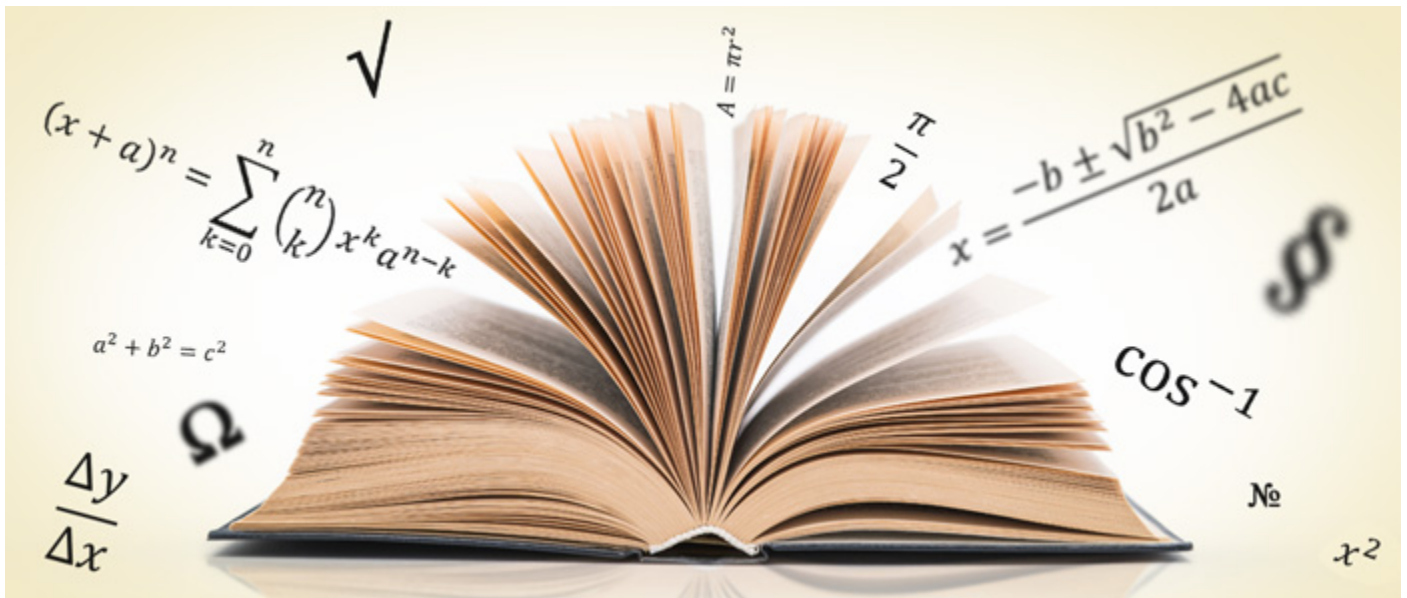


Spaced Repetition: The Most Effective Way to Learn

By *Josette Akresh-Gonzales*

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The first time I remember feeling panicky the day before a test was in seventh grade: My math teacher had handed out a list of what was definitely going to be on the mid-year exam, and half of it I didn't actually remember learning in the first place. Dry mouth, heart pumping, tears threatening to spill over, I showed the list to my mom and said I would most likely fail the test. My mom, who is an internist, brushed off my pre-teen panic and kindly stayed up with me until well past midnight solving for x , pinpointing the gaps in my knowledge of y , flipping the pages of the algebra book and helping me learn — in five or six hours — everything I was supposed to have learned in four months of math class. I managed to earn a decent score, and the precedent was set: I had learned how to cram.

For most students (and professionals), cramming for tests is inevitable. We all know that it is the only way to learn the huge amount of material that is going to be on the exam — but we also know that stuffing a lot of information into our brains all at once is not a good strategy for long-term retention. What we tell ourselves is that the content we need to memorize for the test is *not the same* as what we need to know to do our work every day. Or we tell ourselves that the most important skills and knowledge will stick, somehow, from our

cramming sessions, while the trivia will naturally slip away. Or we say that there's no point in memorizing what can be looked up on the internet.

However, Cramming Is Not a One-Off Emergency Procedure

Cramming is actually part of a larger framework for learning that begins in elementary school and continues through our childhood and adult years: we learn most things through intense focus on one topic, assessing our knowledge of that topic, then moving onto the next topic, testing on that topic, and so on. Often skills and knowledge build on one another, and sometimes we review what we've learned before moving onto the more complex stuff. Think about your medical school education, broken up into blocks where you learned, organ system by organ system, about the human body. And think about your professional career, where often conferences are focused on a single disease or drug, where test-prep books and software move you through chapters and question banks in the same way, first cardiology, then endocrinology, then infectious diseases, and so on.

Short-Term Benefits of Blocking

What I've just described as a common learning strategy is called "blocking" or "massed learning." Decades of studies show that blocking works great for getting to proficiency quickly but falls apart when it comes to retention.

