Students Remember ... What They Think About

By Daniel T. Willingham

Issue: The teacher presents a strong, coherent lesson in which a set of significant facts is clearly connected to a reasonable conclusion. But, at test time, the students show no understanding of the connections. Some students parrot back the conclusion, but no facts. Others spit back memorized facts, but don't see how they fit together. Though the lesson wasn't taught in a rote way, it seems like rote knowledge is what the students took in. Why do well-integrated, coherent lessons often come back to us in a less meaningful, fragmented form? Can cognitive science help explain why this result is so common—and offer ideas about how to avoid it?

Response: Rote knowledge is devoid of all meaning (as discussed in my last column, Winter 2002). The knowledge that these students appear to be regurgitating is probably not rote knowledge. It is probably "shallow" knowledge: The students' knowledge has meaning (unlike rote knowledge), in that the students understand each isolated part, but their knowledge lacks the deeper meaning that comes from understanding the relationship among the parts. For reasons noted below, this is a common problem in the early stages of learning about a new topic. But it also has another remediable source, which is the focus of this column.

Cognitive science has shown that what ends up in a learner's memory is not simply the material presented—it is the product of what the learner thought about when he or she encountered the material. This principle illuminates one important origin of shallow knowledge and also suggests how to help students develop deep and interconnected knowledge.

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Let's start with an example of shallow knowledge. Suppose that you are teaching a high school class unit on World War II and develop a lesson on the Japanese attack on Pearl Harbor. Many facts might be included in such a lesson: (a) Japan had aspirations to be a regional power; (b) Japan was engaged in a protracted war with China; (c) because they were at war, European countries could not protect their colonies in the South Pacific; and (d) the attack on Pearl Harbor resulted in a declaration of war on Japan by the United States. The overarching point of this lesson might be to show that the attack on Pearl Harbor was a strategic mistake for the Japanese, given their war aims. (See Figure 1 for a diagram of the lesson.)

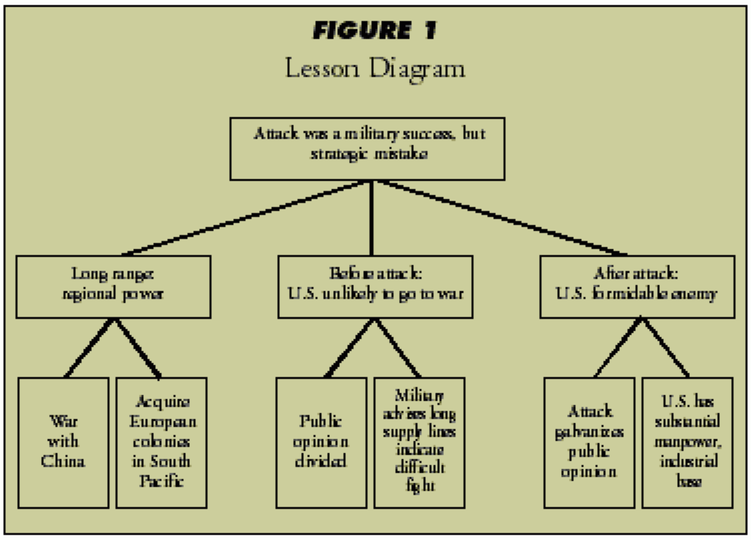


FIGURE 1
Lesson Diagram

We can see two ways that this meaningful lesson might end up as shallow knowledge in the student's mind. The student might commit to memory some or all of these four facts. But knowing these facts without understanding how they relate to one another and can be integrated to support the conclusion leaves the facts isolated; they are not without meaning, but neither are they as rich as they might be. The student has the trees, but no view of the forest.

Alternatively, the student might commit to memory the conclusion, "The attack on Pearl Harbor, although militarily a successful battle for Japan, was ultimately detrimental to its long-range war plans." But memorizing this conclusion without understanding the reasoning behind it and knowing the supporting facts is empty. It isn't rote—the student knows Japan initiated and won a battle at the place called Pearl Harbor. But the knowledge certainly is "shallow"—it has no connections.*

We have all had students memorize phrases from class or a textbook more or less word-for-word, and although what the student says is accurate, we can't help but wonder whether he or she really understands the ideas those words represent. Let's dig deeper.

