

NOTES FROM: *Make It Stick*, by Peter C. Brown, Henry L. Roediger III, and Mark A. McDaniel

SUMMARY: Everything you want in life is on the other side of effort and sacrifice. In life, we appreciate what we worked hardest for, and in education, we remember what we struggled to learn.

That's one of the core messages in *Make It Stick*, which represents the gold standard when it comes to books about effective study strategies and efficient learning.

Basically, we remember the information that we recall to mind most frequently, and the more effortful it is to do so, the more entrenched it becomes in our minds and the less likely we are to forget it when we need to use it.

At the end of the day, the universe rewards effort, exertion, and striving. We need to go *beyond* what we think we can do if we want to find out how far we can really go.

This same theme - the hardest path usually being the best - shows up again and again in life, and *Make It Stick* will show you how applying that wisdom to your studying and your practicing will allow you to reach levels of mastery that are simply unavailable to people who aren't familiar with the science of successful learning.

“It comes down to the simple but no less profound truth that effortful learning changes the brain, building new connections and capability. This single fact - that our intellectual abilities are not fixed from birth but are, to a considerable degree, ours to shape - is a resounding answer to the nagging voice that too often asks us, 'Why bother?' We make the effort because the effort itself extends the boundaries of our abilities. What we do shapes who we become and what we're capable of doing. The more we do, the more we can do.”

“We have been raised to think that the brain is hardwired and our intellectual potential is more or less set from birth. We now know otherwise. Average IQs have risen over the past century with changes in living conditions. When people suffer brain damage from strokes or accidents, scientists have seen the brain somehow reassign duties so that adjacent networks of neurons take over the work of damaged areas, enabling people to regain lost capacities. Competitions between 'memory athletes' like James Paterson and Nelson Dellis have emerged as an international sport among people who have trained themselves to perform astonishing acts of recall. Expert performance in medicine, science, music, chess, or sports has been shown to be the product not just of innate gifts, as had long been thought, but of skills laid down layer by layer, through thousands of hours of dedicated practice. In short, research and the modern record have shown that we and our brains are capable of much greater feats than scientists would have thought possible even a few decades ago.”

“*Rereading text and massed practice* of a skill or new knowledge are by far the preferred study strategies of learners of all stripes, but they're also among the *least productive*.”

“Learning is at least a three-step process: initial encoding of information is held in short-term working memory before being consolidated into a cohesive representation of knowledge in long-term memory. Consolidation reorganizes and stabilizes memory traces, gives them meaning, and makes connections to past experiences and to other knowledge already stored in long-term memory. Retrieval updates learning and enables you to apply it when you need it.”

“Durable, robust learning requires that we do two things. First, as we recode and consolidate new material from short-term memory into long-term memory, we must anchor it there securely. Second, we must associate the material with a diverse set of cues that will make us adept at recalling the knowledge later. Having effective retrieval cues is an aspect of learning that often goes overlooked. The task is more than committing knowledge to memory. Being able to retrieve it when we need it is just as important.”

“It appears that embedding new learning in long-term memory requires a process of consolidation, in which memory traces (the brain's representations of new learning) are strengthened, given meaning, and connected to prior knowledge - a process that unfolds over hours and may take several days.”

“There’s virtually no limit to how much learning we can remember as long as we relate it to what we already know. In fact, because new learning depends on prior learning, the more we learn, the more possible connections we create for further learning. Our retrieval capacity, though, is severely limited. Most of what we've learned is not accessible to us at any given moment. This limitation on retrieval is helpful to us: if every memory were always readily to hand, you would have a hard time sorting through the sheer volume of material to put your finger on the knowledge you need at the moment.”

“The act of retrieving learning from memory has two profound benefits. One, it tells you what you know and don't know, and therefore where to focus further study to improve the areas where you're weak. Two, recalling what you have learned causes your brain to reconsolidate the memory, which strengthens its connections to what you already know and makes it easier to recall in the future. In effect, retrieval - testing - interrupts forgetting.”

