkable skill that we amateurs cannot emulate. They can glance for five seconds at a complex midgame chess position of twenty-five pieces, perform an

intervening task of some sort, then reconstruct on a blank chess board the entire chess position without making any mistakes. Performance on this task correlates almost perfectly with one's chess ranking. Grand masters make no mistakes, masters a very few, and amateurs can get just five or six pieces right. (Remember the magical number seven, plus or minus two!)

On a brilliant hunch, de Groot then performed the same experiment with twenty-five chess pieces in positions that, instead of being taken from an actual chess game, were just placed at random on the board. Under these new conditions, the performances of the three different groups—grand masters, masters, and amateurs—were all exactly the same, each group remembering just five or six pieces correctly.

The experiment suggests the skill difference between a master reader who can easily reproduce the sixteen letters of "the cat is on the mat" and a beginning reader who has trouble reproducing the same letters: t-h-e-c-a-t-i-s-o-n-t-h-e-m-a-t. If, instead of providing expert and child with that sentence, we change the task and ask them to reproduce a sequence of random letters, the performance of the first-grader and the master reader will become much closer. If the sixteen letters had been "rtu kjs vb fw nqi pgf," the expert would exhibit little skill advantage over the novice, and on average neither will get more than a short sequence of the letters right.

Practiced readers, chess grand masters, and other experts do not possess any special, formal abilities that novices lack, and they do not perform any better than novices on formally similar yet unfamiliar tasks. Nonetheless, experts are able to perform remarkable feats of memory with real-world situations such as midgame chess positions and actual sentences. How do they manage?

The sentence "the cat is on the mat" consists of six words that are easily remembered, and expert readers can easily reproduce the sixteen letters not because the letters are individually remembered, but be-

cause they are reconstructed from prior knowledge of written English. What de Groot found, and what subsequent research has continually confirmed, is that the difference in higher-order skill between a novice and an expert does not lie in mental muscles but in what de Groot called "erudition," a vast store of available, relevant, previously acquired knowledge.

Despite the narrow limitations of working memory, the wealth of contents that can be manipulated by experts through this previously acquired "erudition" is immense. If I already know a lot about baseball, the term "sacrifice fly" can represent a page or two of exposition. Such shorthand representation is a chief timesaving technique of higher-order skills. A short manageable element (like a phrase) can represent a much larger complex of already-learned meaning. The phrase "World War II" is short and therefore easily remembered, but the content represented by the phrase is enormous. It cannot be grasped by those who, however skillful in other ways, lack that relevant knowledge. By the time someone had learned the content needed to grasp "World War II," the immediate task would have long disappeared from working memory. The phrase can be understood and communicated only by those who already share the relevant knowledge and associations.

I use this example as a rapid way of indicating why an academic skill like reading depends on learning much more than the foundational ability to form sounds from symbols, turn the sounds into words, and put the words together in sentences. While such formal skills are critically important, they are quite insufficient to comprehend a passage about World War II in the absence of relevant already-learned background knowledge. A shorthand way of saying this is that the skill of reading (and listening) depends on, among other things, a prior knowledge of what most of the words in a text mean and refer to.

This example can be generalized. A skill depends upon prior possession of specifically relevant content knowledge that enables the

mind to circumvent the strict limits of working memory. Academic skills cannot be isolated from the possession of specifically relevant content knowledge.[13]

The subsequent four principles are clarifications of this essential insight.

2. *Academic skills have two components: procedures and contents.*

Procedural skills correspond roughly to activities that have become automatic and unconscious; content skills correspond to activities that are conscious. A complex skill like reading is composed of both procedural elements like decoding and content elements like vocabulary knowledge.[14]

I type these words under a disadvantage. I never learned a system of touch typing. Still, because I have performed this activity so many times, I type fairly fast. Finding the right key takes up very little of my working memory. I never have to ask myself where a letter on the keyboard is; I just hit it without thinking. This is the very model of learning a procedural skill. The activity becomes automatic and unconscious because it is often repeated and nearly invariant. The letters on the keyboard do not move around from one typing session to the next. Similarly, the procedural skills of reading—rapid eye movements from left to right and from line to line, automatic calculation of the highest letter-sound probabilities (decoding)—remain fairly stable and repeatable from one reading event to another and are therefore good candidates for being turned into unconscious, procedural skills.

