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The Importance of Testing as a Learning Strategy

To make learning stick, students must be challenged to recall and apply their knowledge — and quizzes are a good tool for accomplishing that

BY HENRY L. ROEDIGER III AND PETER C. BROWN/*School Administrator, May 2019*

Henry Roediger (center), a psychology professor at Washington University in St. Louis, Mo., promotes student assessment practices as more effective than the high-stakes test.

Testing one's memory requires retrieval practice, which is a central mechanism of learning. All of us experience the benefit of retrieval practice in our daily lives.

If you've ever spent a couple of weeks in a strange city and learned your way around without a GPS, let's suppose it went something like this.

You studied a map and set off. Over the days, by fits and starts, you began to construct a mental layout of streets and shops near your hotel, perhaps the subway routes, how to reach your new haunts. When you made a wrong turn, maybe you checked the map to get back on course and made a mental note of the error. Before long, you were able to plot a route home in your head from any number of points in town, slipping down alley shortcuts you had found, digressing to pick off errands along the way.

Most of what we know in life has been acquired in this way, trying things and succeeding or trying and making errors and correcting them. Durable classroom learning is not much different. We construct understanding of new knowledge less from studying charts, maps and texts than from repeated attempts to recall, explain and apply it — whether working to learn the multiplication tables or how to use Newton's laws of motion to solve a physics problem. Learning comes from active engagement, and retrieval practice with feedback, via quizzing or testing, is an important form of active learning.

Student Exertion

Learning often is thought of as getting new knowledge and skills *into* the brain, but in fact durable learning comes from practice at getting knowledge and skill *out*. Some teachers work at oversimplifying new material in the mistaken belief that this will help it stick, but quite the opposite is true — students learn best when they construct their own under-standing by wrestling to make the unfamiliar coherent. Of course, the teacher can help, but by providing challenges that enable students to work it out rather than by working it out for them.

Compare the student in the classroom to the student athlete on the sports field. The athlete understands that prowess takes learning and that learning requires effort, practice and feedback from the coach. The most effective teachers are like good coaches. They lay out the big picture as well as the component elements and engage students in mastering the new material through elaboration, trial and error, practice and feedback.

So it is with all learning — active engagement, corrective feedback, persistence. Through these, over time, you build complex mental models. The knowledge is there when you need it. To the physics teacher, applying Newton's second law of motion is a shortcut to solving a larger problem, but to the student of physics, the task is not so simple. She must recognize that a problem calls for the laws of motion, remember what they are, select the correct one and apply it.

The student inches toward the solution step by step, like a stranger in the city considering every turn. When mastered through repeated use in varied circumstances, she will bring Newton's laws to hand and apply them almost without thought.

Low-Stakes Quizzing

Retrieval practice coupled with corrective feedback leads to learning. A regimen of frequent low-stakes quizzing, for example, helps students to affirm what they know and discover where they need to bone up. Likewise, it helps teachers discover where students have grasped new material and where they are still struggling.

Low-stakes quizzing is a form of practice that is not burdened with the make-or-break consequences often associated with high-stakes standardized tests. Periodic quizzing helps students get comfortable with and better at retrieval of new knowledge, strengthens retention and builds out the growing mental scaffold that enables further learning.

When learning and practice are spaced out, allowing gaps between episodes of retrieval practice, the learning is stronger and more easily recalled again later. Quizzing helps to reduce the anxiety of being tested by becoming a regular part of class.

In controlled experiments in elementary and middle school settings, as well as at the university level, even simple, no-stakes multiple choice quizzes have been shown to increase scores on subsequent summative exams. Sometimes the gain is by a whole grade compared to exam performance on material that has been reviewed rather than quizzed — and in a study that followed students through their end-of-year exams, the benefit was sustained.

Ineffective Practices

Most students, however, favor strategies like underlining, highlighting, rereading and review, all much less effective for building durable learning or for forming the complex models that lead to conceptual learning and complex mastery.