Here's Robert Bjork, chair of the psychology department at UCLA and a top expert in human learning and memory. He has created a slew of YouTube videos based on his extensive research, and they are all great. [This one](#) on blocking versus spaced learning is pertinent to our discussion here.



In the video, he explains:

Cramming can actually be a good thing to do from the standpoint of your getting a grade. If you don't know the material and haven't appropriately spaced your study across the term, ... if you stay up all night, study, cram whatever and walk into the exam, you can actually perform pretty well on that exam...

You know what's coming though, right? It's what you've been waiting for. The "but."

But the problem is not too long after that, this massed practice will lead to ...very poor retention. So as far as the material in that course carrying over to other courses, to your life in general, it's an awful thing to do.

Spaced Repetition Is Better for Long-Term Retention

What Bjork's research shows (along with many others') is that learning in short bursts over time and repeatedly testing yourself on what you've learned is much more effective for long-term recall than cramming.

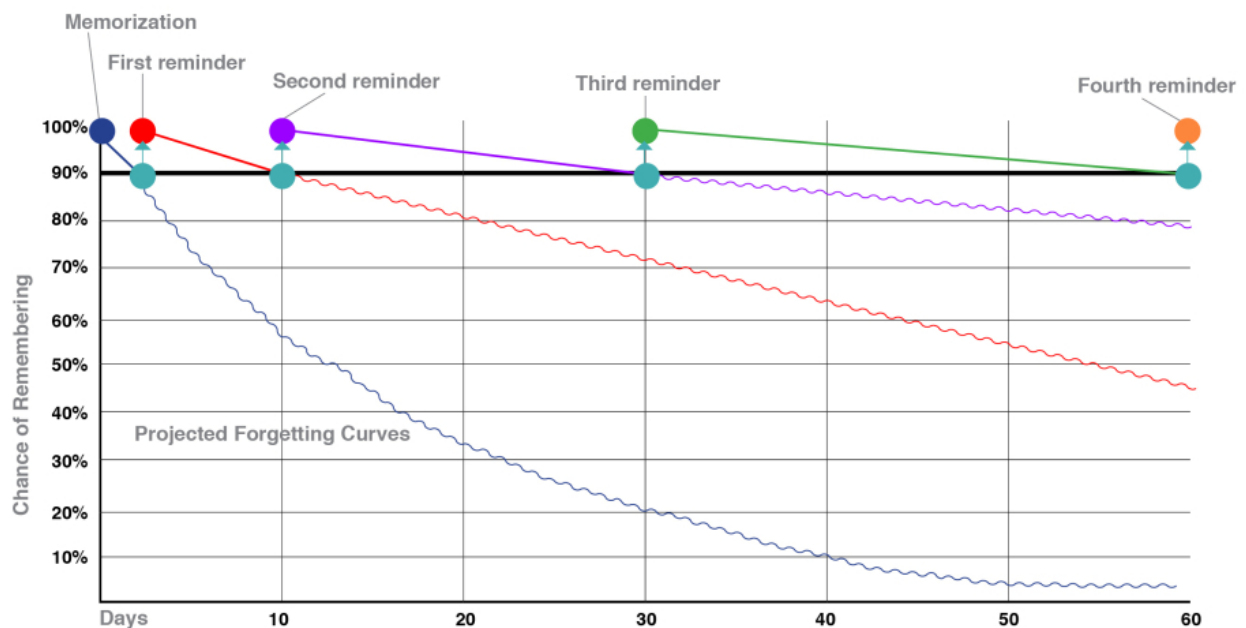
He goes on to explain, in the same video:

...The more things are massed together, the more you will see apparent benefits on the short term, the more they're spread apart, the more you'll see real benefits on the long term. It is possible to space too much. In some ways that's just intuitive. If I let extraordinary time go by between when I first study something and when I restudy it, it'll be almost like that restudy is the first time. ... there is an optimal spacing interval. It tends to be very long, but there's a peak that performance, as I increase that spacing, performance will increase a lot to some point and then gradually I get too much space."

It turns out that thousands of studies have replicated this finding: people forget what they've learned at a predictable rate, but relearning the material at spaced intervals dramatically improves long-term recall. A [study](#) in the journal *Medical Education* in 2011 showed that on tests of basic science, physicians' "performance decreased from approximately 40% correct answers for students still in medical school, to 25-30% correct answers for doctors after many years of practice. When *rehearsal* during the retention interval is controlled for, it appears that little knowledge is lost for 1.5-2 years after it was last used; from then on, retention is best described by a negatively accelerated (logarithmic) forgetting curve. After ≥ 25 years, retention levels were in the range of 15-20%."

I emphasized the word "rehearsal" above, because the retention of knowledge 1.5 to 2 years "after it was last used" *depends* on active recall of this knowledge. Once the physicians stopped reminding themselves of their basic science (i.e. after their residency ended), they began losing what they'd learned, predictably and according to the curve first discovered by [Hermann Ebbinghaus](#) in 1885 and replicated many times since then.

