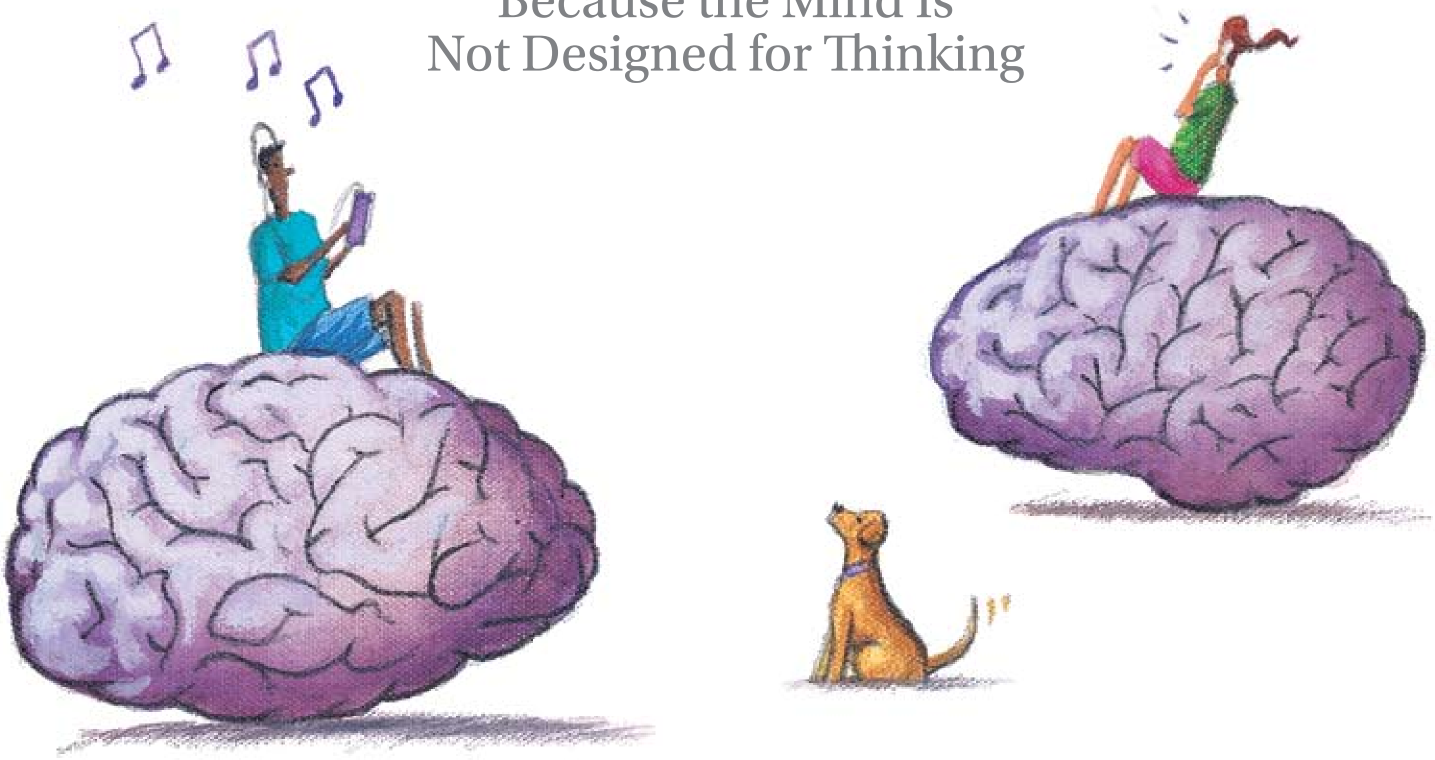
Why Don't Students *Like* School?

Because the Mind Is Not Designed for Thinking



ILLUSTRATED BY PAUL ZWOLAK

BY DANIEL T. WILLINGHAM

Question: Most of the teachers I know entered the profession because they loved school as children. They want to help their students feel the same excitement and passion for learning that they did. They are understandably dejected when they find that some of their pupils don't like school much, and that they, the teachers, have great difficulty inspiring them. Why is it difficult to make school enjoyable for students?

Answer: Contrary to popular belief, the brain is not designed for thinking. It's designed to save you from having to think, because the brain is actually not very good at thinking. Thinking is slow and unreliable. Nevertheless, people enjoy mental work if it is successful. People like to solve problems, but not to work on unsolvable problems. If schoolwork is always just a bit too difficult for a student, it should be no surprise that she doesn't like school much. The cognitive principle that guides this article is: *People are naturally curious, but they are not naturally good thinkers; unless the cognitive conditions are right, people will avoid thinking.* The implication of this principle is that teachers should reconsider how they encourage their students to think in order to maximize the likelihood that students will get the pleasurable rush that comes from successful thought.

What is the essence of being human? What sets us apart from other species? Many would answer that it is our ability to reason—birds fly, fish swim, and humans think. (By "thinking," I mean solving problems, reasoning, reading something complex, or doing any mental work that requires some effort.) Shakespeare extolled our cognitive ability in *Hamlet*: "What a piece of work is man! How noble in reason!" Some 300 years later, however, Henry Ford more cynically observed, "Thinking is the hardest work there is, which is the probable reason why so few people engage in it." They both had a point. Humans are good at certain types of reasoning, particularly in comparison with other animals. But we

