THE TEACHING
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More Learning Strategies

Students don't realize that they need to learn how to learn. But the most effective learning strategies are often counterintuitive. Learning is more durable when it is more active and effortful, yet that very struggle makes students believe they aren't learning much. The problem is that most don't know how to study. They tend to follow passive approaches, such as simply rereading course materials. However, the sense of familiarity that comes from rereading fools them into believing they have mastered the material. Because of this false sense of mastery, many students are surprised and angry with their exam results. They conclude that these exams were "tricky" and "unfair."

In the previous issue of *The Teaching Economist*, I focused on what for many students is the key missing strategy in the learning process—retrieving material from memory. By trying to retrieve course material repeatedly spaced out during the term, students develop learning pathways for that material and identify areas that need more attention. My discussion in the last issue drew on recent research in cognitive science, especially the new book *Make It Stick: The Science of Successful Learning* by cognitive psychologists Henry L. Roediger III and Mark A. McDaniel and "storyteller" Peter C. Brown.

Here I again draw on that cognitive science research to discuss three more learning strategies in addition to retrieving and spacing to help students learn and remember. These three are elaborating, generating, and interleaving. As with retrieving material from memory spaced over time, these learning strategies are active and effective, but they can seem frustrating and counterintuitive.

Elaborating

By *elaborating*, students try to express new material in their own words, then connect that material to what they already know. By putting new material in their own words, students are forced to see how well they understand it. Unfortunately, many students believe that the essence of a new economic concept lies in the exact wording they hear in class or read in the textbook. Thus, they try to memorize that wording rather than focus on the meaning. (Some instructors encourage memorization by testing for exact wording rather than for understanding.)

The better that students can express new material in their own words, the better they understand it. And the better they understand it, the easier they can connect that material to what they already know. Linking new concepts to what they already know could involve using familiar visual images and metaphors. For example, the intersection of supply and demand curves identifies the equilibrium point. Because the intersecting curves form an "X" at the equilibrium point, students could liken a market diagram to a treasure map, where "X" marks the spot. Students who can express a new idea in their own words and then connect that to prior knowledge gain a special advantage in studies and in life.

Generating

Generating is the act of trying to answer a question or solve a problem before being given the solution. Trying to noodle through a new problem leads to better learning, even though errors are to be expected. According to cognitive scientists, as students try to think about a solution, they retrieve bits of related information from memory, and thus begin to form mental pathways for learning even before the answer becomes known. While wrestling with a question, such as how a particular government regulation would affect market competition, the student thrashes about for something to spark an idea. Even if the student is unsuccessful after a struggle, once the solution becomes known, that answer connects with related material still fresh in the student's mind. Thinking about the problem also generates some degree of curiosity, and learning the answer delivers some satisfaction—scratching that itch.

Even unsuccessful attempts to solve a problem are said to lay the groundwork for deeper processing of the correct answer, creating hooks for encoding that answer. All this doesn't happen if the answer is supplied too soon. Again, it's better to try to solve a problem even if attempts are way off than to be given the answer. This wandering in the dark doesn't feel much like learning, so generation seems like a counterintuitive strategy for most students. Intuition suggests that students should be guided to the correct answer. But it's not just the destination, it's also the journey.

Having to come up with answers is a form of active learning, where the student engages in higher-order thinking rather than passively receiving knowledge passed on by others. Better to have your students struggle with a problem than to memorize a solution. Trying to generate answers applies to self-testing, your questions of the class, and graded testing. Having to come up with an answer rather than

selecting from multiple choices involves greater learning. Short essay questions reinforce memory even more.

Interleaving

My dictionary defines *interleaving* as "arranging in alternate layers." Interleaving is learning by mixing different types of problems together rather than focusing on one type at a time. For example, in one study, two groups of college students were trying to learn how to measure the volumes of four different types of geometric solids. One group of students practiced with problems bunched by type. The other group practiced the same problems but mixed by type, or interleaved. Students tested right after practicing on problems bunched by type averaged 89% correct answers, compared to only 60% correct by students who worked on problems in mixed sequence. Yet, in a final test a week later, students who had practiced one type at a time averaged only 20% correct, while students who had practiced by interleaved types averaged 63%. (See Doug Rohrer and Kelli Taylor, "The Shuffling of Mathematics Problems Improves Learning," *Instructional Science*, Vol. 35 (2007): 481-98, available at http://uweb.cas.usf.edu/~drohrer/pdfs/Rohrer%26Taylor2007IS.pdf.). Mixing problem types may slow performance during the learning phase but it boosts final test performance.