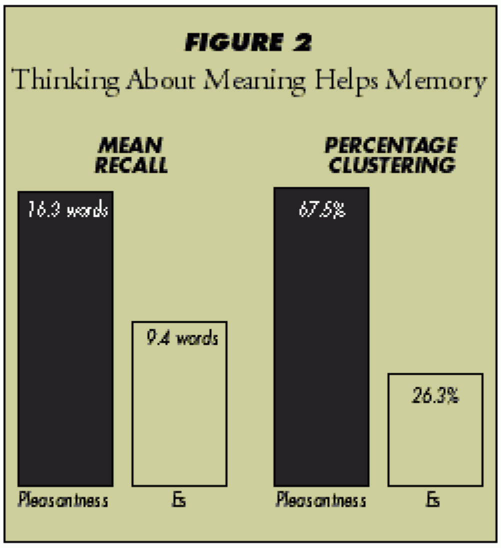
Memory Is as Thinking Does

When students parrot back a teacher's or the textbook's words, they are, of course, drawing on memory. Thus, the question of why students end up with shallow knowledge is really a question about the workings of memory. Needless to say, determining what ends up in memory and in what form is a complex question, but *there is one factor that trumps most others in determining what is remembered: what you think about when you encounter the material*. The fact that the material you are dealing with has meaning does not guarantee that the meaning will be remembered. If you think about that meaning, the meaning *will* reside in memory. If you don't, it won't. For example, if I teach about Pearl Harbor, some sailing enthusiasts may starting thinking about the ships of the era and pay minimal attention to the rest of the class—just a few minutes after the bell rings they won't remember much about the causes and consequences of Pearl Harbor. Memory is as thinking does.

A classic experiment illustrating this principle was conducted by Thomas Hyde and James Jenkins in 1969. It examined how one thinks about material and the effect of that thinking on memory. Subjects in their experiment listened to a list of words at a rate of one word every two seconds. Different groups of subjects were to perform different tasks upon hearing each word. Some were to rate each word as to whether it made them think of pleasant or unpleasant things, whereas others were asked to count the number of times the letter E appeared in the word. Rating the pleasantness forces the subject to think about the word's meaning; the word *garbage* is unpleasant because of what it means—what it is associated with in one's memory. Counting *E*s, on the other hand, forces one to think about the spelling of the word, but not its meaning. Thus, the experimenters manipulated what subjects thought about when they encountered each word. Subjects were not told that their memory for the words would later be tested; they thought they were merely to make the pleasantness or the *E*-counting judgment.

One other detail of the experiment is especially important. The word list actually consisted of 12 pairs of very highly associated words, such as *doctor-nurse*, although this fact was not pointed out to any of the subjects. The order in which the words were read was random (except that related words were not allowed to be next to one another in the list).

The results are shown in Figure 2. First look at the left side of the chart, which shows the mean number of words recalled. Memory was much better when subjects made the pleasantness ratings. Thinking about the meaning of material is especially helpful to memory. This finding is consistent across hundreds of other experiments.



The right side of the figure shows a measure of clustering—the extent to which subjects paired the associated words as they tried to remember them. When a subject recalled a word (e.g., *doctor*), what percentage of the time was the next word recalled the highly associated one (*nurse*)? As the figure shows, subjects who thought about the word's meaning (i.e., rated pleasantness) not only remembered more words, they tended to remember the related words together, even though the related words did not appear together in the list. The subjects who counted *E*s did not tend to remember related words together.

These results forcefully make the point that meaningful structure that is in the environment may or may not end up being stored in memory. In the Hyde and Jenkins experiment, the fact that some of the words were related in meaning was largely lost on the subjects who counted *E*s because thinking about *E*s did not encourage the subjects to process meaning. Subjects who made the pleasantness ratings tended to group the words together by meaning as they recalled them. Whatever subjects thought about when they heard the words (which, teachers will note, depends on what they were *asked* to think about) was what ended up in memory.

