



Summary of Make It Stick

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Although people spend their entire lives learning, most of them are doing it wrong. Strategies like rereading and drilling a skill over and over to commit it to memory take a lot of time and ultimately don't work.

Make It Stick teaches you the strategies that help you achieve **the two primary goals of learning: To *understand* and *remember* what you learn so you can use your knowledge in future situations.** In this summary, learn how a little forgetting helps you remember, and why you're not a good judge of how much you know.

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1-Page Summary

Learning is a lifelong process of building knowledge, experiences, and skills, and then storing them in your memory to apply to problems you encounter. But as natural as it may seem, **you have to learn *how to learn***.

Most people hold false beliefs about learning that lead them to use ineffective study methods, such as rereading and drilling the same skill over and over. These ineffective strategies and learning myths are ingrained in our educational system and perpetuated by teachers, coaches, parents, and peers.

By contrast, the most effective learning strategies are often counterintuitive. That's why **this book teaches you how to learn and study based on data about how your brain comprehends and retains information**.

The book's principles and prescriptions draw from a vast number of research studies. Two of the authors, cognitive scientists Henry Roediger and Mark McDaniel, collaborated with other researchers on a 10-year study about how to apply cognitive psychology to improve learning practices, and a number of their findings are included in the book.

If you want to improve your learning, you must first define your goals for learning and studying. This book doesn't help you simply pass the midterm—it teaches you how to absorb and master new information.

The two main goals of learning a new skill or concept are:

1. **Comprehension:** You want to gain a deep understanding of the underlying principle in order to understand how it applies to different situations.
2. **Retention:** You need to remember the information when a problem or situation calls for it, and when you get a chance to build upon it with more advanced knowledge.

Improve Comprehension Through Structure Building

When you're learning something new, instead of simply memorizing the information from your textbook or lecture notes, you'll gain a more meaningful understanding if you **identify the rules, which are the underlying principles that will guide you when you call on this knowledge to solve real-world problems**. In order to extract the main principles, you need to be able to weed out extraneous information.

Strategies to identify rules include:

1) Examining multiple *examples* at once—instead of one at a time—in order to more clearly see the common thread and extract the underlying principles.

- For instance, if you want to learn more about butterflies, instead of examining species one at a time, study a variety of butterfly species at once and note their similarities and differences.

2) Examining two different *problems* at once, in hopes of finding similarities or differences that illuminate the rules and help you reach each problem's solution.

- For instance, when solving two unrelated problems, such as 1) how to get a large group of firefighters across a river without breaking its fragile bridges and 2) how to treat a tumor without damaging the healthy tissue surrounding it, compare the problems. The similarities (a high volume of

something needs to reach a target, but sending it all at once will cause damage) might lead to solutions (direct smaller forces at the target through different passages—multiple bridges or different angles of radiation—at the same time).

Once you recognize the rules, **connect those principles with prior relevant knowledge**. This process—called structure building—creates context, which deepens your understanding.

Structures help you create mental models, which bring together interrelated concepts or skills into one fluid skillset. For example, driving a car requires knowledge of traffic laws as well as motor skills to push the brake pedal and turn the wheel with the right amount of force. At first, it feels like you're juggling several skills at once, but experience merges them all into a mental model that enables you to drive without consciously thinking about each individual action.

Mental models are essential for achieving mastery—such as the driver who appears to react instantaneously when another car abruptly cuts into her lane or suddenly brakes right in front of her. **The more mental models you have, the better prepared you are to navigate any situation.** Additionally, practicing your mental models in a variety of contexts improves your ability to apply them in different situations. For example, if you're skilled at driving a car in various road, weather, and environmental conditions, you'll be better able to apply those skills to driving a bus or an RV.

Improve Retention Through Retrieval Practice

Knowing a skill is one thing—but *remembering* it when a situation calls for it is what counts. And the better you remember something, the more reflexively you can recall that information when you need it.

Many people try to burn information into their memories by rereading, but this approach only commits the information to their short-term memories, making it a waste of time in the long run. Instead, **the most effective way to improve retention of new information is through retrieval practice**, which is any exercise that requires you to recall what you've learned. You can practice retrieval with classroom quizzes, flashcards, self-testing, and reflection, when you assess how you approached a particular problem and how you can improve next time.

Follow three principles to maximize the benefits of your retrieval practice:

1) More difficult retrieval leads to better retention. The harder your brain has to work to retrieve the information, the more firmly it cements it in your memory.