The so-called basic skills of reading and math are largely of this procedural sort. It is essential that these skills be mastered so that working memory can occupy itself with nonrepeated, content-based skills such as reading comprehension. Given the constraints of working memory, any mental space that is consciously concerned with decod-

ing and identifying words will occupy space that could otherwise be used for higher-order skills.

It should be emphasized, however, that procedural skills are not inherently independent of content. They do not start out as part of a separate system. Before my typing became fast, automatic, and unconscious, it was conscious, slow, and error-prone. This is the usual pattern for learning procedural skills. Before a child masters the automatic decoding of print into speech sounds, he must slog through many hours of conscious and laborious content-filled activities. Such skills are contents before they are procedures. In the early grades, the regularities and probabilities behind the procedural skills are themselves an important content of schooling. But the fact that such preprocedural skills are "basic" doesn't mean they are the only important content of early schooling—a point that deserves mention as a third principle.

3. Procedural skills such as turning letters into sounds must initially be learned as content along with other content necessary to higher-order skills.

Efforts to learn procedural skills such as the decoding of letters into words are at first slow and uncertain because of the narrow limitations of working memory. Some procedural skills, like decoding, become speedy and automatic only after years of practice. The case is different with content-based skills such as vocabulary knowledge.[15] These content elements can be learned rapidly, with few exposures, and are the chief components of higher-order abilities. Knowledge of the broad content that is relevant to the general reading demanded by the modern world should be gained steadily from the earliest years of schooling, along with procedural skills.

The complex skill of reading comprehension is a combination of both types of skills. Reading skill consists of a relatively small store of unconscious procedural skills accompanied by a massive, slowly-built-up store of conscious content skills (for example, vocabulary). If school

time is to be spent effectively in the early grades, the massive buildup of content knowledge that is essential to higher-order skills must not be subordinated to the slow multiyear buildup of foundational procedural skills. To attain maximum effectiveness, both kinds of skill-learning should occur simultaneously.

The procedural/content distinction used by psychologists clarifies the dual, unconscious/conscious character of academic skills. The duality suggests why our schools have been mistaken in assuming that reading skill can be reliably built up simply by wide practice and frequent exposure to arbitrary sorts of content. This conception does work for procedural tasks like eye movements and decoding, which are relatively invariant from one occasion to another. But exposure to arbitrary content cannot reliably build up the knowledge and vocabulary that is the foundation of higher-order reading skill because these content elements are not the same from one task to another. They require conscious attention in working memory.

It is true that broad content knowledge can be built up over time simply from wide desultory reading. Given world enough and time, the reading of many and varied books over many years can yield a good general education. But achieving competence in higher-order, knowledge-based skills such as reading comprehension is a difficult and time-consuming process that the schools need to foster in a time-effective way. Exposing students to content in a hit-or-miss fashion leaves many behind. Exposing them to content in a coherent sequence, as many national systems do, securely provides all students with the content knowledge they need to be competent readers.

Bringing all students to competence in higher-order skills is a fundamental responsibility of the schools of a democracy. If we follow out the implications of the scientific consensus, our schools are duty-bound to adopt a coherent, rational, and sequenced approach to content and vocabulary knowledge—not the content-indifferent approach allowed by a mistakenly formal, purely procedural conception of higher-order skills.