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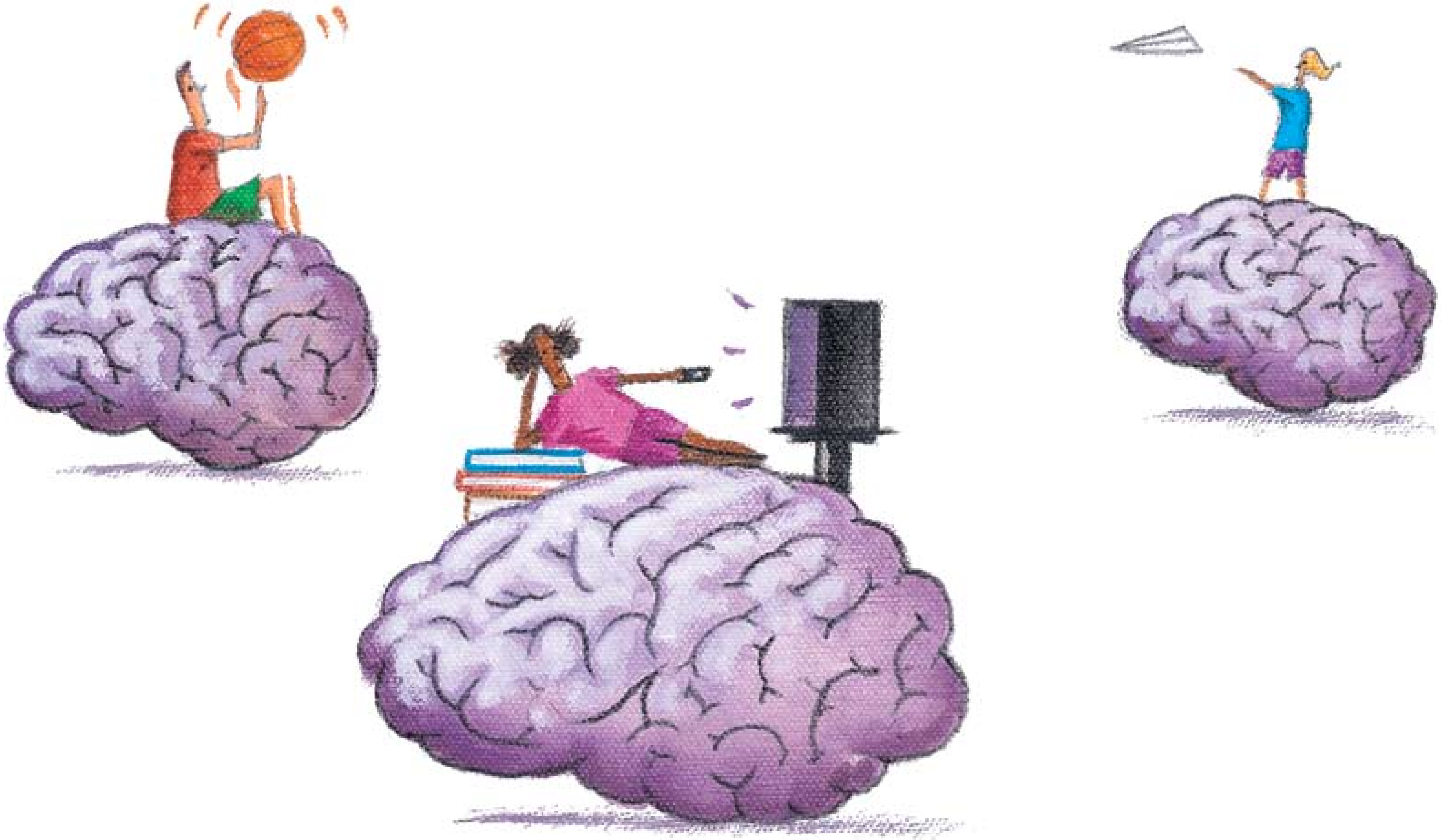
Daniel T. Willingham is professor of cognitive psychology at the University of Virginia and author of numerous articles, including his regular "Ask the Cognitive Scientist" articles for American Educator. *To read more of his work on education, go to **www.danielwillingham.com**. This article is excerpted from his new book,* Why Don't Students Like School? *Copyright © 2009 John Wiley & Sons. Content reprinted by permission of Jossey-Bass: **www.josseybass.com**.*



exercise that ability infrequently. A cognitive scientist would add another observation. Humans don't think very often because our brains are designed not for thought, but for the avoidance of thought. Thinking is not only effortful, as Ford noted, it's also slow and unreliable.

Your brain serves many purposes, and thinking is not the one it does best. Your brain also supports the ability to see and to move, for example, and these functions operate much more efficiently and reliably than our ability to think. It's no accident that most of your brain's real estate is devoted to them. The extra brain power is needed because seeing is actually more difficult than playing chess or solving calculus problems.

Compared with your ability to see and move, thinking is slow, effortful, and uncertain. To get a feel for why I say that, try this problem:

> In an empty room are a candle, some matches, and a box of tacks. The goal is to have the lit candle about five feet off the ground. You've tried melting some of the wax on the bottom of the candle and sticking it to the wall, but that wasn't effective. How can you get the lit candle to be five feet off the ground without your having to hold it there?*

Twenty minutes is the usual maximum time allowed and few people are able to solve it by then, although once you hear the answer you realize that it's not especially tricky. You dump the tacks out of the box, tack the box to the wall, and use it as a platform for the candle.

This problem illustrates three properties of thinking. First, thinking is *slow*. Your visual system instantly takes in a complex scene. When you enter a friend's backyard, you don't think to yourself, "Hmm ... there's some green stuff. Probably grass, but it could be some other ground cover ... and what's that rough brown object sticking up there? A fence, perhaps?" You take in the whole scene—lawn, fence, flower beds, gazebo—at a glance. Your thinking system does not instantly calculate the answer to a problem the way that your visual system immediately takes in a visual scene.

Second, thinking is *effortful*; you don't have to try to see, but thinking takes concentration. You can perform other tasks while you see, but you can't think about something else while you work on a problem.

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*Karl Duncker, "On Problem-Solving," *Psychological Monographs* 58, no. 5 (1945): 113.

Third, thinking is *uncertain*. Your visual system seldom makes mistakes, and when it does, you usually think you see something similar to what is actually out there—you're close, if not exactly right. Your thinking system might not even get you close; your solution to a problem may be far from correct. In fact, your thinking system may not produce an answer at all, which is what happens to most people when they try the candle problem.

If we're all so bad at thinking, how does anyone hold down a job, or manage his money? How does a teacher make the hundreds of decisions necessary to get through her day? The answer is that, when we can get away with it, we don't think. Instead, we rely on memory. Most of the problems you face are ones you've solved before, so you just do what you've done in the past. For example, suppose next week a friend gives you the candle problem. You would immediately say, "Oh, right. I've heard this one. You tack the box to the wall." Just as your visual system takes in a scene and, without any effort on your part, tells you what is in the environment, so too your memory system immediately and effortlessly recognizes that you've heard the problem before and provides the answer. Most people think that they have a terrible memory, and it's true that your memory is not as reliable as your visual or movement systems—but your memory system is much more reliable than your thinking system, and provides answers quickly and with little effort.