“In very short order we lose something like 70 percent of what we've just heard or read. After that, forgetting begins to slow, and the last 30 percent or so falls away more slowly, but the lesson is clear: a central challenge to improving the way we learn is finding a way to interrupt the process of forgetting.”

“When practice is spaced, interleaved, and varied, it requires more effort. You feel the increased effort, but not the benefits the effort produces. Learning feels slower from this kind of practice, and you don't get the rapid improvements and affirmations you're accustomed to seeing from massed practice.”

“Reflection can involve several cognitive activities we have discussed that lead to stronger learning. These include retrieval (recalling recently learned knowledge to mind), elaboration (for example, connecting new knowledge to what you already know), and generation (for example, rephrasing key ideas in your own words or visualizing and mentally rehearsing what you might do differently next time).”

“How ably you can explain a text is an excellent cue for judging comprehension, because you must recall the salient points from memory, put them into your own words, and explain why they are significant - how they relate to the larger subject.”

“Students who have been quizzed have a double advantage over those who have not: a more accurate sense of what they know and don't know, and the strengthening of learning that accrues from retrieval practice.”

“Most important is to make frequent use of testing and retrieval practice to verify what you really do know versus what you think you know. Frequent low-stakes quizzes in class help the instructor verify that students are in fact learning as well as they appear to be and reveal the areas where extra attention is needed. Doing cumulative quizzing is especially powerful for consolidating learning and knitting the concepts from one stage of a course into new material encountered later.”

Aeschylus: “Memory is the mother of all wisdom.”

“If you're good at learning, you have an advantage in life.”

“We are *poor judges* of when we are learning well and when we are not. When the going is harder and slower and it doesn't feel productive, we are drawn to strategies that feel more fruitful, unaware that the gains from these strategies are often temporary.”

“*Retrieval practice* - recalling facts or concepts or events from memory - is a more effective learning strategy than review by rereading. Flashcards are a simple example. Retrieval strengthens the memory and interrupts forgetting. A single, simple quiz after reading a text or hearing a lecture produces better learning and remembering than rereading the text or reviewing lecture notes. While the brain is not a muscle that gets stronger with exercise, the neural pathways that make up a body of learning do get stronger when the memory is retrieved and the learning is practiced. Periodic practice arrests forgetting, strengthens retrieval routes, and is essential for hanging onto the knowledge you want to gain.”

“Retrieval practice that you perform at different times and in different contexts and that interleaves different learning material has the benefit of linking new associations to the material. This process builds interconnected networks of knowledge that bolster and support mastery of your field. It also multiplies the cues for retrieving the knowledge, increasing the versatility with which you can later apply it.”

"When you *space out practice* at a task and get a little rusty between sessions, or you interleave the practice of two or more subjects, retrieval is harder and feels less productive, but the effort produces longer lasting learning and enables more versatile application of it in later settings."
"Trying to solve a problem *before being taught the solution* leads to better learning, even when errors are made in the attempt."

"If you practice *elaboration*, there's no known limit to how much you can learn. Elaboration is the process of giving new material meaning by expressing it in your own words and connecting it with what you already know. The more you can explain about the way your new learning relates to your prior knowledge, the stronger your grasp of the new learning will be, and the more connections you create that will help you remember it later."

"People who learn to *extract the key ideas from new material and organize them into a mental model* and connect that model to prior knowledge show an advantage in learning complex mastery."

"Many people believe that their intellectual ability is hardwired from birth, and that failure to meet a learning challenge is an indictment of their native ability. But every time you learn something new, *you change the brain* - the residue of your experiences is stored. It's true that we start life with the gift of our genes, but it's also true that we become capable through the learning and development of mental models that enable us to reason, solve, and create. In other words, the elements that shape your intellectual abilities lie to a surprising extent within your own control. Understanding that this is so enables you to see failure as a badge of effort and a source of useful information - the need to dig deeper or to try a different strategy. The need to understand that when learning is hard, you're doing important work."