One way to create this “desirable difficulty” is by using generation, which requires you to generate the answer from memory (for example, using flashcards or short-answer questions instead of multiple-choice questions). Another way is to delay your retrieval practice long enough that your memory has gotten a little fuzzy and your brain has to work harder to retrieve the information.

2) Frequent testing improves retention. Regular testing deepens your comprehension, which improves your ability to apply the knowledge in different contexts. And the longer you continue regular testing—even after you feel that you've mastered the skill—the longer-lasting your retention will be.

The most effective testing schedule is to build in a slight delay before the first test, and then follow up with regular testing at various intervals.

3) Corrective feedback is crucial to prevent students from remembering the wrong answer, and to reinforce the correct information.

Corrective feedback is most effective when it's slightly delayed, because immediate feedback can become a crutch in learning and mastering the material. Immediate feedback is like learning to ride a bike with training wheels—the correction is so automatic that you begin to rely on that support, which inhibits you from truly learning and mastering the skill.

Spaced Practice

As we mentioned, spacing out your retrieval practice creates desirable difficulties that improve your retention. Instead of focusing on one skill or topic at a time—a strategy called massed practice—**spaced practice gives your brain the time it needs to strengthen new knowledge and store it in your long-term memory through a process called consolidation.**

There are two strategies that naturally space your practice:

1) **Interleaved practice mixes your practice among multiple related topics or skills.** For example, if you're learning how to calculate volumes of different geometric shapes, mix up the problems—doing a sphere problem, then a cube problem, then another sphere problem—instead of grouping your practice problems by shape. Not only does interleaving space your practice, but it also helps you make mental connections to the other subjects you mix in.

The key to interleaving is to switch to the next skill or concept before you've finished practicing one. It feels frustrating to switch gears before you're ready, but this method improves your long-term retention.

2) **Varied practice involves practicing a skill in different contexts.** This strategy strengthens your understanding of the underlying principles and your ability to apply that skill in a variety of situations, as in the example of improving your driving skills by practicing in various weather conditions.

Inaccurate Self-Assessment Inhibits Learning

In order to expand your learning, you need to know what you know, what you don't know, and what you need to work on. But **people are poor judges of their own knowledge and abilities, and those miscalculations can inhibit learning.**

There are several reasons humans struggle to accurately gauge their own competencies:

- **Perceptual illusions** distort your senses and make you misinterpret images, sounds, or other sensations. For example, pilots can encounter optical illusions or, in extreme situations, illusions that make them think the plane is flying level when it's actually tilted.
- **Cognitive biases** are caused by systematic problems with your way of thinking that impact your judgment and decision making. For example, the bandwagon effect is a cognitive bias that makes people more likely to think or do something if other people think or do it.
- A **"hunger for narrative"**—the natural desire to create narratives that explain why things are the way they are—leads people to misinterpret situations. Narratives are a stronger influence than objective facts, yet people fail to recognize or vastly underestimate this influence. For example, if your parents made a lot of money from running their own business, you may extoll the concept of pulling yourself up by your bootstraps and climbing the socioeconomic ladder, and you may have a hard time understanding anyone's argument for social welfare programs.
- **Distorted memories** lead people to color their memories with false details, and even claim to remember something that never happened. The human memory is inherently moldable, lending itself to distortions and false memories. For example, if a witness to a crime views photos of suspects

and then subsequently looks at a lineup, she's more likely to falsely accuse someone in the lineup if she's already seen his photo.

- **Misdiagnosing a problem** and failing to recognize that it requires a different approach than what your mental model dictates. For example, brain surgeons typically have to perform surgery slowly and steadily, but if certain conditions create pressure in the brain, their patients' lives depend on them doing the opposite and working as quickly as possible.
- **Oblivious incompetence** makes people overestimate their own abilities and underestimate their need to improve.

When these factors impede your ability to accurately gauge your knowledge and ability, you don't know where your gaps in knowledge are. You're less likely to spend the extra time practicing the things you need to work on, and when a real-life situation calls for that knowledge, you fall flat.