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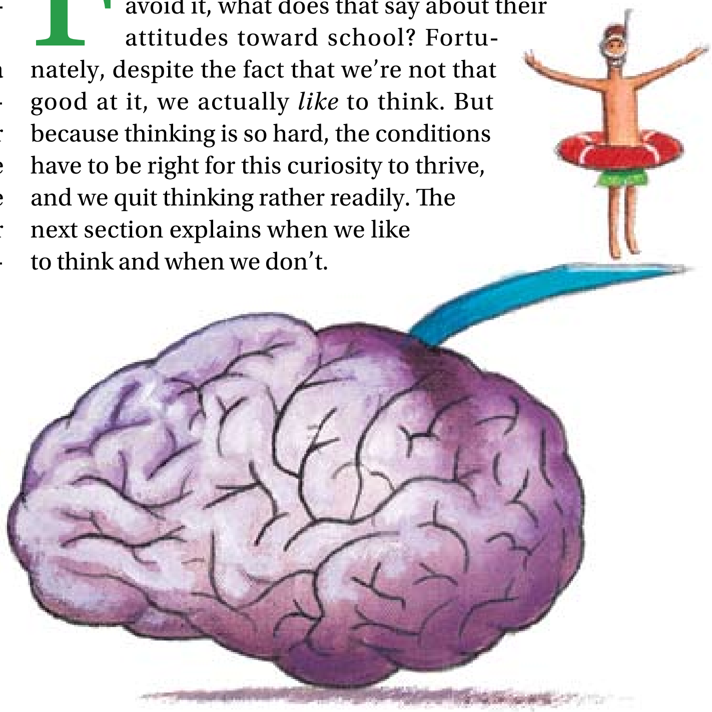
We normally think of memory as storing personal events (e.g., memories of my wedding) and facts (e.g., George Washington was the first president of the United States). Your memory also stores procedures to guide what you should do: where to turn when you're driving home, how to handle a minor dispute when you're monitoring recess, what to do when a pot on the stove starts to boil over. For the vast majority of decisions you make, you don't stop to consider what you might do, reason about it, anticipate possible consequences, and so on. You do take such steps when faced with a new problem, but not when faced with a problem you've already encountered many times. That's because one more way that your brain saves you from having to think is by changing. If you repeat the same thought-demanding task again and again, it will eventually become automatic; your brain will change so that you can complete the task without thinking about it. When you feel as though you are "on autopilot," even if you're doing something rather complex, such as driving home from your school, it's because you are using memory to guide your behavior. Using memory doesn't require much of your attention, so you are free to daydream, even as you're stopping at red lights, passing cars, watching for pedestrians, and so on.

For education, the implications of this section sound rather grim. If people are bad at thinking and try to avoid it, what does that say about their attitudes toward school? Fortunately, despite the fact that we're not that good at it, we actually *like* to think. But because thinking is so hard, the conditions have to be right for this curiosity to thrive, and we quit thinking rather readily. The next section explains when we like to think and when we don't.



People Are Naturally Curious, But Curiosity Is Fragile

Even though our brains are not set up for very efficient thinking, people actually enjoy mental activity, at least in some circumstances. They have hobbies like solving crossword puzzles or scrutinizing maps. They watch information-packed documentaries. They pursue careers—such as teaching—that offer greater mental challenge than competing careers, even if the pay is lower. Not only are they willing to think, they intentionally seek out situations that demand thought.

Solving problems brings pleasure. When I say "problem solving" here, I mean any cognitive work that succeeds; it might be understanding a difficult passage of prose, planning a garden, or sizing up an investment opportunity. There is a sense of satisfaction, of fulfillment, in successful thinking. In the last 10 years, neuroscientists have discovered that there is overlap in the brain areas and chemicals that are important in learning and those that are important in the brain's natural reward system. Many neuroscientists suspect that the two systems are related, even though they haven't worked out the explicit tie between them yet.

It's notable too that the pleasure is in the *solving* of the problem. Working on a problem with no sense that you're making progress is not pleasurable. In fact, it's frustrating. And there's not great pleasure in simply knowing the answer either. I told you the solution to the candle problem; did you get any fun out of it? Think how much more fun it would have been if you had solved it yourself—in fact, the problem would have seemed more clever, just as a joke that you get is funnier than a joke that has to be explained. Even if someone doesn't tell you the answer to a problem, once you've had too many hints you lose the sense that *you've* solved the problem and getting the answer doesn't bring the same mental snap of satisfaction.

Mental work appeals to us because it offers the opportunity for that pleasant feeling when it succeeds. But not all types of thinking are equally attractive. People choose to work crossword puzzles, but not algebra problems. A biography of the vocalist Bono is more likely to sell well than a biography of the poet Keats. What characterizes the mental activity that people enjoy?

The answer most people would give may seem obvious. "I think crossword puzzles are fun and Bono is cool, but math is boring and so is Keats." In other words, it's the content that matters. But I don't think that content drives interest. We've all attended a lecture or watched a TV show (perhaps against our will) about a subject we thought we weren't interested in, only to find ourselves fascinated. And it's easy to get bored even when you usually like the topic. I'll never forget my anticipation for the day my middle school teacher was to talk about sex. As a teenage boy in a staid 1970s suburban culture, I fizzed with anticipation of any talk about sex, anytime, anywhere. But when the big day came, my friends and I were absolutely disabled with boredom. It's not that the teacher talked about flowers and pollination, he really did talk about human sexuality, but somehow it was still dull. I actually wish I could remember how he did it; boring a bunch of hormonal teenagers with a sex talk is quite a feat.

> Working on problems that are at the right level of difficulty is rewarding, but working on problems that are too easy or too difficult is unpleasant.

So if content is not enough to keep your attention, when does curiosity have staying power? The answer may lie in the difficulty of the problem. If we get a little burst of pleasure from solving a problem, then there's no point in working on a problem that is too easy—there'll be no pleasure when it's solved because it didn't feel like much of a problem in the first place. Then too, when you size up a problem as very difficult, you are judging that you're unlikely to solve it, and therefore unlikely to get the satisfaction that would come with the solution. So there is no inconsistency in claiming that people avoid thought and in claiming that people are naturally curious—curiosity prompts people to explore new ideas and problems, but when they do, they quickly evaluate how much mental work it will take to solve the problem. If it's too much or too little, people stop working on the problem if they can.

