

Study smart

Make the most of your study time with these drawn-from-the-research tips.

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You probably think you know how to study.

After all, you've made it to graduate school. You've successfully turned in homework assignments and passed exams for at least 16 years. And there's a good chance that you have your study routine set, whether it's a cup of tea and your textbooks in bed, or a quiet library carrel you've claimed as your own.

But it may be that the study habits you've honed for a decade or two aren't serving you as well as you think they are.

Research has shown that some "common sense" study techniques — such as always reading in the same quiet location, or spending hours at a time concentrating on one subject — don't promote long-term learning. And some habits that you might suspect aren't so great, like last-minute cramming for exams, may be even worse than you thought.

We've rounded up three principles, drawn from decades of cognitive psychology research, to help you get the most out of your studying hours.

Space Your Study Sessions

As course reading piles up, it can be tempting to let yourself fall behind, all the

while reassuring yourself that you'll spend two days cramming right before an exam. But while last-minute cramming may allow you to pass a test, you won't remember the material for long, according to Williams College psychologist Nate Kornell, PhD.

Decades of research have demonstrated that spacing out study sessions over a longer period of time improves long-term memory. In other words, if you have 12 hours to spend on a subject, it's better to study it for three hours each week for four weeks than to cram all 12 hours into week four.

And for the most part, the more time you take between study sessions, the better off you are — at least within the time limits of an academic semester.

"At some point, waiting too long [between sessions] could have a negative effect [on learning]," Kornell says. "However, most of us space far too little. Practically speaking, too much spacing is not really a danger anyone should worry about."

Researchers aren't exactly sure why spacing is so effective. However, one possible cause is that, over time, people forget what they learned in their initial study session. Then, when they come back to the material later, the new study session jogs their memory and they recall what they learned the first time around. That process — forgetting and retrieval — helps cement the new knowledge in place.

In one study, published in 2009 in *Applied Cognitive Psychology*, Kornell showed that the spacing effect works on a smaller time scale as well. He asked college students to study a "stack" of 20 digital vocabulary

flashcards. The students all studied each word four times. But half of the students studied the words in one big stack — they went through all 20 words, then started over. The other half of the students studied the words in four smaller stacks of five cards each. So, the students who used the one big stack had a longer spacing time between each of the four times they saw a word.

On a test the next day, the students in the “big stack” group remembered significantly more of the words than the students in the “four small stacks” group — 49 percent as compared with 36 percent.

When it comes to spacing, students are often led astray by their own experiences, says Kent State University psychology professor Katherine Rawson, PhD, who also studies learning. “They cram right before an exam, and to be honest that’s probably OK for doing fine on your exam,” she says. “But the problem is that it’s horrible for long-term retention. Students don’t realize that they’re really undercutting their own learning.”

Interweave Your Subjects

You might think that if you want to learn one thing well, the best thing to do would be to sit down and concentrate on it for as long as you can stand. But research shows that mixing tasks and topics is a better bet.

In one study, published in *Psychological Science* in 2008, Kornell and University of California, Los Angeles psychologist Robert Bjork, PhD, asked 120 participants to learn the painting styles of 12 artists by looking at six examples of each artist’s work. For half of the artists, the participants saw all six paintings in a row. For the other half of the artists, they saw the paintings in a mixed-

up order. At the end of the experiment, the participants did a distracting task (counting backward by threes from 547), and then had to identify which artist had painted a new painting. The participants were significantly better at identifying the artists’ whose paintings they had studied in an “interwoven” style than the artists whose paintings they’d studied in blocks.

Why does mixing up subject matter help students learn? Again, as in spacing, the key may be in the learning, forgetting and relearning that helps the brain cement the new information for the long-term.

Another factor, Bjork says, could be that the mixing — he calls it “interleaving” — forces students to notice and process the similarities and differences among the things they’re trying to learn, giving them a better, deeper understanding of the material.

Despite strong evidence that interleaving works, it can be tough for teachers to work the mixed-up style of teaching into their lectures, he says.

“People expect to be taught the way they’re used to being taught,” he says. “Most courses involve blocking by topic. If you start interleaving you’re going to seem disorganized.”

But, he adds, students can bring the method into their own study sessions.

Test Yourself

Testing gets a bad rap: Students don’t enjoy taking quizzes, teachers don’t like to grade them, and some people bemoan that too many exams can force teachers to “teach to the test” and squeeze creativity out of the classroom.

But done right, testing can be a useful tool to help students learn, researchers say. Decades of research has shown that making yourself recall information helps strengthen your long-term learning, says Henry Roediger, PhD, a psychologist at Washington University in St. Louis who has done some of the key research in the area. In other words, students might not enjoy taking a quiz at the end of every class or testing themselves every time they finish reading a chapter, but doing so would probably help them remember the material on the final exam — and even after the class ended.

University of Louisville psychologist Keith Lyle, PhD, used a captive audience — students in his undergraduate statistics classes — to prove the point. In one 75-person class, at the end of each class session he asked students to complete a four- to six-question short-answer quiz about material that had been presented during the lecture. Cumulatively, the quizzes counted for just 8 percent of the students' final grade.

Lyle taught a second class using the same syllabus, but didn't do the daily quizzes. At the end of the semester, he found that students in the quiz class significantly outscored students in the nonquiz class on all four midterm exams.

Roediger says that even though most professors won't use daily quizzes in their courses, students can — and should — test themselves by asking themselves questions during study sessions.

"The problem with repeated rereading, which is what most students do to study, is that it gives you a false sense of familiarity. You feel like you know the material, but you've never tried retrieving it," he says.

Taking the Hard Route

If decades of research have demonstrated that spacing, interweaving and testing help people to learn more effectively, then why don't more students and teachers use these strategies? Perhaps because they're difficult, say Kornell, Bjork and the other researchers.

It's hard to study a topic, then switch to a different subject and wait a week to come back to the first one. When you do, you might feel like you're relearning the material — and, in a sense, you are.

Learning researchers recognize that these strategies aren't easy or fun to put into practice. Bjork, in fact, has labeled the strategies "desirable difficulties." The strategies work because they are difficult — it's the process of learning, forgetting, retrieving and relearning that eventually registers the knowledge in our long-term memory.

"In the short term it's easier not to [use these strategies], but in the long term it pays off a thousand times over," says Kornell.

Putting in the extra work to learn material for the long haul is particularly important for graduate students, he says, because by the time you reach graduate school you're not just trying to pass a test — you're learning things you'll need to have a handle on for the rest of your working life.

"One of the most important transitions you make [at the beginning of graduate school] is realizing that you are really there to learn, not just get good grades," he says.