

Make It Stick

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Many people believe learning is better when it is easier, but certain kinds of difficulties that require more effort make it stronger and longer lasting. Practice in retrieving new material from memory is more effective for durable learning than review by rereading. Learning is stronger still when retrieval practice is spaced out, requiring one to overcome some forgetting, and when practice is varied and interleaved with the practice of other knowledge or skills. Rereading and massed practice (like cramming or single-minded repetition of a new skill) are the more commonly used strategies, but are less effective than people believe. (Chapter 1)

Practice at retrieving knowledge or skill from memory is a potent tool for learning and retention. Simply including one test (retrieval practice) in a class yields a large improvement in final-exam scores, and gains increase as the frequency of practice increases. After an initial test, delaying subsequent retrieval practice is more potent for reinforcing retention than closely spaced practice, because delayed retrieval requires more effort. Spaced retrieval produces knowledge that can be retrieved more readily, in more varied settings, and applied to a wider variety of problems. Testing doesn't need to be instructor-initiated: think flashcards, for example. (Chapter 2)

Spacing practice by allowing time to elapse between sessions makes the practice more potent, producing stronger learning and memory. Interleaving two or more kinds of problems during practice provides a form of spacing and can improve your ability to discriminate later between those problems and select the right solutions. Like interleaving, varying practice helps learners develop an ability to assess changing conditions and adjust responses to fit. Arguably, interleaving and variation help learners reach beyond memorization to higher levels of conceptual learning and application, building more rounded, deeper and more durable learning. (Chapter 3)

Short-term impediments that make practice more effortful (like retrieval that's spaced, varied, or interleaved) are "desirable difficulties" because they make for stronger learning and memory. Arduous retrieval both strengthens the routes to memory and makes the memory pliable again, updating it with new information and more recent learning. Effortful practice helps integrate related ideas or a sequence of motor skills into a meaningful whole that can be applied automatically in the future. To be desirable, difficulties must be ones the learner can overcome. (Chapter 4)

We are all susceptible to illusions that can cloud our judgment of what we know and don't know. For example, reading a text repeatedly creates fluency with the writing that is often mistaken for mastery of content: the re-reader develops an "illusion of knowing" based on familiarity of the content but struggles later at test time when asked to explain the underlying concepts. Learners need tools to keep their judgments of knowing aligned with reality. Chief among these is testing in all its varied forms, from classroom quizzing to self-administered flashcards. Testing both strengthens learning and shows where improvement is needed. (Chapter 5)

The theory that people learn best from instruction that matches their learning style is not confirmed by empirical research. But other learning differences do matter: one's prior knowledge, language fluency, and determination all affect learning. People learn better if they can detect underlying rules that differentiate types of problems and apply these rules later to categorize new problems. The ability to distill key ideas from a text, organize them into a mental model, and relate the model to what one already knows is called structure building, and this skill contributes to concept learning and complex mastery. (Chapter 6)

Intellectual abilities are commonly thought to be set from birth by our genetic wiring, but science is finding the brain is surprisingly mutable: Effortful learning builds new connections and mental abilities. Evidence suggests the path to expert performance may rely more on discipline and persistence than on genetic gifts. Memory athletes using mental tools for organizing large bodies of information are now performing astonishing feats of recall. In sum, our intellectual abilities are to a considerable degree ours to shape. Learners who adopt a growth mindset and show grit prove more successful in school and in their later pursuits. (Chapter 7)

Students and lifelong learners alike will benefit from structured learning that includes spaced and interleaved retrieval practice, elaboration, generation, reflection, and use of mnemonic devices. Teachers should explain how learning works, teach learners how to study, incorporate desirable difficulties in the classroom, and make retrieval practice a cornerstone of student learning. (Chapter 8)