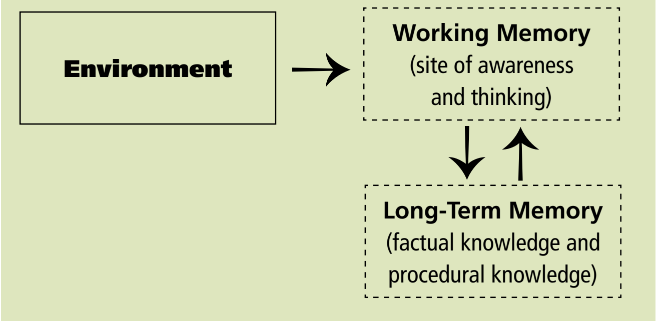
Our analysis of the sorts of mental work that people seek out or avoid provides one answer to why more students don't like school. Working on problems that are at the right level of difficulty is rewarding, but working on problems that are too easy or too difficult is unpleasant. Students can't opt out of these problems the way that adults often can. If the student routinely gets work that is a bit too difficult, it's little wonder that he doesn't care much for school.

So what's the solution? Give the student easier work? You could, but of course you'd have to be careful not to make it so easy that the student would be bored. And anyway, wouldn't it be better to boost the student's ability a little bit? Instead of making the work easier, is it possible to make thinking easier?

How Thinking Works

Understanding a bit about how thinking happens will help you understand what makes thinking hard. That, in turn, will help you understand how to make thinking easier for your students, and therefore help them enjoy school more.

Just about the simplest model of the mind possible.



Let's begin with a very simple model of the mind. The figure above shows the environment on the left, full of things to see and hear, problems to be solved, and so on. On the right is one component of your mind that scientists call *working memory*; it holds the stuff that you're thinking about and is the part of your mind where you are aware of what is around you: the sight of a shaft of light falling on a dusty table, the sound of a dog barking in the distance, and so forth. Of course, you can also be aware of things that are not currently in the environment; for example, you can recall the sound of your mother's voice, even if she's not in the room (or indeed, no longer living). *Long-term memory* is the vast storehouse in which you maintain your factual knowledge of the world: that ladybugs have spots, that triangles are closed figures with three sides, that your 3-year-old surprised you yesterday by mentioning kumquats, and so on. All of the information in long-term memory resides outside of awareness. It lies quietly until it is needed, and then enters working memory, and so becomes conscious.

Thinking occurs when you combine information (from the environment and from long-term memory) in new ways. That combination happens in working memory. To get a feel for this process, think back to what you did as you tried to solve the candle problem. You began by taking information from the environment—the scenario described in the problem—and then you imagined ways to solve it.

Knowing *how* to combine and rearrange ideas in working memory is essential to successful thinking. If you hadn't seen the candle problem before, you probably felt like you were pretty much guessing. You didn't have any information in long-term memory to guide you. But if you have had experience with a particular type of problem, then you likely have information in long-term memory about how to solve it, even if the information is not foolproof. For example, try to work this math problem in your head:

$$\begin{array}{r} \mathbf{18} \\ \underline{\mathbf{x\ 7}} \end{array}$$

You know just what to do for this problem. Your long-term memory not only contains factual information, such as the value of 8 x 7, it also contains what we'll call *procedural knowledge*, which is your knowledge of the mental procedures necessary to execute tasks. If "thinking" is combining information in working memory, then procedural knowledge is a list of what to combine and when—it's like a recipe to get a particular type of thought accomplished. You might have stored procedures for the steps needed to calculate the area of a triangle, or to duplicate a computer file using Windows, or to drive from your home to work.

Successful thinking relies on information from the environment, facts and procedures in long-term memory, and space in working memory.

It's pretty obvious that having the appropriate procedure stored in long-term memory helps a great deal when we're thinking. That's why it was easy to solve the math problem and hard to solve the candle problem. But how about factual knowledge? Does that help you think as well? It does, in several different ways, some which are described in the sidebar below. For now,

How Can Learning Facts Make Thinking More Enjoyable—and More Effective?

In the main article, I defined "thinking" as combining information in new ways. The information can come from long-term memory—facts you've memorized—or from the environment. In today's world, is there a reason to memorize anything? You can find any factual information you need in seconds via the Internet. Then too, things change so quickly that half of the information you commit to memory will be out of date in five years—or so the argument goes. Perhaps instead of learning facts, it's better to practice critical thinking. Have students work at *evaluating* all that information available on the Internet, rather than trying to commit some small part of it to memory.

Appealing though it may be, it turns out that this argument is false. Data from the last 30 years lead to a conclusion that is not scientifically challengeable: thinking well requires knowing facts, and that's true not simply because you need something to think *about*. The very processes that teachers care about most—critical thinking processes like reasoning and problem solving—are intimately intertwined with factual knowledge that is in long-term memory (not just in the environment).

It's hard for many people to conceive of thinking processes as intertwined with knowledge. Most people believe that thinking processes are akin to those of a calculator. A calculator has a set of procedures available (addition, multiplication, and so on) that can manipulate numbers, and those procedures can be applied to *any set of numbers*. There is a separation of data (the numbers) and the operations that manipulate the data. Thus, if you learn a new thinking operation (for example, how to critically analyze historical documents), it seems like that operation should be applicable to all historical documents.

The human mind does not work that way. When we learn to think critically about, say, the start of the Second World War, that does not mean that we can think critically about a chess game, or about the current situation in the Middle East, or even about the start of the American Revolutionary War. The critical thinking processes are tied to the background knowledge.*

Much of the time that we see people apparently engaged in logical thinking, they are actually engaged in memory retrieval. As I described in the main article, memory is the cognitive process of *first* resort. When faced with a problem, you will first search for a solution in memory, and if you find one, you will very likely use it.