Teachers and students sense that their grasp of each type of problem develops more slowly with interleaving, and the compensating longer-term advantage is not apparent to them. As a result, interleaving is less popular and less used. But extensive research shows unequivocally that long-term retention is much better with interleaving. Again, intuition is a poor guide about how we learn.

If you think about it, exam questions are interleaved—that is, types of problems usually appear in random order. This is especially true if the instructor creates two or three versions of the same exam, as is often the case in large lecture classes. Students who study problems that are grouped by type are less sure how to solve exam problems in mixed sequence, which is how they usually encounter such problems on exams and in life more generally.

To review, this and the last issues of *The Teaching Economist* have focused on five effective learning strategies: retrieving material from memory; spacing retrieval sessions throughout the term; elaborating a new concept by putting it in your own words then linking it to what you already know; generating an answer before being given a solution; and interleaving, or mixing, the types of problems to be solved. Because these strategies are usually counterintuitive, instructors should be up front about some of the frustrations and difficulties that real learning entails. Strategies that seem to slow down learning in the short run promote learning that is more durable and transferable to new situations. Students should know that when learning is hard they are doing important work, readying their brains for a changing world.

Twitter Twenty Update

In the Spring 2015 issue of *The Teaching Economist*, I ranked U.S. academic economists based on their number of followers on Twitter ("Twitter Top Twenty," Issue 48). Here are my updated rankings twenty months later as of September 15, 2016 (with thousands of followers in parentheses): 1. Paul Krugman (1,678.1); 2. Nouriel Roubini (393.4); 3. Robert Reich (297.2); 4. Jeffrey Sachs (223.4); 5. Richard Florida (187.9); 6. Joseph Stiglitz (152.0); 7. Michael Porter (135.4); 8. Dan Ariely (117.4): 9. Justin Wolfers (106.5); 10. Calestous Juma (100.0); 11. Erik Brynjolfsson (96.9); 12. William Easterly (87.3); 13. Robert Shiller (81.4); 14. Ricardo Hausmann (77.1); 15. Kaushik Basu (69.9); 15 (tie). Lawrence Summers (69.9); 17. Dani Rodrik (68.0); 18. Tyler Cowen (67.9); 19. Austan Goolsbee (60.2); and 20. Richard Thaler (54.0).

Harvard's Larry Summers, is the only new member of my top twenty, tied for 15th. Berkeley's J. Bradford DeLong, who was 18th in my initial rankings, slipped out of the top twenty. Thus, only one moved into the top twenty, suggesting relative stability in my rankings. Based on academic affiliations, Harvard leads with five on the list (Porter, Juma, Hausmann, Summers, and Rodrik) and NYU has three (Roubini, Florida, and Easterly). With two each are Columbia (Sachs and Stiglitz) and Chicago (Goolsbee and Thaler). Thus, twelve of my top twenty tweet from four distinguished institutions and ten of my twenty are in the Boston or New York metro areas.

All of my original top twenty increased their following between my snapshots, with a median gain of 39%. Nobelist Joseph Stigler had the largest percentage gain at 226%, moving him up from 15th to 6th in my rankings. The second largest gainer was MIT information expert Erik Brynjolfsson, whose 217% gain lifted him from 20th to 11th. Only one saw just single digit growth: Richard Florida's following inched up just 4.6%, but because his original base was so large, he slipped only one spot, from 4th to 5th. To appreciate how competitive these rankings are, consider that Professor DeLong fell out of the top twenty (dropping from 18th to 21st) despite increasing his followers by 58%.

Among my top twenty, sustainable development expert Calestous Juma tweeted a total of 149,254 times since joining Twitter in April 2009, ranking him first in total tweets. Nobelist Robert Shiller tweeted only 167 times since joining in May 2012, ranking him twentieth. By dividing the number of followers by the number of tweets, I get what I argue could be another measure of influence. Based on this measure, Shiller ranks first among my top twenty, with 487.4 followers per tweet. Juma ranks last among my top twenty, with 0.7 followers per tweet. The top three based on this measure are the three Nobelists on the list; Shiller, Stiglitz and Krugman, in that order. Incidentally, based on this second measure of influence, DeLong still drops out of my top twenty with 0.6 followers per tweet.