However, you can improve your gauge of your own competence. Use these learning strategies to help you keep an accurate view:

- **Apprenticeship:** Learning alongside a seasoned veteran gives you a clearer view of your skill level compared to an expert's.
- **Peer Instruction:** Collaborative learning with your peers helps you to avoid the kinds of misconceptions you can have when you study by yourself.
- **Peer Review:** Your fellow students or professionals can tell if you're doing a good job or not, and if they give you honest feedback, you can adjust and improve as needed.
- **Team Learning:** When you work in a team of people who have complementary skills, each member of the team has an opportunity to learn from the others. Additionally, each person's strengths are on display, and it's often apparent if someone is falling short.
- **Real-World Simulations:** Training under conditions that resemble what you will face in real-life situations is the best way to hone your skills and see any gaps between conceptual learning and application.

Don't Let Learning Styles Limit You

Aside from illusions that alter your perception of your *knowledge*, your learning can also be impeded by myths about your *ability* to learn. There's a common belief that everyone has a learning style—such as auditory, kinesthetic, or visual—and that individuals learn best when the style of instruction matches their learning style.

There are two problems with this belief:

1. While it may be true that people have distinct preferences about the way they learn, research shows that learning isn't inhibited if the style of teaching doesn't match the learning style. In fact, **everyone learns best when the style of instruction matches the subject of the lesson**, such as using visual means to teach geometry, audio to teach foreign language, or kinesthetic to teach physics principles on motion.
2. **A focus on learning styles tends to limit a student's views of her own abilities and potential.** That limitation can affect the student's confidence to try new things, how much effort she puts forth, and her perseverance in the face of obstacles.

Intelligence Isn't Fixed

In addition to the myth of learning styles, the myth that intelligence is fixed also impedes people's learning. When people believe they're born with a predetermined capacity for learning, they don't put as much effort into learning. However, **intelligence isn't fixed**.

In fact, Americans' average IQ has risen over time. Several factors affect IQ scores, including a person's genes, environment, socioeconomic status, and nutrition.

Make the Most of Your Intelligence

You don't have to raise your IQ score to maximize your intelligence.

Here are three strategies for raising your abilities:

1) **Have a growth mindset.** People with growth mindsets understand that effort and discipline are critical to learning, so they work harder, take more risks, and view failures as learning opportunities. By contrast, people with fixed mindsets believe intelligence is fixed and that it determines success, so they become helpless in the face of failure because they attribute it to their lack of innate ability.

2) **Perform deliberate practice.** Deliberate practice is crucial to reaching mastery, and it's distinct from mere repetition because it's solitary, it's goal-oriented, and it consistently pushes you past your current ability. Pushing yourself, failing, troubleshooting, and trying again are necessary to create mental models and achieve mastery.

3) **Use memory cues.** Memory cues help you organize and retain information using familiar triggers. Memory cues include mnemonic devices like acronyms or more complex tools like memory palaces.

Put These Strategies Into Practice

Now that you understand the principles of effective learning, here are some tips for applying them.

Students and learners, take an active approach to your learning:

- Pause regularly to ask yourself questions about the key concepts in the material you're learning.
- Think of a metaphor or image that demonstrates the principle you're learning.
- Try to define concepts before finding the definition, and try to solve math and science problems before learning the formula.
- As you study, create questions to quiz yourself later.
- Regularly quiz yourself on new and past material, interleaving multiple subjects. Study the topics of the questions you get wrong.

Teachers, teach your students about the principles and strategies of effective learning—the importance of desirable difficulties, failure, and pushing beyond current ability. Incorporate them into your curriculum by:

- Using the principles of spacing, interleaving, and variation in your lesson planning.
- Giving frequent, low-stakes quizzes that incorporate past material.
- Providing study aids that use retrieval practice, elaboration, and generation—such as practice tests and short-answer exercises.
- Asking students to spend 10 minutes at the end of class writing about everything they remember from the day's lessons. After the 10 minutes, they should revisit their notes to find out what they've forgotten, and then study that information.
- Putting students into small groups to collaborate on high-level conceptual questions posed by the

teacher, or on concepts they're struggling with in the material.

Introduction

Learning is a lifelong process of building knowledge, experiences, and skills, and then storing them in your memory to apply to problems you encounter. But as natural as it may seem, **you have to learn *how to learn***.

Most people hold false beliefs about learning that lead students to study ineffectively and teachers to teach ineffectively. These methods include:

- Rereading a text multiple times
- Drilling the same skill over and over
- Presenting information in an easily digestible way
- Designing lessons that match students' learning styles

The most effective strategies for deep comprehension and long-term retention are actually counterintuitive to the logic behind the most common methods. That's why this book teaches you how to learn and study based on data about how your brain comprehends and retains information.