In fact, people draw on memory to solve problems more often than you might expect. For example, it appears that much of the difference among the world's best chess players is not their ability to reason about the game or to plan the best move; rather, it is their memory for game positions. When tournament-level chess players select a move, they first size up the game, deciding which part of the board is the most critical, the location of weak spots in their own defense and their opponents', and so on. That process relies on the player's memory for similar board positions and it greatly narrows the possible moves that the player might

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*There is one important exception—how experts think. Building expertise actually changes the thought process, but such change takes many years of advanced study and therefore is not very relevant to the K–12 setting. To learn more about the differences between novices' and experts' thinking, see "Inflexible Knowledge: The First Step to Expertise," from the Winter 2002 issue of *American Educator*, online at **www.aft.org/pubs-reports/american_educator/winter2002/CogSci.html**.

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note that solving the math problem required the retrieval of factual information, such as the fact that 8 x 7 = 56 or the fact that 18 can be broken into 10 and 8. Oftentimes, the information provided in the environment is not sufficient to solve a problem—you need to supplement it with information from long-term memory.

There's a final necessity for thinking: sufficient space in working memory. Thinking becomes increasingly difficult as working memory gets crowded. A math problem requiring lots of steps, for example, would be hard to solve in your head because the steps would occupy so much space in working memory that it would be difficult to keep them all in mind.

In sum, successful thinking relies on four factors: information from the environment, facts in long-term memory, procedures in long-term memory, and space in working memory. If any one of them is inadequate, thinking will likely fail.

What Does This Mean for the Classroom?

Let's begin with the question that opened this article: what can teachers do to make school enjoyable for students? From a cognitive perspective, an important factor is whether a student consistently experiences the pleasurable rush of solving a problem. So, what can teachers do to ensure that each student gets that pleasure?

Be Sure That There Are Problems to Be Solved

By "problem," I don't necessarily mean a question posed to the class by the teacher, or a mathematical puzzle. I mean cognitive work that presents a moderate challenge, including things like understanding a poem or thinking of novel uses for recyclable materials. This sort of cognitive work is, of course, the main stuff of teaching—we want our students to think. But without some attention, a lesson plan can become a long string of teacher explanations, with little opportunity for students to solve problems. So scan each lesson plan with an eye toward the cognitive work that students will be doing. How often does such work occur? Is it intermixed with cognitive breaks? When you have identified the challenges, consider whether they are open to negative outcomes like the students failing to understand what they are to do, or

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make. Only then does the player engage reasoning processes to select the best among several candidate moves. Psychologists estimate that top chess players may have 50,000 board positions in long-term memory. Thus, background knowledge is decisive even in chess, which we might consider the prototypical game of reasoning.

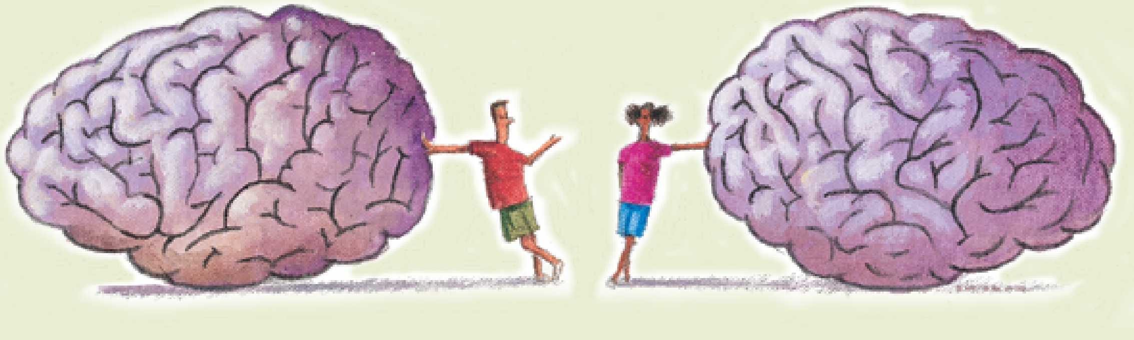
That's not to say that all problems are solved by comparing them to cases you've seen in the past. You do, of course, sometimes reason. Even in these situations, background knowledge can help. Here's an example. Do you have a friend who can walk into someone else's kitchen and rapidly produce a nice dinner from whatever food is around, usually to the astonishment of whoever's kitchen it is? When that person looks in a cupboard, she doesn't see ingredients, she sees recipes. She draws on extensive background knowledge about food and cooking.

Here's a classroom-based example. Take two algebra students—one is still a little shaky on the distributive property, whereas the other knows it cold. When the first student is trying to solve a problem and sees $a(b + c)$, he's unsure whether that's the same as $ab + c$ or $b + ac$ or $ab + ac$. So he stops working on the problem, and substitutes small numbers into $a(b + c)$ to be sure that he's got it right. The second student recognizes $a(b + c)$, and doesn't need to stop and occupy space in working memory with this subcomponent of the problem. Clearly, the second student is more likely to successfully complete the problem.

Here is one more key point about knowledge and thinking skills. Much of what experts tell us they do in the course of thinking about their fields *requires* background knowledge, even if it's not described that way. Let's take science as an example. We could tell students that when interpreting the results of an experiment, scientists are especially interested in anomalous (that is, unexpected) outcomes. Unexpected outcomes indicate that their knowledge is incomplete, and that this experiment contains hidden seeds of new knowledge. But in order for results to be unexpected, you must have an expectation! An expectation about the outcome would be based on your knowledge of the field. Most or all of what we tell students about scientific thinking strategies is impossible to use without appropriate background knowledge.

The same holds true for history, language arts, music, and so on. Generalizations that we can offer to students about how to successfully think and reason in the field may *look* like they don't require background knowledge, but when you consider how to apply them, they actually do.

–D.T.W.



Can We Make School More Enjoyable—and Effective—for "Slow" Students Too?

Americans, like other Westerners, tend to view intelligence as a fixed attribute, like eye color. If you win the genetic lottery, you're smart, but if you lose, you're not. In China, Japan, and other Eastern countries, intelligence is more often viewed as malleable. If you fail a test or don't understand a concept, it's not that you're stupid—you just haven't worked hard enough yet. So which view is correct, the Western or the Eastern? There is some truth in both. Your genetic inheritance does impact your intelligence, but it seems to do so mostly through the environment. Recent research indicates that children do differ in intelligence, but *intelligence can be changed through sustained hard work*.

