How Relearning Old Concepts Alongside New Ones Makes It All Stick

MindShift
Oct 28, 2014

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UCLA researcher Dick Schmidt gazes across the driving range at a line of golfers trying to improve their game. It's a breezy day at the Westchester Golf Course and there's a relentless roar of jet traffic from the nearby Los Angeles airport. Schmidt is a retired professor of psychology at UCLA, and an authority on how humans learn and develop motor skills.

As Schmidt watches the golfers practice the same swing with the same clubs, over and over, he chuckles. There's a much better way to learn than this kind of rote physical memorization.

"I give conference presentations to golf instructors and professionals," Schmidt said. "They're quite surprised."

Schmidt explains that repetitive drilling on the same task is called "block practice." You do the same thing, over and over, in one block of activity. He argues that a better way to learn is to practice several new things in succession, a technique called "variable practice" or "interleaving." So a golfer would interleave her exercises at the range by aiming at different targets each time, by mixing up the kinds of shots she takes or switching the clubs she uses.

Tim Lee draws a five-iron from his bag to demonstrate. Like Dick Schmidt, Lee is a kinesiologist -- one who studies human movement. Lee and Schmidt co-wrote an influential book on motor skills acquisition and they've played golf together for years. Lee is hitting into the wind so he's going to practice low shots. Instead of blocking his practice, Lee is interleaving the different shots.

“So I might try to hit a knockdown shot to start with, and then I might try a hook and then a slice,” Lee said.

Lee recently retired from McMaster University in Canada. He's in Los Angeles to visit Schmidt, a longtime friend and colleague. Joining them on the links is UCLA psychologist Bob Bjork, a veteran golfer who has studied cognitive skill learning with Schmidt. Their collective work on how humans learn best suggests that much of the way students are taught — and how they study and practice — could be much more effective, be it on the driving range or in the classroom.

Bjork studies interleaving in his psychology lab at UCLA. One experiment uses art to compare the effectiveness of blocking versus interleaving in learning. One test asks participants to look at images on a computer screen to learn the artistic styles of a group of modern painters. Participants don’t know it up-front, but they are offered one set of painters and names in a block. Another set is interleaved. When they’re tested later, most people do far better at identifying the artists they learned about through interleaved images than the ones that were blocked. Most get about 35 percent of the blocked examples but 60 percent of the interleaved.

"The thing that's really interesting that's come out of this study and related studies is that people consistently don't understand what's good for their own learning," said graduate student Veronica Yan, who helps run the experiment. Participants are asked afterward which worked better for them, blocking or interleaving. Some 70 percent of participants believe blocking was the more effective way to learn, even though it wasn’t.

Bjork says interleaving works better in all but the youngest learners because it seems to fit the mind’s natural capacity to detect patterns and recognize differences. Interleaving images present more chances to compare the stylistic variations of the 12 artists than blocking does.

In the laboratory, the same amount of time is given for each approach. But in the real world, there's another benefit of interleaving, Bjork says: It tends to encourage the learner to spread out his studies. For example, when college students cram for a test, they don't learn as well in the long run. "It can produce good exam performance," Bjork said. "You stay up all night and cram; people can perform well. But then the forgetting is dramatic after that. Long-term recall is really enhanced by spacing study sessions."

When students interleave their studies over a spread-out period of time, the repeated act of recalling the information likely leads to deeper, more long-term learning, Bjork said.

Bjork is also interested in how making mistakes can enhance long-term learning. Humans obviously learn a lot of things through trial and error. A level of "desirable difficulty" built into a learning and exam process appears to boost the overall retention of new skills or knowledge. He says frequent, low-stakes quizzes and tests can be a great opportunity to learn from mistakes. So is group discussion.

"I once taught a small undergraduate seminar where I said, 'Until you say something completely wrong, for the wrong reason, you have not contributed to the discussion,' " Bjork said. "You are contributing to the class when you make an error."

Bjork argues we all need to become smarter learners. "In almost any job, you have to keep managing some new kind of technology," Bjork said. "People shift their careers. So this is a kind of lifelong thing where just knowing how to manage your own learning is very important."

PUTTING THE THEORY TO WORK IN A CLASSROOM

Jen DeMik is a seventh-grade pre-algebra teacher at Liberty Middle School in Tampa Bay, Florida. DeMik is one of those powerhouse teachers uniquely skilled at getting kids excited about math. Watching her teach is like watching some mashup of motivational speaker, preacher and mom. Alternately cajoling, praising, and scolding, she calls her

kids “baby” and “honey” and jokes about peeing in her pants. When trying to get students to understand the concept of slope, DeMik will throw out three metaphors, one after another: a ski run, a skate park and, when that didn’t work, the Tampa Bay Buccaneers stadium.