"What's the conclusion? It makes sense to reread a text once if there's been a meaningful lapse of time since the first reading, but doing multiple readings in close succession is a time-consuming study strategy that yields negligible benefits at the expense of much more effective strategies that take less time."

"How did he study for the test? she asks. Well, he'd gone back and highlighted his notes, and then reviewed the highlighted notes and his highlighted text material several times until he felt he was thoroughly familiar with all of it. How could it be that he had pulled a D on the exam? Had he used the set of key concepts at the back of each chapter to test himself? Could he look at a concept like 'conditioned stimulus,' define it, and use it in a paragraph? While he was reading, had he thought of converting the main points of the text into a series of questions and then later tried to answer them while he was studying? Had he at least rephrased the main ideas in his own words as he read? Had he tried to relate them to what he already knew? Had he looked for examples outside the text? The answer was no in every case. He sees himself as the model student, diligent to a fault, but the truth is he doesn't know how to study effectively."

"Giving feedback strengthens retention more than testing alone does, and, interestingly, some evidence shows that delaying the feedback briefly produces better long-term learning than immediate feedback."

“After an initial test, *delaying subsequent retrieval practice* is more potent for reinforcing retention than immediate practice, because delayed retrieval requires more effort.”

“*Repeated retrieval* not only makes memories more durable but produces knowledge that can be retrieved more readily, in more varied settings, and applied to a wider variety of problems.”

“For Coach Dooley's team, it's all there: retrieval, spacing, interleaving, variation, reflection, and elaboration. The seasoned quarterback going into Saturday's game - mentally running through the plays, the reactions, the adjustments - is doing the same thing as the seasoned neurosurgeon who's rehearsing what's about to unfold in the operating room.”

“The time periods between sessions of practice let memories consolidate. Sleep seems to play a large role in memory consolidation, so practice with at least a day in between sessions is good.”
“Interleaving can also help you develop your ability to *discriminate* later between different kinds of problems and select the right tool from your growing toolkit of solutions. In interleaving, you don't move from a complete practice set of one topic to go to another. *You switch before each practice is complete.*”

“Like interleaving, *varied practice* helps learners build a broad schema, an ability to assess changing conditions and adjust responses to fit.”

“Problems and opportunities come at us unpredictably, out of sequence. For our learning to have practical value, we must be adept at discerning 'What kind of problem is this?' so we can select and apply an appropriate solution.”

“*Reflection is a form of retrieval practice* (What happened? What did I do? How did it work out?), enhanced with elaboration (What would I do differently next time?).”

“New learning is labile: its meaning is not fully formed and therefore is easily altered. In consolidation, the brain reorganizes and stabilizes the memory traces. This may occur over several hours or longer and involves deep processing of the new material, during which scientists believe that the brain replays or rehearses the learning, giving it meaning, filling in blank spots, and making connections to past experiences and to other knowledge already stored in long-term memory. Prior knowledge is a prerequisite for making sense of new learning, and forming those connections is an important task of consolidation.”

“An apt analogy for how the brain consolidates new learning may be the experience of composing an essay. The first draft is rangy, imprecise. You discover what you want to say by trying to write it. After a couple of revisions, you have sharpened the piece and cut away some of the extraneous points. You put it aside to let it ferment. When you pick it up again a day or two later, what you want to say has become clearer in your mind. Perhaps you now perceive that there are three main points you are making. You connect them to examples and supporting information familiar to your audience. You rearrange and draw together the elements of your argument to make it more effective and elegant. Similarly, the process of learning something often starts out feeling disorganized and unwieldy; the most important aspects are not always salient.

Consolidation helps organize and solidify learning, and, notably, so does retrieval after a lapse of some time, because the act of retrieving a memory from long-term storage can both strengthen the memory traces and at the same time make them modifiable again, enabling them, for example, to connect to more recent learning. This process is called *reconsolidation*. This is how retrieval practice modifies and strengthens learning."