The book's principles and prescriptions draw from a vast number of research studies. Two of the authors, cognitive scientists Henry Roediger and Mark McDaniel, collaborated with other researchers on a 10-year study about how to apply cognitive psychology to improve learning practices, and a number of their findings are included in the book.

We'll explore principles and strategies to become a more effective learner. The principles include:

1. When learning is hard, it sticks with you.
2. Making and learning from mistakes are necessary aspects of the learning process.
3. You're not a good judge of how well you're absorbing a lesson, or how well you know something you learned previously.
4. Students don't learn any better when the lesson matches their preferred learning styles.
5. Your intelligence is not predetermined.

The strategies you'll learn include:

1. **Creating Mental Models:** Group interrelated concepts or skills into one fluid skillset
2. **Retrieval Practice:** Recalling information from memory
3. **Generative Learning:** Trying to solve a problem before you're given the solution, even if you do it wrong
4. **Spaced Practice:** Spacing out your study and practice sessions
5. **Interleaving:** Mixing your studying among multiple related subjects
6. **Varied Practice:** Practicing a skill in different contexts

Exercise: How Do You Learn?

What are you doing right—and wrong—when you learn and study a new skill?

Imagine you're in class and the teacher assigns a chapter of reading. How do you approach that text to

maximize your learning? (For instance, do you read the text multiple times? Attempt to memorize key facts?)

The next day, the teacher lectures on the material from the chapter. What do you do? (For example, do you write down every word? Simply listen and absorb the information?)

Describe a situation when you diligently performed your go-to study methods and still fell short on the test.

To what did you attribute that underperformance?

1: What Happens In Your Brain When You Learn

Before we dig into the strategies for maximizing your learning, let's explore what happens in your brain when you learn.

1) **Encoding:** When you learn something new, your brain encodes it by creating memory traces, which are mental representations of the information. The memory traces are stored in the short-term memory, **as if your brain were taking notes in a notebook.**

2) **Consolidation:** The memory traces in your short-term memory are still somewhat pliable, so **the consolidation process strengthens the knowledge and transfers it to your long-term memory.** Scientists believe that during consolidation, your brain rehashes the lesson, fleshes out gaps in the memory traces, and connects the new information to your prior knowledge and experiences. This process requires hours or days, and experts believe sleep aids in consolidation. (Shortform note: Read more about how sleep improves learning [in our summary of Why We Sleep.](#))

Compare consolidation to revising an essay: Your first draft is rough but gets the general ideas down, like the encoding process. Then, as you edit the paper, you fill in the gaps and it becomes more refined. Finally, after you put it away for a while and then come back to write the final draft, your thoughts clarify and you gain a better sense of what your thesis is and how to illustrate it to readers by drawing links to information they already know.

3) **Retrieval:** The purpose of learning is to have that knowledge on hand when you need it—whether you're solving a math problem or speaking a second language. This requires that you commit the information to your long-term memory, and that you create retrieval cues, which connect the new information to your prior knowledge and experiences.

For example, a Marine learning to parachute in jump school must learn how to hit the ground to minimize injury. First, trainees practice falling from a standing position and get corrective feedback on their positioning. Then, they do the same from two feet off the ground. The Marines apply their knowledge to each progressive level of difficulty as they fall from higher and higher off the ground, incorporating more complicated skills at each level.

Each time you practice, you create a new experience, creating a new cue and further cementing that knowledge in your memory. **Retrieval cues help you pull up the information in different situations, making the difference between retaining static facts and being able to use the knowledge when a situation calls for it.** The more retrieval cues you have, the more readily you can recall information.

Additionally, when you retrieve knowledge from your memory, you trigger *reconsolidation*, which further bolsters the memory traces and allows you to form even more connections with information you've learned since the knowledge was first consolidated.

Your Brain Is Built for Learning

Learning is a lifelong process. Your brain is designed with plasticity and flexibility that allow you to learn and adapt—for example, the way a blind person's brain heightens her other senses to compensate for her lack of vision.

You're born with billions of nerve cells called neurons. Your neurons sprout axons, which stretch like

branches to connect with other neurons' receiving ports, called dendrites. When an axon connects with a dendrite, this connection is called a synapse. Synapses are the circuits through which signals and information travel.