4. An advance in skill, whether in procedure or content, is correlated with an advance in speed of processing.

For repeated, procedural activities such as translating visual symbols to sounds, speed is increased by "automaticity." For content skills such as reading comprehension, speed is increased by "chunking."[16]

An advance in skill requires an advance in speed because the contents of working memory begin to disintegrate and dissolve after a few seconds. Correlating what we are thinking or reading about has to be done fast before the elements disappear. Working memory imposes an unforgiving temporal limitation on what we can attend to before the elements of thought evaporate.

The magnitude of what we are able to accomplish in this small window of conscious attention depends first of all on our enabling the procedural aspects of the task to take up less and less mental time and space. We can attend only to a very few things at a time, so if we attend to the basic process, we can't attend to much else. The more automatically and rapidly we can turn letters into words and sentences, the more rapidly we can read. The beginner cannot remember the sixteen letters of t-h-e-c-a-t-i-s-o-n-t-h-e-m-a-t because his working memory gets filled up by the conscious process of attaching names and sounds to the visual symbols, leaving no mental space for active attention to the letter sequence itself. Speed is of the essence. The higher-order processes cannot begin to function well until these underlying processes have become fast and automatic.

Once the underlying processes of reading have become fast and automatic we must still be able to deal with the substance of what the decoded words signify. Being able effortlessly to turn w-o-r-l-d-w-a-r-I-I into World War Two doesn't count for much if we don't comprehend what the phrase means. In this sphere of content, speed also counts for a great deal. The rapid availability of a phrase's meaning enables us actively to combine that meaning with other meanings before the elements dissolve into oblivion.

The general skill of reading comprehension correlates very highly with the possession of a broad, quickly available general vocabulary, which is unsurprising since vocabulary knowledge is a component of the skill of reading comprehension.[17] A vocabulary item like World War Two can be unpacked by a comprehending reader into a large number of implicitly included meanings like Axis powers, Allies, 1939–1945, Holocaust, atom bomb, and so forth, and these can themselves be further unpacked. All these meanings are implicitly included in the phrase, but the phrase itself is so compact that it can be manipulated with other large complexes of meaning before the elements dissipate.

The concentration of complex meaning into a simple, small packet that can be accommodated in working memory is the chief trick of the mind in higher-order skills. When psychologists first began experimenting with the limits of working memory, they found that a chief device for improving performance was "chunking," that is, turning a large number of discrete items into a small number of chunks. If you want to remember the telephone number 7265346519, you will do well to turn these eleven discrete items into three chunks: 726-534-6519.

In order for we humans to think effectively, the elements that we attend to must be grasped rapidly and therefore must be few in number. Later on, the numerous implications of those few elements can be unpacked and analyzed at leisure. It was rapid concentration of meaning that de Groot's chess masters engaged in—a kind of chess vocabulary, whether or not formed into words—when they observed a midgame position. They immediately identified a familiar structure that could have been named, say, "Queen's Pawn Gambit Declined, Lasker Variation." Later, they could unpack this quasi-vocabulary item and reconstruct the position with perfect fidelity. The fundamental need of the mind for such speedy meaning-concentration explains why higher-order skills require the possession of relevant prior knowledge and its associated vocabulary.

5. A higher-order academic skill such as reading comprehension requires prior knowledge of domain-specific content; the higher-order skill for that domain does not readily transfer to other content domains.

De Groot showed that being an expert in chess does not improve one's memory for randomized chess positions. Tracing the implications of that discovery, psychologists have found that being expert in chess is even less likely to improve one's skills in areas that are still more remote from chess, like math problem-solving or the ability to think logically about politics.[18] A famous example was Bobby Fisher. He was one of the greatest chess grand masters America has produced, with unparalleled critical thinking skills for analyzing chess strategy—but he had famously poor critical-thinking skills in the affairs of everyday life.