With reminders of your initially learned material at particular intervals that are in direct relation to the forgetting curve, you can achieve much better long-term retention of the material. Instead of the projected curve below the line in the graph, you want 90% of what you'd initially memorized to stick in your mind.



Algorithms Do It Better

Human beings have an unrivaled capacity to learn — but knowing precisely when we should remind ourselves of knowledge we are *about to forget* is not our strength.

To put it simply, [computers are better at this](#) than we are.

Take board exam prep, for example. If you are using print question books to study for a board exam, you'd have to set up a complex system of reminders on the basis of the forgetting curve that take into account your own personal performance on self-assessments to achieve what a software program can do for you quietly in the background. With the scope of knowledge you need to commit to memory so large, and a system that needs to be both predictable (the forgetting curve is universal) and adapted to your particular needs (each person starts with a unique level of proficiency) it is no wonder adaptive learning software is better at spaced repetition than the human brain.

Spaced Learning in NEJM Knowledge+

In the medical education world, NEJM Knowledge+ is among the first providers of learning for physicians that uses spaced repetition in its software algorithms. Our adaptive learning platform uses the [thousands of case-based questions we've written](#) to test physicians on their current proficiency across topics mapped to their board's blueprint — then it repeats those same questions and variations on those questions at spaced intervals so that you retain that knowledge over time.

NEJM Knowledge+ offers a personalized review feature, called "[Recharge](#)," which picks 20 questions from

areas you've struggled with or simply haven't seen for a while — to reinforce your learning. The algorithms that form the basis of the NEJM Knowledge+ platform take into account how long it's been since you learned a given module and subtopic, how confident you were in your answers, and even how long it took you to answer a given question.

It uses a spaced repetition algorithm to determine which correctly answered questions you need to retake at any given time. Because you may need to refresh your knowledge of cases you struggled with, it also includes incorrectly answered questions. If you've had a hard time with lupus questions, for instance, or if it has been a set amount of time since you answered those lupus questions, Recharge will draw those questions out and present them to you again, enabling you to review the concepts and to recall the correct choices. ([Area Learning](#), which created this software, advises using Recharge every couple of weeks.)

So Should You Stop Cramming?

In a word, yes.

Realistically, though, I know you won't.

I certainly didn't, even though by college I'd realized that I had forgotten a lot of what I'd learned in school. *Except* — and this is important — *except* for the material that proved to be the building blocks of more-complex skills and knowledge. I can remember, for example, that my knowledge of American geography, which I'd learned and relearned in elementary school, middle school, and high school, proved useful when I needed to analyze novels and poems about the Civil War in college. My basic knowledge of where our states, rivers, and mountain ranges lay seemed idiotic to memorize when I was a kid — why not just look at a map, I reasoned?

However, making inferences and associations with knowledge you have learned by heart is a crucial element of skillfully and quickly absorbing new information, [say experts like Nate Kornell](#) and others. Synthesizing facts and observations that you can recall without too much effort brings powerful insights to the fore — at the ready for you to come to rapid and complex conclusions.

With caring for patients as your first priority, I think it makes sense to have as much knowledge committed to memory as you can reasonably expect of yourself; perhaps adaptive learning software that uses the principles of spaced learning (like NEJM Knowledge+) can be the key to both successfully preparing for your board exams *and* bringing the material you've learned into your everyday practice of medicine.

What do you think about spaced repetition in medical education? Have you used software or your own methods to put spaced learning principles into practice? If not, why not?

For more on science-based learning strategies employed in NEJM Knowledge+:

[Recharge: What It Is, How It Works, and When to Use It](#)

[ABIM Review — Using Reflection to Improve your Performance](#)

[What Is the Testing Effect, and How Does It Affect Learning, Knowledge, and Retention?](#)

[Test Anxiety: Why the Struggle to Remember Is Worth It](#)

4 Comments



Gerald Tevrow December 1, 2015 at 8:02 pm - [Reply](#) >

I came upon the Spaced Repetition method doing some CME's on Qstream about four years ago. I changed the frequency of days between right and wrong answers somewhat. 5 days for right and 3 days for wrong answers. I received 5 questions daily. I needed to answer the questions correctly twice consecutively in order to retire each of the 40 questions. Over the period of two months, I had retired all. I took the same CME six months ago and retired all the questions in 3 weeks time. For me, there's no doubt that Spaced Repetition greatly enhanced my knowledge retention.



Indran Muthiah December 6, 2015 at 8:04 pm - [Reply](#) >

I accept that spaced repetition is good for long term memory retention and recall. Simple strategies like keeping good notes of even the questions helps in study.

Positive sites for parents and teenagers | Nicola Morgan June 12, 2017 at 8:39 am - [Reply](#) >

[...] knowledgeplus.nejm.org/blog/spaced-repetition-the-most-effective-way-to-learn/ [...]

Practice Power products use the technique of learning by repetition June 16, 2017 at 10:08 pm - [Reply](#) >

[...] professionals found that spacing intervals of repetition is the most effective way to learn. Their article by the same name reports that: "people forget what they've learned at a predictable rate, but [...]"

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