In the Hyde and Jenkins experiment, the "what they think about" principle is divided into thinking about meaning versus not thinking about meaning. Other experiments show that even if one thinks about meaning, the particular *aspect* of the meaning that one considers will be stored in memory, and other aspects of meaning will not. For example, in one experiment (Barclay et al., 1974), subjects were presented with words to remember in the context of a sentence. The sentence biased subjects to think of one or another feature of the to-be-remembered word: For example, some subjects read "The man lifted the *piano*," which encouraged thinking about the fact that pianos are heavy. Other subjects read "The man tuned the *piano*," which encouraged considering that pianos produce music. In the next phase of the experiment subjects were told that their memory for some of the nouns in the sentences would be tested and that for each sentence they would get a hint.
For *piano*, some subjects were given the hint, "something heavy." If they had read the sentence about lifting the piano, this hint matched the feature they had thought about, but if they read the sentence about tuning the piano, the hint didn't match. (Other subjects saw a hint that matched the piano tuning sentence; that hint was "something with a nice sound.")

The results showed that subjects remembered about three times as many words when the hint for the test matched what subjects had thought about when they first read the word. Again, the point is that what is stored in memory is quite specific to what you think about when you encounter the material. It is not the case that if you think about *piano*, then *piano* and all of its features are stored in memory. You might think about its music-producing qualities, its weight, its cost, and so on. Or you might not focus on the referent at all, but rather on the physical properties of the word itself, as when Hyde and Jenkins asked subjects to count *E*s. In each case, what you think about is what you remember.

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So what does this have to do with shallow knowledge? It shows where shallow knowledge might come from. Meaning that is in the environment won't end up in memory if students don't think about it. Students with shallow knowledge have apparently thought about the material in a shallow way. This conclusion reframes the question we might ask: Why would students think about the material in a shallow way, given that we didn't present it to them that way? Obviously, a student would learn only isolated facts or unsupported conclusions if that is what the teacher taught, but I find it difficult to believe that this is a common practice. The notion that education should emphasize meaning is deeply ingrained in our system and has been for a generation or more. There cannot be many teachers who ask their students to learn facts without concern for a larger picture. So how do students end up with shallow knowledge? There are several possible answers.

1. As noted at the beginning of this article, in one form, shallow knowledge is simply a step on the way to deep knowledge. Consider again the hierarchical diagram shown in Figure 1. I argued that shallow knowledge could either be memorization of the conclusion (top of the hierarchy) without knowing the facts that back it up (bottom of the hierarchy), or memorization of the facts without integrating them into a conclusion. Clearly the sort of deep knowledge we want our students to have is objectively harder to obtain than shallow knowledge, because knowledge of the facts *and* knowledge of the conclusion *and* knowledge of their interrelationships are prerequisite to it. We want students to know how the different levels of hierarchy relate to one another; it's not enough to have memorized each level in isolation of the others. That connected knowledge will inevitably be the last thing that the student acquires. Thus, some students' knowledge will be shallow simply because they are not far enough along yet.

2. Other students may effectively quit learning before they reach the deep understanding that is our goal for them. A student may learn the facts about Pearl Harbor and think "All right, I've learned a lot about this stuff." The student is correct (so far as it goes) and simply doesn't realize that there is yet more to do.

3. Students' perception of what they are supposed to learn—and what it means to learn—may contribute to shallow knowledge. A student may seek to memorize definitions and pat phrases word-for-word from the book because the student *knows* that this information is correct and cannot be contested. When I was in eighth grade, we were given a list of vocabulary terms that we were to define and then study in preparation for a weekly test. A friend defined "cherub" as "an angel of the second order." My friends and I teased him because his definition missed what we thought was the key aspect of the word—that a cherub is small, chubby, and

rosy-cheeked. He was unmoved and kept repeating "that's what the dictionary said." He liked the fact that his answer was uncontestable. Students may memorize exactly what the teacher or textbook says in order to be certain that they are *correct*, and worry less about the extent to which they understand.