A textbook diagram is usually presented as a finished product, often obscuring the steps involved in constructing that diagram. Does that matter? Cognitive scientists **Logan Fiorella** of the University of Georgia and **Richard E. Mayer** of UC Santa Barbara ran several experiments to find out. A control group of students viewed already-drawn diagrams while listening to a concurrent explanation. Another group listened to that same explanation while watching a video of an instructor drawing the diagrams by hand. This second group later performed significantly better than the first group when tested on the material. A third group that saw only the instructor's hand drawing the diagrams while they listen to the same explanation also outperformed those who saw only the finished diagrams while hearing the explanation. A fourth group heard the explanation and saw the diagrams being drawn but without seeing even a hand; this no-hand group did no better than those seeing only the finished diagrams while hearing the explanation. (I'll note here that the Khan Academy economics videos I have seen show diagrams drawn with no hand involved.) In a final experiment, those who saw only the instructor's hand drawing the diagrams tested slightly better than those who observed the instructor's entire body. (I'll speculate that perhaps the entire body was a bit more distracting than just a hand.) The authors suggest that observing the instructor or even just the hand draw diagrams may provide an important social cue that helps learners make sense of the material. Beats me. See "Effects of Observing the Instructor Draw Diagrams on Learning from Multimedia Messages," *Journal of Educational Psychology*, Vol. 108 (May 2016): 328-346.

Burt Abrams of the University of Delaware begins the first class in his Money and Banking course by showing the film clip from *The Titanic* where the ship heads for and hits the iceberg. He then compares that clip with monetary and fiscal policymaker attempts to steer their ship, the economy. In the movie, the ship is going too fast, the lookouts aren't attentive, communications with the bridge are delayed, and the ship is slow to respond to directions from the bridge. Professor Abrams parallels these with fiscal and monetary lags: the recognition lag, the decision-making lag, the implementation lag, and the effectiveness lag.

The American Economic Association in the 1970s began offering a summer program to foster racial and ethnic diversity among economists. **Cecilia Elena Rouse** and **Mingyu Chen** of Princeton and **Charles M. Becker** of Duke tried to estimate the effectiveness of this program. Using a comparison group consisting of those who applied to but did not attend the program while controlling for many background characteristics, they found that program participants were over 40 percentage points more likely to apply to and attend a Ph.D. program in economics, 26 percentage points more likely to earn a Ph.D., and about 15 percentage points more likely to work in an economics-related academic job. Based on these findings, they calculated that the summer program may have directly accounted for 17 to 21 percent of the Ph.D.s awarded to minorities in economics during the past 20 years. Of course, despite the many controlling variables, there may still be some missing factors distinguishing those who attended the program from those who applied for but did not attend. See, "Can a Summer Make a Difference? The Impact of the American Economic Association Summer Program on Minority Student Outcomes," *Economics of Education Review*, Vol. 53 (August 2016): 46-71.

For more than a quarter century, *The Teaching Economist* has presented strategies about teaching and learning from the cognitive sciences. **Austin Boyle** and **William L. Goffe**, both of Penn State, tried to uncover the effect of many of these strategies, such as retrieving, spacing, elaborating, generating, and interleaving, on two large macroeconomic principles classes taught by Professor Goffe. These "research-based teaching methods" are too numerous to detail here, but here are some examples of what he tried to do in the course: get nearly all students to read the material before class; connect new ideas with material already covered; interleave topics on five written homework assignments; lead with an example before introducing the abstract idea behind it; ask about five clicker questions per class period that stressed understanding rather than computations; use clicker questions, class discussion, seven quizzes, and the cumulative final exam to space retrieval of key concepts throughout the term; structure PowerPoint slides so that words appear a line at a time and diagrams build in sequence as they are explained; and provide abundant feedback throughout the term, for example, by reviewing the reasoning behind each answer immediately after each quiz. The changes introduced seem ambitious, even exhausting, for an instructor, but he said he enjoyed seeing students learn more effectively. To assess the effect of all these strategies, the Test for Understanding Economics (TUCE) was given at the beginning and end of the semester. The authors argue that because this test was normed in 83 sections of macro principles courses at 53 institutions taught by instructors who volunteered for the norming process, instructors with at least an average interest in teaching, TUCE results should offer a reliable comparison. The 508 students in the course who took the TUCE averaged four more correct answers (out of 30 questions) than the norm and in so doing achieved 0.77 standard deviations more learning in the course. See "Beyond the Flipped Class: The Impact of Research-Based Teaching Methods in a Macroeconomics Principles Class," (May 29, 2016), available at http://cook.rfe.org/Beyond_Flipped_Boyle_Goffe.pdf .