Rereading, for example, has three strikes against it. Rereading does not engage the mind in wrestling with the underlying content. Familiarity with the text creates an illusion of knowing, and studies show the content does not stick. Far better to work at rephrasing new material in your own words, relating it to what you already know, and to practice re-calling it from memory and applying it. Elaborating on new learning helps create understanding, and the act of recalling it from time to time strengthens connections to what you already know and makes you better at recalling the learning again later when you need it.

Even when students do understand the importance of retrieval practice, they are still susceptible to low-value methods, notably massed and blocked practice. Massed practice is the single-minded repetition of new learning, like cramming for an exam, or practicing the same tennis serve over and over to get it "nailed."

Blocked practice is similar. It is the tendency to practice many examples of one kind of problem before moving on to practice many examples of another. For instance, in solid geometry, students practice finding the volumes of several different wedges before moving on to practice finding the volumes of cones, then some spheroids, and so on. Learners are drawn to massed and blocked practice because much instructional material is organized in this way and, more compellingly, because they see evidence of improvement during practice.

What they do not understand is that the improvement they see during this kind of practice leans on short-term memory and quickly fades. They need to learn to discern what kind of problem they are seeing in order to select the right formula, and blocked practice does not require this step because the type of problem is given at the beginning of the block.

Neuroscientists discuss the concept of consolidation, basically letting new learning sink in and be absorbed in a more permanent state. New learning can take hours to be consolidated. Sleep helps consolidation, so a good night of sleep is critical to learning (no all-nighters).

But massed and blocked practice, such as single-minded repetition of tennis serves or of a solid geometry problem, leans on short-term memory. Improvements are temporary because the learning has not been consolidated. But, of course, this is not apparent to the learner who thinks she is doing fine using massed and blocked practice.

The problem is that learning strategies that work fine in the short term (massing, blocking, repeated reading) and that are therefore favored by students, do not deliver durable learning. In study after study, where students were learning solid geometry, bird identification, the works of painters or how to hit different kinds of baseball pitches, performance during practice was better when the practice problems were blocked by type rather than mixed. However, later, when facing the problems in random order on delayed tests, performance was better in all cases where the problem types had been mixed up during study. Blocked practice shows fast learning, but fast forgetting. Mixed practice is necessary to establish durable knowledge.

Students may ace an exam after cramming all night — and feel affirmed in their knowledge of the material — but if tested a week later they may have forgotten half or more of what they thought they knew. Those who use spaced and mixed retrieval practice as a study strategy leading up to exams will do well in the exam and carry the learning forward.

Excellent Prep

Given that few students come to effective strategies on their own, teachers have a twofold challenge. In addition to helping students learn course content, it's essential to help them learn and internalize the non-intuitive strategies that will power their continued success.

Both objectives can be accomplished by teachers explaining how learning works and modelling the strategies in class and homework so students experience success at using them. (See related story.)

Doesn't more testing mean more stress for students? Actually, low- and no-stakes quizzing dials down stress by making retrieval practice routine.

Students in classes with regular low-stakes quizzing and other forms of active learning reach the end of their courses on top of their material and comfortable with retrieval. Regular low-stakes quizzing prepares students to excel at exams, and students in such classes who have expressed concern at the outset reach the end of the course wishing they had such structure in their other courses. Although it seems counterintuitive at first, using quizzing and testing is a great way to help students learn.

HENRY ROEDIGER III is James S. McDonnell distinguished university professor at Washington University in St. Louis, Mo. **PETER BROWN** is a professional writer in St. Paul, Minn. They are co-authors, with Mark McDaniel, of *Make It Stick: The Science of Successful Learning* (Harvard University Press, 2014).

Additional Resources

These resources suggested by Henry Roediger and Peter Brown elaborate on the ideas in their article.

» www.MakeItStick.com. This is a website related to their book *Make It Stick: The Science of Successful Learning.*

» www.RetrievalPractice.org and www.LearningScientists.org. These two websites and blogs were created by psychologists to explicate the concepts of retrieval practice, interleaving and spacing, and their application in classrooms.

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