4. Despite what was offered to students in the teacher's lesson, the students attended to (thought about) something different—and that's what they remembered.

What Does This Mean for Teachers?

This fundamental principle of memory—memory is as thinking does—yields a clear strategy to encourage deep, meaningful knowledge. If students think about the meaning of material, meaning will end up in memory. How can teachers be sure that students are thinking about meaning?

Obviously there is no one way to ensure that students think about the meaning of material. A compelling story may be appropriate for one lesson, whereas a carefully designed laboratory project works for a second, and a well-structured group discussion for a third. One possible common misconception is that learners can only understand meaning if they themselves construct the meaning in a physically active way. A moment's reflection should tell us that "listening" does not imply passivity or shallowness. We have all been to "active, participatory" workshops that felt like a waste of time, and we have been to lectures where we "just listened" that were gripping and informative. Constructing meaning is a matter of being *mentally* engaged; being physically engaged might help at times, but it is not necessary.

How can we ensure that students are mentally engaged? While there is still more to learn about applying this research on thinking and memory to teaching, several key principles have emerged to guide teachers in developing assignments, classroom activities, and assessments.

• **Anticipate what your lesson will lead students to think about.** The direct relationship between thought and memory is so important that it could be used as a self-check for a teacher preparing virtually any assignment: *Always try to anticipate what students will be thinking when they are doing the assignment*. Doing so may make it clear that some assignments designed with one purpose in mind will achieve another. For example, a teacher once told me that, as part of a unit on the Underground Railroad, he had his students bake biscuits so that they would appreciate what escaped slaves ate most nights. He asked what I thought of the assignment and my reply was that his students will remember baking biscuits. In other words, his students probably thought for 30 seconds about the relation of the baking to the course material, and then spent 30 minutes thinking about measuring flour, mixing dough, and so on.

Another example comes from my recent observation of my nephew as he completed a book report. The teacher asked the students to draw a poster that depicted all of the events of the book. The purpose of the assignment was to have students think of the book as a whole, and to consider how the separate events related to one another. This purpose got lost in the execution. My nephew spent a lot more time thinking about how to draw a good castle than he did about the plot of the book.

• **Use discovery learning carefully.** The principle above—anticipate the students' thoughts—also illuminates the use and misuse of discovery learning. There is little doubt that students remember material they generate themselves better than material that is handed to them. This "generation effect," as it is called (Slamecka & Graf, 1978), is indeed powerful, and it is due, in part, to forcing the learner to think about the meaning of material (although other techniques can do that as well). Part of the effect does seem to be unique to the actual generation of the answer, over and above thinking about meaning. One might suppose, therefore, that discovery learning should be employed whenever possible. However, given that memory follows thought, one thing is clear: *Students will remember incorrect "discoveries" just as well as correct ones.*

Considerable care must be taken to ensure that the path of students' thoughts will be a profitable one. For example, advocates of discovery learning often point out that children learn to use some computer software rapidly and effectively merely by "playing around with it." That may be true, but that learning environment is also quite structured in that profitless actions are immediately discouraged by the system not working. In effect, the system is so structured that profitless discoveries are impossible; but few classroom activities can achieve this kind of structure. How much anatomy will students learn by "playing around" with frog dissection? Can one anticipate the thoughts of students who dissect frogs with little direction? Although discovery learning may be powerful in highly structured contexts that make the correct discovery virtually inevitable, in others it is likely to prove unproductive.

• **Design reading assignments that require students to actively process the text.** Many concrete strategies have been suggested for helping students to get more out of reading that likely have some or all of their effect by making readers think about the meaning of what they are reading. *Techniques such as writing outlines, self-examination during learning, review questions, and previews can encourage or require students to integrate the material and to thereby process (i.e., think about) the meaning.* These different techniques are more or less effective in different situations, perhaps due to the specific materials being studied (e.g., McDaniel & Einstein, 1989); general principles guiding when each technique should be used have not been forthcoming. Nevertheless, although one technique or another may be more effective for a given lesson or group of students, using any strategy that encourages the processing of meaning is almost always better than not using one.