Until about 20 years ago, most researchers seemed to have the sense that the range of intelligence was mostly set by genetics, and that a good or poor environment moved one's intelligence up or down a bit within that range. A real turning point in this work came during the 1980s with the discovery that IQ scores over the last half century have shown quite substantial gains. For example, in Holland, scores went up 21 points in just 30 years (1952–1982), based on scores from Dutch military draftees. This is not an isolated case. The effect has been observed in over a dozen countries throughout the world, including the United States.* Not all countries have data available to be tested—you need very large numbers of people to be sure that you're not looking at a quirky subset—but where the data are available, the effect has been found. These increases in IQ scores are much too large to have been caused by changes in genes. Some of the increase may have come from better nutrition and health care. Some of it may have come from the fact that our environment has gotten more complex, and people are more often called on to think abstractly, and to solve unfamiliar problems—the exact sorts of things you're often asked to do on IQ tests. Whatever the cause, it must be environmental.

But how does that fit with previous research, which indicated that intelligence is mostly determined by genetics? No one is completely sure. But researchers James Flynn and Bill Dickens have a pretty good suggestion. They claim that the effect of genetics is actually fairly modest. It *looks* large because the effect of genetics is to make a person likely to *seek out* particular environments. Dickens offers the following analogy. Suppose identical twins are separated at birth, and adopted into different families. Their genes make them unusually tall at a young age, and they continue to grow. Because each is tall, he tends to do well in informal basketball games around the neighborhood. For that reason, each asks his parents to put a net up at home. The skills of each twin improve with practice, and each is recruited for his junior high school basketball team. More practice leads to still better skill; by the end of high school, each twin plays quite well—not a future professional, perhaps, but better than 98 percent of the population, let's say.

Now notice what has happened. These were identical twins, raised apart. So if a researcher tracked down each twin and administered some test of basketball skill, she would find that both were quite good, and because they were raised apart, the researcher would conclude that this was a genetic effect, that skill in basketball is largely determined by one's genes. But the researcher would be mistaken. What's actually happened was that their genes made them tall, and being tall nudged them toward environments that included a lot of basketball practice. Practice—an environmental effect—made them good at basketball, not their genes.

Now think of how that might apply to intelligence. Maybe genetics has some small effect on your intelligence—it makes you a little quicker to understand things, or your memory a little bit better, or it makes you more persistent on cognitive tasks, or it simply makes you more curious. Your parents notice this, and encourage your interest. They may not even be aware that they are encouraging you. They might talk to you about more sophisticated subjects than they otherwise would and use a broader vocabulary. As you get older, you see yourself, more and more, as one of the "smart kids." You make friends with other smart kids, and enter in friendly, but quite real, competition for the highest grades. Then too, maybe genetics subtly pushes you away from other endeavors. You may be quicker cognitively, but a little clumsier physically. That makes you avoid situations that might develop your athletic skills (like pickup basketball games), and instead stay inside and read.

The key idea here is that genetics and the environment interact. Small differences in genetic inheritance can steer people to seek different experiences in their environments, and it is these environmental differences, especially over the long term, that have large cognitive consequences.

What does all this mean for education? If intelligence were all a matter of one's genetic inheritance, then there wouldn't be much point in trying to make kids smarter. Instead, you'd try to get students to do the best they could, given the genetically determined intelligence they had. But that's not the way things are. *Intelligence is malleable*. *It can be improved*.

So, what can you do for slow learners? Recognize that they probably differ little from your other students in terms of their potential.† But they probably differ a good bit from your other students in what they know, their motivation, their persistence in the face of academic setbacks, and in their self-image as students. I fully believe that these students can catch up, but it must be acknowledged that they are far behind, and that catching up will take enormous effort. To help slow learners catch up, you must first be sure that they believe that they can improve, and next you must try to persuade them that it will be worth it.

1. Praise Effort, Not Ability

Students should think of their intelligence as under their control, and should know that they can develop their intelligence through hard work. Therefore, you should

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*James R. Flynn, "Massive IQ Gains in 14 Nations: What IQ Tests Really Measure," *Psychological Bulletin* 101 (1987): 171–191.

†This is not to say that students don't have learning disabilities. Some do. This discussion does not apply to students with learning disabilities.

praise *processes*, rather than ability (e.g., by following "Good job" with "you must have worked hard" instead of "you're smart").[‡] In addition to praising effort (when appropriate), you might praise a student for persistence in the face of challenges or for taking responsibility for her work. Avoid insincere praise, however. Dishonest praise is actually destructive. If you tell a student, "Wow, you really worked hard on this project!" when the student knows good and well that she didn't, you lose credibility.

2. Tell Them That Hard Work Pays Off

Praising process rather than ability sends the unspoken message that intelligence is under the student's control. There is no reason not to make that message explicit as well. I once had a student who was on the football team and devoted a great deal of time to practice, with little time left over for academics. But he attributed his poor grades to the fact that he was "a dumb jock." I had a conversation with him that went something like this:

> *D.T.W.*: Is there a player on the team who has a lot of natural ability, but who just doesn't work very hard, goofs off during practices, and that sort of thing?
>
> *Student*: Of course. There's a guy like that on every team.
>
> *D.T.W.*: Do the other players respect him?
>
> *Student*: Of course not. They think he's an idiot because he's got talent that he's not developing.
>
> *D.T.W.*: But don't they respect him because he's the best player?
>
> *Student*: He's not the best. He's good, but lots of other guys are better.
>
> *D.T.W.*: Academics is just the same. Most people have to work really hard at it. There are a few who get by without working very hard, but not many. And nobody likes or respects them very much.

3. Treat Failure as a Natural Part of Learning

If you want to increase your intelligence, you have to challenge yourself. That means taking on tasks that are a bit beyond your reach, and that means you may very well fail, at least the first time around. Fear of failure can therefore be a significant obstacle to tackling this sort of challenging work. But failure should not be a big deal. Michael Jordan put it this way: "I've missed more than 9,000 shots in my career. I've lost almost 300 games. Twenty-six times, I've been trusted to take the game winning shot and missed. I've failed over and over and over again in my life. And that is why I succeed."

Try to create a classroom atmosphere in which failure, while not desirable, is neither embarrassing nor wholly negative. Failure means you're about to learn something. You're going to find out that there's something you didn't understand, or didn't know how to do. Most important, *model* this attitude for your students. When you fail—and who doesn't?—let them see you take a positive, learning attitude.