"It is a critical point that as you learn new things, you don't lose from long-term memory most of what you have learned well in life; rather, through disuse or the reassignment of cues, you forget it in the sense that you're unable to call it up easily. For example, if you've moved several times, you may not be able to recall a previous address from twenty years ago. But if you are given a multiple choice test for the address, you can probably pick it out easily, for it still abides, as it were, in the uncleaned closet of your mind. If you have ever immersed yourself in writing stories of your past, picturing the people and places of earlier days, you may have been surprised by the memories that started flooding back, things long forgotten now coming to mind. Context can unleash memories, as when the right key works to open an old lock."

"It's better to solve a problem than memorize a solution."

"Good judgment is a skill one must acquire, becoming an astute observer of one's own thinking and performance. We start at a disadvantage for several reasons. One is that when we're incompetent, we tend to overestimate our competence and see little reason to change. Another is that, as humans, we are readily misled by illusions, cognitive biases, and the stories we construct to explain the world around us and our place within it. To become more competent, or even expert, we must learn to recognize competence when we see it in others, become more accurate judges of what we ourselves know and don't know, adopt learning strategies that get results, and find objective ways to track our progress."

"Learning when to trust your intuition and when to question it is a big part of how you improve your competence in the world at large and in any field where you want to be an expert."

"The discomfort with ambiguity and arbitrariness is equally powerful, or more so, in our need for a rational understanding of our own lives. We strive to fit the events of our lives into a cohesive story that accounts for our circumstances, the things that befall us, and the choices we make. Each of us has a different narrative that has many threads woven into it from our shared culture and experience of being human, as well as many distinct threads that explain the singular events of one's personal past. All these experiences influence what comes to mind in a current situation and the narrative through which you make sense of it."

"It is a confounding paradox, then, that the changeable nature of our memory not only can skew our perceptions but also is essential to our ability to learn."

"What psychologists call the *curse of knowledge* is our tendency to underestimate how long it will take another person to learn something new or perform a task that we have already mastered."

“Something you once heard that you hear again later carries a warmth of familiarity that can be mistaken for memory, a shred of something you once knew and cannot quite place but are inclined to believe. In the world of propaganda, this is called "the big lie" technique - even a big lie told repeatedly can come to be accepted as truth."

“Our memories are also subject to *social influence* and tend to align with the memories of the people around us. If you are in a group reminiscing about past experiences and someone adds a wrong detail about the story, you will tend to incorporate this detail into your own memory and later remember the experience with the erroneous detail. This process is called 'memory conformity,' or the 'social contagion of memory': one person's error can 'infect' another person's memory. Of course, social influences are not always bad. If someone recalls details of a joint memory on which you are somewhat hazy, your subsequent memory will be updated and will hold a more accurate record of the past event."

"Humans are predisposed to assume that others share their beliefs, a process called the *false consensus effect*. We generally fail to recognize the idiosyncratic nature of our personal understanding of the world and interpretation of events and that ours differ from others."
“Action beats reaction every time.”

“Sometimes the most powerful feedback for calibrating your sense of what you do and don't know are the mistakes you make in the field, assuming you survive them and are receptive to the lesson."

“We acknowledge that everyone has learning preferences, but we are not persuaded that you learn better when the manner of instruction fits those preferences."

“Rich people were probably no smarter than he was, they just had knowledge he lacked.”

“People who as a matter of habit extract underlying principles or rules from new experiences are more successful learners than those who take their experiences at face value, failing to infer lessons that can be applied later in similar situations. Likewise, people who single out salient concepts from the less important information they encounter in new material and who link these key ideas into a mental structure are more successful learners than those who cannot separate the wheat from the chaff and understand how the wheat is made into flour."

“Each of us has a large basket of resources in the form of aptitudes, prior knowledge, intelligence, interests, and sense of personal empowerment that shape how we learn and how we overcome our shortcomings. Some of these differences matter a lot - for example, our ability to abstract underlying principles from new experiences and to convert new knowledge into mental structures. Other differences we may think count for a lot, for example having a verbal or visual learning style, actually don't."