• **Design lessons so that students can't avoid thinking about the lesson's goal.** On a more positive note, the "memory is as thinking does" principle can yield steps teachers can take to help students develop deep, interconnected knowledge: *Lessons should be directed so that students are very likely to think (or can't help but think) about the goal of the lesson.* The goal of the Underground Railroad lesson was not really about biscuits—it was to encourage students to consider the experience of escaped slaves. Therefore, a more effective starting point for that lesson would be to ask students leading questions that encourage consideration of what escaped slaves' experiences would be like, which might include questions of how they would obtain food, and what the constraints were on the food they could get (inexpensive, cooked rapidly, etc.). My nephew would have gotten more out of his book report project if it had emphasized what the teacher was really interested in (the connection among the book's events), perhaps by having the students label the events and connections among them (e.g., this event moves the character towards his goal; this event causes that event) and de-emphasizing the students' artistic contribution by having them use clip art or simply writing the events in words.

• **Design tests that lead students to think about and integrate the most important material.** The "memory is as thinking does" principle may also be applied to methods of assessing student knowledge: *Like lessons, study guides for texts should be developed that force students to think about the goals of the lessons being assessed*. For better or worse, some students expend their greatest effort to understand material as they prepare for an examination. Even if you would rather see such students motivated by a passion to learn, you can use the students' motivation to earn a good grade to ensure that they are getting the most out of your lessons. Announcing the general topics to be covered on an exam leaves the specifics of what to learn up to the student. Even if the teacher emphasizes that deep understanding will be tested, the student may misconstrue what is deep or, as noted earlier, the student may quit once some facts have been memorized, believing that he or she has already done quite a bit of studying. Suppose, however, that the teacher provides a list of integrative questions for the students to study from, such as "Describe why the attack on Pearl Harbor was a strategic mistake by Japan, given its war aims." Suppose further that the students know that the examination will consist of five questions from the 30-question list that they have been given, with an essay to be written on each of the five questions. Students will very likely restrict their studying to the 30 question list, but that might be just fine with the teacher if he or she feels that any student who can answer those 30 questions has mastered the material. This method of testing has the advantage of ensuring that while students are highly motivated, they think about the deepest meaning of the material that the teacher intended.

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In summary, in the early stages of learning, students may display "shallow" learning. These students have acquired bits of knowledge that aren't well-integrated into a larger picture. Research tells us that deep, connected knowledge can be encouraged by getting students to think about the interrelation of the various pieces of knowledge that they have acquired. Cognitive science has not progressed to the point that it can issue prescriptions of exactly how that can be achieved—that job is very much in the hands of experienced teachers. But in considering how to encourage students to acquire meaningful knowledge, teachers will do well to keep the "memory is as thinking does" principle in mind.

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*My last column (Winter 2002, available at www.aft.org/newspubs/periodicals/ae/winter2002/willingham.cfm) discussed another common problem for students: inflexible knowledge. Like shallow knowledge, inflexible knowledge is meaningful—the catch is that it doesn't translate well to other relevant situations. To extend our World War II example, a student with inflexible knowledge may learn the conclusion and an adequate number of supporting facts, developing a real understanding of Japan's mistake. But, when the history class moved on to study another war, the student may not recognize an analogous strategic mistake. Developing flexible knowledge, such as being able to track strategic mistakes as a theme throughout military history (or to generalize, for example, to corporate history) requires much further study. (back to article)

References

Barclay, J. R., Bransford, J. D., Franks, J. J., McCarrel, N. S., & Nitsch, K. (1974). Comprehension and semantic flexibility. *Journal of Verbal Learning & Verbal Behavior*, 13, 471–481.

Hyde, T. S. & Jenkins, J. J. (1969). Differential effects of incidental tasks on the organization of recall of a list of highly associated words. *Journal of Experimental Psychology*, 82, 472–481.

McDaniel, M. A. & Einstein, G. O. (1989). Material-appropriate processing: A contextualist approach to reading and studying strategies. *Educational Psychology Review*, 1, 113–145.

Slamecka, N. J, & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning & Memor*y, 4, 592–604.