Random Thoughts . . .

WHY STUDENTS FAIL TESTS
1. INEFFECTIVE STUDYING

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There's some unhappiness in the faculty lounge today. Let's eavesdrop.

> *"I just gave my first midterm exam and thought I was giving the students an early Christmas present—I expected an average in the 80s, and they came in with a 56. I don't understand how most of them ever got this far."*
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> *"I know, right? I ask questions straight from my lectures or the text, and the students act like they've never seen anything like it in their lives."*
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> *"Yeah—I put a problem on my last midterm almost exactly like one in the homework with just a few minor changes, and half of them couldn't even start the solution, let alone finish."*

And so on. To listen to the professors, many of their students don't belong in engineering school and couldn't survive for a day as professionals. Mysteriously, though, most of them will go on to graduate, get jobs, and do just fine. So what's going on with those test grades?

In the last two decades cognitive science has provided some clues about what might be going on. The problems fall into two broad categories: some involve ineffective studying and others relate to ineffective teaching. This column concerns problems of the first type, and a later column will examine the second category. What follows draws heavily on two excellent books: *Make It Stick: The Science of Successful Learning*,[1] and *A Mind for Numbers: How to Excel at Math and Science*.[2]

- **Ways in which students commonly study for exams don't work.**

Many students rely heavily on one or more of four strategies to study for exams: (1) rereading the text and class handouts and notes, maybe underlining or highlighting parts they consider important; (2) rereading homework and old test problem solutions; (3) studying mainly the night before the exam, and (4) not studying at all. There's no need to discuss (4)—students either know it doesn't work or they find out on their first exam, and if they stay on that path, they deserve the consequences. Less obviously, it turns out that (1)–(3) are almost as ineffective as (4). Rereading old material and cramming for tests are easy strategies to use—which is one reason they're so popular—and they may help students on memory tests given soon after the cramming, but they don't lead to long-term remembering and even less to understanding. If a test requires more than short-term memorization, the students who use those strategies probably won't care too much for their grades.

- **Rereading leads to illusions of knowing.**

Another drawback of studying by rereading is that it is seriously misleading. When students look at a problem solution over and over again, they can easily convince themselves that they understand the solution method well enough to apply it to related problems. That's an illusion—one of several common student self-deceptions called *illusions of knowing* or *illusions of competence*. The students may be able to replicate that exact solution on a test soon after they memorized it, but

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if the test problem is even slightly different they may not be able to solve it at all. Even if the identical problem shows up on a test a more than a day or two after the cramming session, many students will have forgotten the solution.

So if rereading and cramming are ineffective test preparation strategies, what are better ones? We'll describe several, but we'll begin with a short oversimplified description of the learning process from a cognitive science viewpoint.

- **For course material to be truly "learned," it must be stored in long-term memory in such a way that it can subsequently be retrieved and transferred to new contexts.**

Most information that comes in through your senses is filtered out before you are conscious of it. If it gets through that initial sensory filter, it goes into your working memory, where a control center in your brain evaluates it. If it meets certain criteria (which we'll describe in the next column), it is integrated into your long-term memory as a *memory trace*—an interconnected network of nerve cells. If it isn't integrated, it is lost to you—you won't be able to recall it later because in effect you never knew it. The story doesn't end there, however. Even if information makes it into long-term memory, its trace may initially be weak and hard to access, but each subsequent retrieval strengthens the network and makes the information more accessible when it is later needed. This phenomenon provides the basis for a much better approach to studying than rereading and cramming.

- **Varied retrieval practice is the way to study.**

A powerful strategy for strengthening learning is *retrieval practice*—recalling information without looking back at it. *Spaced retrieval practice* (letting enough time elapse between successive retrievals for some forgetting to occur) is far more effective than *massed practice* (rapid repetition of the same material). Learners can increase the effectiveness of retrieval practice even more by using *interleaving*, periodically jumping from one topic or type of problem or solution method to another rather than focusing at length on one topic or type or method at a time, and *elaborating*, restating retrieved material in their own words and connecting it to prior knowledge.

- **Varied retrieval practice imposes desirable difficulties on learners.**

Extensive research has made it clear that varied retrieval practice leads to much better learning and test performance than rereading and cramming can produce, but what it doesn't do is make the learner's life easier. On the contrary, trying to remember information without looking back at the source and to solve problems without looking back at solutions is hard, and students who use those strategies often believe they are learning less and getting lower grades because of them. Even if the students are given evidence that those methods lead to better learning and higher grades, they are likely to cling to their mistaken sense that retrieval practice is slowing them down and hurting their academic performance.

As the Rolling Stones sagely observed in a different context, you can't always get what you want, but sometimes you get what you need. Varied retrieval practice imposes *desirable difficulties*, strengthening memory traces of material in long-term storage and bolstering cues for its subsequent retrieval. That doesn't mean all difficulties are desirable: if instructors impose tasks that students lack the background knowledge and skills to complete with a reasonable effort or that don't strengthen skills targeted in the instructor's learning objectives, nothing useful is likely to result. If retrieval practice tasks are reasonable and address targeted skills, however, the resulting learning gains more than compensate for the added struggles the tasks impose on the students.

- **How to help your students improve their performance on tests.**

Give your students retrieval practice by imbedding low-stakes quizzes and self-tests in your class sessions and online lessons. Make your assignments and exams cumulative, covering not just material introduced since the last test but bringing back material from earlier in the course. Tell your students that when they read a text or article, they shouldn't just read through it like a novel but should periodically stop and quiz themselves, restating text content in their own words, and instead of just rereading problem solutions they should try to solve the problems without looking back at the solutions. When they get stuck on something, they may look back at the text or problem solution, unstick themselves, and then go back to answering self-tests and solving problems on their own. When they can work through the text or problem without looking, they're ready to move on to something else. Then they should do it again after some time passes. When you make these suggestions to the students, acknowledge that adopting them may not be easy, and be ready to cite evidence supporting them from References 1 and 2. By taking these steps, you will not only help your students succeed in your course, you'll help them become self-directed learners in their subsequent courses and professional careers.

REFERENCES

1. Brown, P.C., H.L. Roediger III, and M.A. McDaniel, *Make It Stick: The Science of Successful Learning*, Cambridge, MA: Belknap Press (2014)
2. Oakley, B.A. , *A Mind for Numbers: How to Excel at Math and Science (Even If You Flunked Algebra),* New York: Tarcher/Penguin (2014) ❒

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