Small differences in genetic inheritance can steer people to seek different experiences in their environments. These environmental differences, especially long term, have large cognitive consequences.

4. Don't Take Study Skills for Granted

Make a list of all of the things that you ask students to do at home. Consider which of these things have other tasks embedded in them, and ask yourself whether the slower students really know how to do them. For older students, if you announce that there will be a quiz, you assume that students will study for it. Do your slower students really know how to study? Do they know how to assess the importance of different things that they've read and heard and seen? Do they know how long they ought to study for a quiz? (At the college level, my low-performing students frequently protest their low grades by telling me, "But I studied for three or four hours for this test!" I know that the better students study about 20 hours.) Do your slower students know some simple tricks to help plan and organize their time? Don't take for granted that your slower students have these skills, even if they *should have* acquired them in previous grades.

5. Catching Up Is the *Long-Term* Goal

It is important to be realistic about what it will take for students to catch up. The more you know, the easier it is to learn new things. Thus, if your slower students know less than your brighter students, they can't simply work at the same pace as the bright students; doing only that, they will continue to fall behind! To catch up, slower students must work *harder* than the brighter students.

6. Show Students That You Have Confidence in Them

Ask 10 people you know, "Who was the most important teacher in your life?" I've asked dozens of people this question and have noticed two interesting things. First, most people have a ready answer. Second, the reason that one teacher made a strong impression is almost always emotional. The reasons are never things like, "She taught me a lot of math." People say things like, "She made me believe in myself" or "She taught me to love knowledge." In addition, people tell me that their important teacher set high standards and believed that they could meet those standards.

In considering how to communicate that confidence to your students, we return to the subject of praise. Be wary of praising second-rate work from your slower students. Suppose you have a student who usually fails to complete his work. He manages to submit a project on time, but it's not very good. It's tempting to praise the student—after all, the fact that he submitted something is an improvement over his past performance. But consider the message that such praise sends. You say, "Good job," but that really means, "Good job *for someone like you*." The student is probably not so naïve as to think that his project is really all that great. By praising substandard work, you send the message that you have lower expectations for this student. Better to say, "I appreciate that you finished the project on time, and I thought your opening paragraph was interesting. But I think you could have done a better job organizing it. Let's talk about how." That way, you send the message that you know the student can improve.

–D.T.W.

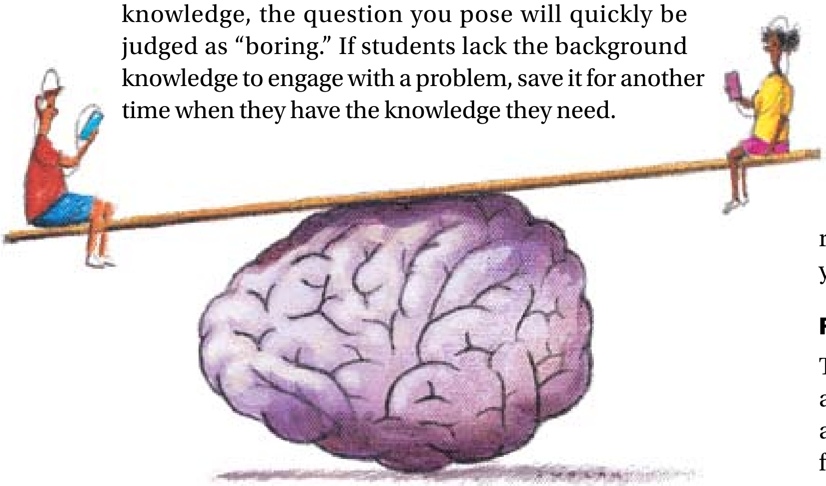
[‡] Claudia M. Mueller and Carol S. Dweck, "Praise for Intelligence Can Undermine Children's Motivation and Performance," *Journal of Personality and Social Psychology* 75 (1998): 33–52

(Continued from page 9)

students being unlikely to solve the problem, or students simply trying to guess what you would like them to say or do.

Respect Students' Limited Knowledge and Space in Working Memory

When trying to develop effective mental challenges for your students, bear in mind the cognitive limitations discussed here. For example, suppose you began a history lesson with a question: "You've all heard of the Boston Tea Party; why do you suppose the colonists dressed as Indians and dumped tea in the Boston harbor?" Do your students have the necessary background knowledge in memory to consider this question? What do they know about the relationship of the colonies and the British crown in 1773? Do they know about the social and economic significance of tea? Could they generate reasonable alternative courses of action? If they lack the appropriate background knowledge, the question you pose will quickly be judged as "boring." If students lack the background knowledge to engage with a problem, save it for another time when they have the knowledge they need.



Equally important is the limit on working memory. Remember that people can only keep so much information in mind at once. Overloads to working memory are caused by things like multistep instructions, lists of unconnected facts, chains of logic more than two or three steps long, and the application of a just-learned concept to new material (unless the concept is quite simple). The solution to working memory overloads is straightforward: slow the pace and use memory aids, such as writing on the blackboard, that save students from keeping as much information in working memory.

Identify Key Questions and Ensure That Problems Are Solvable

How can you make the problem interesting? A common strategy is to try to make the material "relevant" to students. This strategy sometimes works well, but it's hard to use for some material. I remember my daughter's math teacher telling me that he liked to use "real world" problems to capture his students' interest, and gave an example from geometry that entailed a ladder propped against a house. I didn't think that would do much for my 14-year-old. Another difficulty is that a teacher's class may include two football fans, a doll collector, a NASCAR enthusiast, a horseback riding competitor—you get the idea. Our curiosity is provoked when we perceive a problem that we believe we can solve. What is the question that will engage students and make them want to know the answer?

One way to view schoolwork is as a series of *answers*. We want students to know Boyle's law, or three causes of the U.S. Civil War, or why Poe's raven kept saying "Nevermore." Sometimes I think that we, as teachers, are so eager to get to the answers that we do not devote sufficient time to developing the question. But it's the *question* that piques people's interest. Being told an answer doesn't do anything for you. When you plan a lesson, you start with the information you want students to know by its end. As a next step, consider what the key question for that lesson might be, and how you can frame that question so that it will be of the right level of difficulty to engage your students, and will respect your students' cognitive limitations.