“On any list of differences that matter most for learning, the level of *language fluency and reading ability* will be at or near the top."

“They found very few studies designed to be capable of testing the validity of learning styles theory in education, and of those, they found that virtually none validate it and several flatly contradict it. Moreover, their review showed that it is more important that the mode of instruction match the nature of the *subject* being taught: visual instruction for geometry and geography, verbal instruction for poetry, and so on. When instructional style matches the nature of the content, all learners learn better, regardless of their differing preferences for how the material is taught.”

“Psychologists today generally accept that individuals possess at least two kinds of intelligence. *Fluid intelligence* is the ability to reason, see relationships, think abstractly, and hold information in mind while working on a problem; *crystallized intelligence* is one's accumulated knowledge of the world and the procedures or mental models one has developed from past learning and experience. Together, these two kinds of intelligence enable us to learn, reason, and solve problems.”

“We're all in a state of developing expertise, and any test that measures only what we know at any given moment is a static measure that tells us nothing about our *potential* in the realm the test measures.”

“Just to predict the speed with which a horse would run the final quarter mile, the experts relied on a complex mental model involving as many as seven variables. The study found that IQ is unrelated to handicapping ability, and 'whatever it is that an IQ test measures, it is not the ability to engage in cognitively complex forms of multivariate reasoning.'”

“All knowledge and memory are physiological phenomena, held in our neurons and neural pathways. The idea that the brain is not hardwired but plastic, mutable, something that reorganizes itself with each new task, is a recent revelation, and we are just at the forefront of understanding what it means and how it works.”

“Another fundamental sign of the brain's enduring mutability is the discovery that the hippocampus, where we consolidate learning and memory, is able to generate new neurons throughout life. This phenomenon, called neurogenesis, is thought to play a central role in the brain's ability to recover from physical injury and in humans' lifelong ability to learn. The relationship of neurogenesis to learning and memory is a new field of inquiry, but already scientists have shown that the activity of associative learning (that is, of learning and remembering the relationship between unrelated items, such as names and faces) stimulates an increase in the creation of new neurons in the hippocampus. This rise in neurogenesis starts *before* the new learning activity is undertaken, suggesting the brain's intention to learn, and continues for a period *after* the learning activity, suggesting that neurogenesis plays a role in the consolidation of memory and the beneficial effects that spaced and effortful retrieval practice have on long-term retention.”

“IQ is a product of genes and environment. Compare it to height: it's mostly inherited, but over the decades as nutrition has improved, subsequent generations have grown taller. Likewise, IQs in every industrialized part of the world have shown a sustained rise since the start of standardized sampling in 1932, a phenomenon called the Flynn effect after the political scientist who first brought it to wide attention.”

“Richard Nisbett, in his book *Intelligence and How to Get It*, discusses the pervasiveness of stimuli in modern society that didn't exist years ago, offering as one example a puzzle maze McDonald's included in its Happy Meals a few years ago that was more difficult than the mazes included in an IQ test for gifted children. Nisbett also writes about 'environmental multipliers,' suggesting that a tall kid who goes out for basketball develops a proficiency in the sport that a shorter kid with the same aptitudes won't develop, just as a curious kid who goes for learning gets smarter than the equally bright but incurious kid who doesn't. The options for learning have expanded exponentially. It may be a very small genetic difference that makes one kid more curious than another, but the effect is multiplied in an environment where curiosity is easily piqued and readily satisfied.”

“When you praise for intelligence, kids get the message that being seen as smart is the name of the game. 'Emphasizing effort gives a child a rare variable they can control,' Dweck says. But 'emphasizing natural intelligence takes it out of a child's control, and it provides no good recipe for responding to a failure.’”

“Imagery serves to contribute vividness and connective links to memory. Humans remember pictures more easily than words. (For example, the image of an elephant is easier to recall than the word 'elephant.')