Does the earnings power of a degree depend on the selectivity of the college attended? To examine that question, **Paul Attewell** and **Dirk Witteveen** of the City University of New York drew on the federal *Baccalaureate and Beyond Longitudinal Study* and *Barron's* college guides, which group college selectivity based on SAT/ACT scores and the percentage of applicants admitted. To control for student specific characteristics other than the college selectivity, the authors used an array of factors that could contribute to earnings such as gender, age, race, parental income, parental education, SATs, college GPA, college major, advanced degrees after college, and region of employment after graduation. They found for a sample of nearly 5,000 graduates that ten years after college, those from the "most competitive colleges" (the top twenty or so) earned 8% on average more than graduates of "very selective colleges," 11% more than graduates of "competitive colleges," and 19% more than graduates of colleges that are not competitive in admissions. Women earned less. This study has not yet been peer reviewed.

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Odds and Ends

▼ Students often ask what they can do with an economics degree. As one example, I offer my graduating class from Holy Cross College, in Worcester, Mass., at the time an all male institution. Among the 400, or so, graduates, 65, or about one in six, majored in economics. Several pursued graduate study in economics, though all but I left before earning a Ph.D. For example, Chris Matthews, host of *Hardball* on MSNBC, left UNC economics after a year to join the Peace Corps. Some economics majors earned MBAs. In one impressive achievement, a blind economics major earned a doctorate in education from Harvard. And one major even earned an M.D. The most popular graduate pursuit among economics majors was law; 11 of the 65 practice law. Of course, even without graduate study, many economics majors have successful careers in business, education, non-profits, and government, such as former six-term Congressman Jim Moran of Virginia.

▼ After six seasons on PBS, *Downton Abbey* ended last December. The series was rich in economic content. For example, the Great War thinned the supply of males to estate service and farm work. In the series, the Lord Grantham character noted that by 1925 the (nominal) wages of servants were triple those before the war. Servants' wages grew faster than rents from estate farm land, the main source of income for the gentry. As a result, service staffing was cut. To supplement rental income, some lords married rich American women perhaps interested in a title of their own. Still, as dramatized in the series, some estates had to be shut down and the contents auctioned off, thinning the landscape of the landed gentry.

▼ Twenty states now require high school students to take a course in economics. This is up from 13 in 1998 but down from a high of 22 in 2014. After hitting a high of 27 in 2002, the number of states requiring standardized testing of economic concepts fell to only 16 in 2011, where it remains. See the Council for Economic Education's *Survey of the States: 2016* at councilforeconed.org/wp/wp-content/uploads/2016/02/sos-16-final.pdf.

▼ For a lively debate about the future of U.S. productivity, see the square-off between Northwestern's Robert Gordon and MIT's Erik Brynjolfsson at www.bloomberg.com/news/articles/2016-09-12/the-great-debate-can-technology-transform-the-economy-again.

▼ A record 974,926 international students were enrolled at accredited two- and four-year U.S. institutions during the 2014-15 academic year, a 10% jump from the year earlier, according to the Institute of International Education. Nearly one-third of them were from China.

▼ "Anyone who stops learning is old, whether twenty or eighty. Anyone who keeps learning stays young. The greatest thing in life is to keep your mind young."

— Henry Ford

Ideas for the Grapevine

If you have developed any attention-getting examples, ways to "sensationalize" economic ideas, useful online resources, or more generally, ways to teach just for the fun of it, please share these with colleagues in "The Grapevine" by sending them to:

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