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Reconsider When to Puzzle Students

Teachers often seek to draw students in to a lesson by presenting a problem that they believe interests students, or by conducting a demonstration or presenting a fact that they think students will find surprising. In either case, the goal is to puzzle students, to make them curious. This is a useful technique, but it's worth considering whether these strategies might also be used not at the beginning of a lesson, but *after* the basic concepts have been learned. For example, a classic science demonstration is to put a burning piece of paper in a milk bottle and then put a boiled egg over the bottle opening. After the paper burns, the egg is sucked into the bottle. Students will no doubt be astonished, but if they don't know the principle behind it, the demonstration is like a magic trick—it's a momentary thrill, but one's curiosity to understand may not be long lasting. Another strategy would be to conduct the demonstration after students know that warm air expands and that cooling air contracts, potentially forming a vacuum. That way they can use their new knowledge to think about the demonstration, which is no longer just a magic trick.

Act on Variations in Student Preparation

As I describe in the sidebar on page 10, I don't accept that some students are "just not very bright." But it's naïve to pretend that all students come to your class equally prepared to excel; they have had different preparation, as well as different levels of support at home, and they will, therefore, differ in their current abilities. If that's true, and if what I've said in this article is true, it is self-defeating to give all of your students the same work or to offer all of them the same level of support. To the extent that you

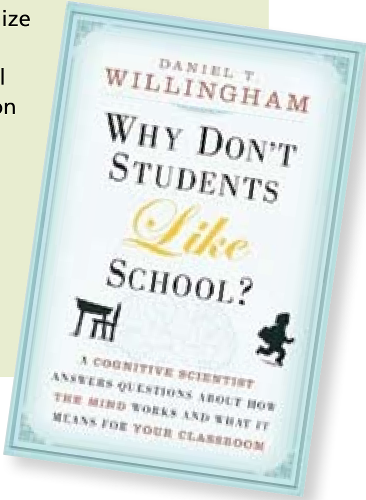
Why Don't Students Like School? began as a list of nine principles that are so fundamental to the mind's operation that they are as true in the classroom as they are in the laboratory, and therefore can reliably be applied to classroom situations. Many of these principles likely won't surprise you: factual knowledge is important, practice is necessary, and so on. What may surprise you are the implications for teaching that follow. You'll discover that authors routinely write only a fraction of what they mean, which I'll argue implies very little for reading instruction, but a great deal for the factual knowledge that your students must gain. You'll explore why you remember the plot of *Star Wars* without even trying, and you'll learn how to harness that ease of learning for your classroom. You'll follow the brilliant mind of the television doctor Gregory House as he solves a case, and you'll discover why you should *not* try to get your students to think like real scientists.

Cognitive scientists do know more about the mind than these nine principles. These nine were selected because they meet the following four criteria.

1. Each principle is true *all* the time, whether the person is in the laboratory or the classroom, alone or in a group.
2. Each principle is supported by an enormous amount of data, not just a few studies.
3. Using the principle can have a big impact on student learning.
4. Each principle suggests classroom applications that teachers might not already know.

Education is similar to other fields of study in that scientific findings are useful, but not decisive. Cognitive principles do not prescribe how to teach, but they can help you predict how much your students are likely to learn. If you follow them, you maximize the chances that your students will flourish. Education makes better minds, and knowledge of the mind can make better education.

–D.T.W.



can, I think it's smart to assign work to individuals or groups of students that is appropriate to their current level of competence, and/or to offer more (or less) support to students depending on how challenging you think they will find the assignment. Naturally, one wants to do this in a sensitive way, minimizing the extent to which these students will perceive themselves as behind the others. But the fact is that they *are* behind the others; giving them work that is beyond them is unlikely to help them catch up, and is likely to make them fall still further behind.

Change the Pace

Change grabs attention, as you no doubt know. When you change topics, start a new activity, or in some other way show that you are shifting gears, virtually every student's attention comes back to you. So plan these shifts and monitor your class's attention to see whether you need to make them more often or less frequently.

Keep a Diary

The core idea presented in this article is that solving a problem gives people pleasure, but the problem must be easy enough to be solved yet difficult enough that it takes some mental effort. Finding this sweet spot of difficulty is not easy. Your experience in the classroom is your best guide. But don't expect that you will remember how well a lesson plan worked a year later. When a lesson goes brilliantly well or down in flames, it feels at the time that we'll never forget what happened; but the ravages of memory can surprise us, so write it down. Even if it's just a quick scratch on a sticky note, try to make a habit of recording your success in gauging the level of difficulty in the problems you pose for your students. ❐

For Further Reading

Less Technical

Mihaly Csikszentmihalyi, *Flow: The Psychology of Optimal Experience* (New York: Harper Perennial, 1990). The author describes the ultimate state of interest, when one is completely absorbed in what one is doing to the point that time itself stops. The book does not tell you how to enter this state yourself, but is an interesting read in its own right.

Steven Pinker, *How the Mind Works* (New York: W. W. Norton, 1997). This book covers not only thinking, but emotion, visual imagery and other related topics. Pinker is a wonderful writer, and draws in references from many academic fields, and from pop culture. Not for the faint-hearted, but great fun if the topic appeals to you.

More Technical

Alan Baddeley, *Working Memory, Thought, and Action* (London: Oxford University Press, 2007). Written by the originator of the working memory theory, this book summarizes an enormous amount of research that is consistent with that theory.

Wolfram Schultz, "Behavioral Dopamine Signals," *Trends in Neurosciences* 30 (2007): 203–210. A review of the role of dopamine, a neurochemical, in learning, problem solving, and reward.

Paul J. Silvia, "Interest—The Curious Emotion," *Current Directions in Psychological Science* 17 (2008): 57–60. The author provides a brief overview of theories of interest, highlighting his own, which is similar to the account provided here: we evaluate situations as interesting if they are novel, complex, and comprehensible.

Daniel T. Willingham, *Cognition: The Thinking Animal,* 3rd ed. (New York: Prentice Hall, 2007). This is a college-level textbook on cognitive psychology, and can serve as an introduction to the field. It assumes no background, but it is a textbook, and so although it is thorough, it might be a bit more detailed than you would want.