Being good at one mental skill does not necessarily train the mind to be skilled in other domains.[19] This could be called the principle of nontransferability. It is one of the most solid findings in psychology, confirmed and reconfirmed many times, tested so often possibly because it has been such a surprising and unwelcome finding. People who have just finished a course in logic are barely more logical than those who have never taken such a course.[20] People who have been carefully trained how to solve a problem in one domain are rarely able to solve a problem that has identical structure but lies in a different domain. Those who are skilled at diverse tasks in various domains are people who have managed to acquire broad general knowledge that includes knowledge relevant to those diverse domains. Such generalized skill is in fact a practical aim of a broad, general education. Students who score well on the verbal SAT invariably possess a broad vocabulary that represents broad general knowledge—which is hardly surprising since the verbal SAT is essentially an advanced vocabulary test.[21]

The so-called higher-order skills are therefore those that are least susceptible to transfer. They are the most dependent upon domain-

specific knowledge. All of the examples and analyses in this chapter hint at why higher skills are so dependent upon specific knowledge. They show that problem solving and critical thinking are not mental muscles. They are not abstract rules of operation. If remembering chess positions had been based on internalized rules, then the grand masters would have been able to apply them to a completely random chess position. There do exist internalized rules of operation in a skill, of course, but these never concern aspects that we call higher-order skills. They are more like the rules of grammar in a language. These stable grammar rules transfer from one sentence and domain to another, because they are relatively invariant. But they are also relatively basic. A six-year-old has already internalized most of the intricacies of grammar rules. What the six-year-old lacks is world knowledge and its associated vocabulary. Such knowledge is not imparted by schools that place their educational faith in the power of formal skills and the assumption that they will empower a child to acquire knowledge and vocabulary on her own.

For practical purposes, there are no such things as transferable higher skills of problem solving and reading comprehension. The ability to solve a math problem depends on having a specifically relevant and available math vocabulary. The ability to comprehend a printed text depends on having a specifically relevant and available linguistic vocabulary that comprises at least 90 percent of the words of the text.[22] The vague hope that students will be able to apply what they know in depth about supermarkets to new domains is not sustained by experience or psychological theory.

That is not to say that the mental transfer of structure from one problem to another never occurs. On the contrary, one of the features of expert performance in a domain (after about ten years of practice) is the ability to intuit the deep structure of problems and their connections with other problems in that domain. But this is a kind of skill that comes after long experience.[23] The hope that skilled intuition of deep structural similarities among superficially dissimilar problems

can be successfully taught to novices has been shown to be incorrect. Some improvement in reading can come from making students aware of the need to look for the main idea or to ask questions and make inferences, but this improvement levels off very quickly after about six lessons and yields an initial and unchanging effect size that is the same as that yielded by twenty-five such lessons. There are no significant shortcuts to gaining structural skills in a domain.[24]

If mental transfer is difficult among problems within a domain, it is exceedingly difficult from one domain to another. Such analogous thinking is rare; it represents the pinnacle of human thought, the epitome of creative thinking. When it happens, a new art form or field of thought is born. The great physicist Erwin Schroedinger wrote a little book entitled *What Is Life?* in which he suggested that life is a kind of crystal that enables the living molecule to replicate itself, as do the molecules of a crystal.[25] This thought transfer from physics to biology was so captivating that it caused a whole generation of physicists to turn their attention to biology, resulting in the Crick-Watson discovery of DNA and, ultimately, in the transformation of modern biology and medicine. For most of us, though, most of the time, such leaps of thought are very rare precisely because they are so difficult.

Our American faith that teaching students biology will teach them the nature of science or that teaching students to think critically about the Civil War will teach them how to think critically about current affairs is a misplaced faith that is supported neither by large-scale results nor by the laboratory. The practical result of our faith in the transferability of higher skills has been an incoherent curriculum that is especially damaging to those students who have not gained broad academic knowledge outside of school.

Needed: A Coherent and Specific Curriculum

There are clear policy implications to be drawn from understanding the domain- and content-specific character of higher-order skills.