So it stands to reason that associating vivid mental images with verbal or abstract material makes that material easier to retrieve from memory. A strong mental image can prove as secure and bountiful as a loaded stringer of fish. Tug on it, and a whole day's catch comes to the surface. When a friend is reminding you of a conversation with somebody the two of you met on a trip, you struggle to recall it. She tells you where the discussion happened, and you picture the place. Ah, yes, it all comes flooding back. Images cue memories.”

“The versatility of mnemonic devices is almost endless. What they hold in common is a structure of some kind - number scheme, travel route, floor plan, song, poem, aphorism, acronym - that is deeply familiar and whose elements can be easily linked to the target information to be remembered.”

“It comes down to the simple but no less profound truth that *effortful learning changes the brain*, building new connections and capability. This single fact - that our intellectual abilities are not fixed from birth but are, to a considerable degree, ours to shape - is a resounding answer to the nagging voice that too often asks us, 'Why bother?' We make the effort because the effort itself extends the boundaries of our abilities. What we do shapes who we become and what we're capable of doing. The more we do, the more we can do. To embrace this principle and reap its benefits is to be sustained through life by a *growth mindset*. And it comes down to the simple fact that the path to complex mastery or expert performance does not necessarily start from exceptional genes, but it most certainly entails *self-discipline*, *grit*, and *persistence*; with these qualities in healthy measure, if you want to become an expert, you probably can.”

And whatever you are striving to master, whether it's a poem you wrote for a friend's birthday, the concept of classical conditioning in psychology, or the second violin part in Hayden's Fifth Symphony, *conscious mnemonic devices* can help to organize and cue the learning for ready retrieval until sustained, deliberate practice and repeated use form the deeper encoding and subconscious mastery that characterize expert performance."

"Retrieving knowledge and skill from memory should become your primary study strategy in place of rereading."

"The harder it is for you to recall new learning from memory, the greater the benefit of doing so. Making errors will not set you back, so long as you check your answers and correct your mistakes."

"What you don't sense when you're struggling to retrieve new learning is the fact that every time you work hard to recall a memory, you actually strengthen it. If you restudy something after failing to recall it, you actually learn it better than if you had not tried to recall it. The effort of retrieving knowledge or skills strengthens its staying power and your ability to recall it in the future."

"Anything you want to remember must be periodically recalled from memory."

"If you're trying to learn mathematical formulas, study more than one type at a time, so that you are alternating between different problems that call for different solutions. If you are studying biology specimens, Dutch painters, or the principles of macroeconomics, mix up the examples."

"Bloom's taxonomy classifies cognitive learning on six levels. It was developed in 1956 by a committee of educators chaired by psychologist Benjamin Bloom. The six levels range from gaining *knowledge* (the most fundamental level), to developing *comprehension* of the underlying facts and ideas, being able to *apply* learning to solve problems, being able to *analyze* ideas and relationships so as to make inferences, being able to *synthesize* knowledge and ideas in new ways, and, at the most sophisticated level, being able to use learning to *evaluate* opinions and ideas and make judgments based on evidence and objective criteria."

"Our brains are like a forest, and your memory is in there somewhere. You're here, and the memory is over there. The more times you make a path to that memory, the better the path is, so that the next time you need the memory, it's going to be easier to find it. But as soon as you get your notes out, you have short-circuited the path. You are not exploring for the path anymore; someone has told you the way."

"We have talked throughout this book about learning, not about education. The responsibility for learning rests with every individual, whereas the responsibility for education (and training, too) rests with the institutions of society. Education embraces a world of difficult questions. Are we teaching the right things? Do we reach children young enough? How should we measure outcomes? Are our young people mortgaging their futures to pay for a college degree? These are urgent issues, and we need to wrestle through them."

But while we're doing that, the techniques for highly effective learning that are outlined in this book can be put to use right now everywhere learners, teachers, and trainers are at work. They come at no cost, they require no structural reform, and the benefits they promise are both real and long-lasting."