“When you look at algebra and high school math, seventh grade is the last shot you have to convince kids they can still do this,” DeMik said. “Because if they go into algebra not thinking they can do it, they’re going to have struggles the rest of their careers. So if we can get them now, they’re good.”

So when a psychologist from the University of South Florida named Doug Rohrer came to DeMik three years ago and told her he wanted to redesign her curriculum so her kids would learn better, she actually gave him the time of day.

'Everything we're seeing here suggests that schools could be more effective. People could learn much more effectively than they're learning.'
Rohrer had done work on interleaving in the lab. Now he wanted to try out the concept in a real classroom. Liberty Middle School was just down the street from Rohrer’s house, so he called up DeMik and explained the research on interleaving and how, in the lab, it seemed to lead to big gains in learning. He told her he wanted to try interleaving her students’ homework assignments.

“My eyes lit up,” DeMik said. “I was like, this makes so much sense. But are our resources currently designed like that? No, they’re not. So I thought it was fantastic, and I was all for it.” DeMik was also getting tired of the standard model of math homework, which is to give kids lots of problems on the concepts they’ve just learned, with only the specific numbers changed.

“We call that drill and kill,” DeMik said. “We’ll just keep drilling you until we kill you, and then you will definitely hate math. So why are we doing 400 math problems that are the same?”

Researchers say that the problem with "drill and kill" and other kinds of blocked study isn't just that they're boring. They also stunt student learning. **"There are always two steps to solving a problem: identify the solving strategy, and then execute it," Rohrer said. "In blocked study, [students] know that this is a unit on, say, the Pythagorean theorem, so they don't need to choose a strategy. All they have to do is execute, over and over."**

When teachers give homework sets made up of only one kind of problem, they deny their students the chance to practice choosing a solving strategy. Later, when students are faced with a mix of types of problems on an exam, they're unprepared.

So Rohrer designed a simple experiment to interleave homework in DeMik's and two other teachers' classrooms. Half of the class's homework assignments would stay the same. But for the other half, Rohrer would take all the homework questions the teachers had used last year and mix them up. So the interleaved assignments would have some questions about what the class was currently studying, and some questions about things they had studied earlier in the year.

DeMik teaches two seventh-grade classes and the material for the year is broken up into four units. As a way of controlling the study, Rohrer interleaved different assignments for each of DeMik's two classes. For example, while one group of seventh-graders had traditional homework for linear equations, the other class had interleaved homework for that unit. This approach helped Rohrer isolate the impact of the interleaved homework.

The students in DeMik's class took a while to warm to the new homework.

"Because it's been so long since you've actually seen how to do it, so when it comes back you're just like, "Wait, what? I don't remember this,' " said student Marigny Duga.

But once they got used to it, the students started to like the new homework.

“When you’re reviewing, there’s an aha moment — oh I remember that,” said Sebastian Lancaster. “And it just kind of clicks and you’re like, ‘I know how to do that.’ ”
Another student, Courtney Mortz, said, “When it comes time for the tests you’re not like, ‘Eek! — what?’”

At the end of the study, Doug Rohrer walked into DeMik’s classroom and gave the kids an unannounced test on everything they had covered until then, both interleaved and standard. The kids did better on the interleaved materials — significantly better. For the kinds of problems they learned with interleaved practice, the kids averaged 72 percent correct. With blocked practice, they averaged only 38 percent. (You can read Rohrer’s description of the study, and its results, here.)

Rohrer stresses that further research is critical to make sure that the effects he found at Liberty Middle School generalize to other kinds of material, students of different levels and students in different grades. But, he says, the findings represent “a big difference. I think we can safely say these results demonstrate that there’s something to interleaving.”

Still, even when research has extremely promising results, it can be hard to get new methods of teaching into the classroom. Psychologist Bjork says that these kinds of innovations move “agonizingly slowly” into actual classroom practice, especially in the K-12 system. He says there are few incentives for schools to change long-held ways of teaching, and people stick to the learning methods they’re used to, even when those methods don’t actually work very well.

“There’s a broad feeling that we could learn better, our kids could learn better, that it’s important,” Bjork said. “And everything we’re seeing here suggests that schools could be more effective. People could learn much more effectively than they’re learning.”

This article first appeared on American RadioWorks. It is part of a longer radio documentary called "The Science of Smart."