These do not include continuing to follow popular slogans about local control of curriculum and letting a thousand flowers bloom. The goal of a literate citizenry can be reached only by offering ideas for educational reform that specify a coherent curriculum. The writers of *A Nation at Risk* did not recommend a coherent, grade-by-grade-specific elementary curriculum because its writers did not understand as fully as we do now the degree to which higher skills are dependent upon a sound base of general knowledge. Schools cannot be sure of offering all students a sound base of general knowledge until the states *specify* the core content of the early curriculum.

A beginning has been made in the state-standards movement. Currently most state standards are vague and fail to offer grade-by-grade guidance. State tests are not effectively tied to specific, grade-by-grade knowledge. The few states, like Virginia and Massachusetts, that are farthest along that path, have made significant progress in both excellence and equity. The many states that lag behind in setting specific grade-by-grade standards have shown little educational progress. I believe that our best hope for widespread improvement in K–12 education lies in the standards movement, which potentially offers a more effective educational arrangement than any we have had, not least because by defining the knowledge that students need we also implicitly specify the knowledge that teachers should possess. We need a good core curriculum for each state. Our best hope for succeeding where the generation that wrote *A Nation at Risk* failed is to act on this unavoidable yet still unpopular implication of the content-ridden nature of higher-order skills.

Notes

1. Anne E. Cunningham and Keith E. Stanovich, "Early Reading Acquisition and Its Relation to Reading Experience and Ability 10 Years Later," *Developmental Psychology* 33 (November 1977): 934–45.

2. E. D. Hirsch, *Cultural Literacy*, (Boston: Houghton Mifflin, 1987), 110–13; see also *The Schools We Need* (New York: Doubleday, 1996), 218–22.
3. The up-to-date psychological literature on problem solving and other higher-order skills is summarized in Daniel B. Willingham, *The Thinking Animal* (Upper Saddle River, N.J.: Prentice-Hall, 2001), 382–478. Another excellent overview is Rosemary J. Stevenson, *Language, Thought and Representation* (New York: John Wiley & Sons, 1993).
4. George A. Miller, "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information," *The Psychology of Communication*, Basic Books, 1967. See also Alan D. Baddeley, *Human Memory: Theory and Practice* (revised edition), (Needham Heights, Mass.: Allyn & Bacon, 1998).
5. Daniel B. Willingham, *The Thinking Animal*, 318–25.
6. Alan D. Baddeley, *Human Memory: Theory and Practice*, 120–25, 149–51, 299–300. See also Rosemary J. Stevenson, *Language, Thought and Representation*, 231–56.
7. Robert Kail, "Development of Processing Speed in Childhood and Adolescence," *Advances in Child Development and Behavior* (v. 23, 1991), 151–85.
8. Walter Kintsch, *Comprehension: A Paradigm for Cognition* (New York: Cambridge University Press, 1998), 287–90.
9. George A. Miller, op. cit. Alan D. Baddeley, *Human Memory: Theory and Practice.*
10. See note 4.
11. Alan D. Baddeley, *Human Memory: Theory and Practice*, 29–32.
12. A. de Groot, *Het Denken van den Shaker*, 1946. English: *Thought and Choice in Chess*, Mouton, The Hague, 1965.
13. Rosemary J. Stevenson, *Language, Thought and Representation*, 231–56.
14. Walter Kintsch, *Comprehension: A Paradigm for Cognition.*
15. Rosemary J. Stevenson, *Language, Thought and Representation*, 231–56.
16. "Chunking" was first used by Miller in "The Magical Number Seven, Plus or Minus Two: Some Limits on Our Capacity for Processing Information."
17. W. E. Nagy, and J. Scott, "Vocabulary Processes" in Kamil, M., et al., *Handbook of Reading Research, Volume III* (Mahwah, N.J.: Erlbaum, 2000), 269–84.

18. S. E. Newstead, and J. Evans, eds., *Perspectives on Thinking and Reasoning* (Hillsdale, N.J.: Erlbaum, 1995).
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