Some axons have a waxy coating called myelin, which acts like the plastic that's wrapped around the wires on electrical cords. Scientists believe that **the more you practice a skill, the thicker the myelin coating on the associated axons—and the thicker the myelin, the stronger and faster the signals to perform that skill**. This explains how, after thousands of hours of practice, professional basketball players' dribbling synapses are so heavily myelinated that they can do it reflexively.

When skills become habit, experts believe your brain links the motor skill with the cognitive action so that they fire off simultaneously and subconsciously, rather than through a conscious (albeit rapid) thought process. The habit is then recoded and stored deep in the brain, in the basal ganglia, where eye movements and other subconscious acts originate. Many people experience this in the way they type on a computer keyboard without thinking about what their fingers are doing.

Your brain continues to make new neurons your entire life. This process is called neurogenesis, and it happens in the hippocampus—the same area that consolidates new information and memories. Research is ongoing about the connection between neurogenesis and learning and memory, but there is evidence that **when you make connections between different types of information, it stimulates neurogenesis**.

2: Improve Comprehension: Identify Underlying Principles

Now let's explore how to put this information to use with strategies to help you learn and study more effectively.

The two main goals of learning a new skill or concept are:

1. **Comprehension:** You want to gain a deep understanding of the underlying principle in order to understand how it applies to different situations.
2. **Retention:** You need to remember the information when a problem or situation calls for it, and when you get a chance to build upon it with more advanced knowledge

In this section, we'll tackle how to improve your comprehension.

Step 1: Rule Learning

When you're learning something new, simply memorizing the information from your textbook or lecture notes leads to a shallow comprehension of the topic. Instead, you'll gain a more meaningful understanding if you first identify the underlying principles—the rules. **The rules are the common denominators among different examples and contexts, and they'll guide you when you call on this knowledge to solve real-world problems.**

People who are naturally adept at recognizing the key concepts in lessons and situations are *rule learners*. Rule learners know how to weed out irrelevant information to distill the main points.

By contrast, *example learners* remember specific examples, but they struggle to extract the underlying principles. As a result, they don't know how to navigate new situations that don't match the examples.

How Example Learners Can Improve

Example learners aren't destined to struggle—there are strategies to improve.

One method is to **study multiple examples at once—instead of one at a time—in order to more clearly see the common thread** and extract the underlying principles.

Similarly, another method is to examine two different problems at once, in hopes of finding similarities or differences that illuminate the rules and help you reach each problem's solution. For example, in one study, students are given two problems:

1. An army attacking a castle must cross a moat, but the bridges are designed to explode if too many people cross at once.
2. An inoperable tumor must be treated with radiation, but the amounts of radiation that are small enough to avoid damaging the surrounding healthy tissue aren't enough to destroy the tumor.

The students struggle to find a solution to either question in isolation, until they look at both and try to discern the commonalities between them. In both problems:

1. Something relatively large needs to reach a target

2. Sending the full force all at once will cause disaster
3. Smaller portions of the force avoid disaster, but they don't deliver enough power to solve the problem

When students extract these similarities, they're more likely to reach a solution in which they direct smaller forces at the target through different passages—multiple bridges or different angles of radiation—at the same time. Additionally, **once students identify the underlying principles of the solution, they're able to apply it to all different kinds of problems.**

Step 2: Structure Building

After you've identified the rules, connect those principles with prior relevant knowledge. This process—called structure building—creates context, which deepens your understanding. Structure building also develops mental models, which bring together interrelated concepts or skills into one fluid skill set. We'll talk more about mental models next.

High structure builders are adept not only at rule learning, but also at recognizing when additional information adds values to their structures. *Low structure builders*, on the other hand, struggle with these skills.

How Low Structure Builders Can Improve

Experts are unsure whether high structure builders have an innate cognitive advantage, or pick up the skill intuitively.

Regardless of the explanation, low structure builders can improve using these methods:

1. **Regularly stop while listening to a lesson or reading a text** to ask yourself what the main concepts are.
2. Reflect on what you're learning or how you applied the knowledge in a particular situation. Think about how you solved a problem, what you could have done differently, and how you can improve next time. **Reflecting on a problem naturally crystallizes the main ideas.**

Mental Models

As we mentioned, mental models group knowledge and skills together to create more complex skills.

For example, driving a car involves a broad range of knowledge and skills: You must understand traffic laws, know how hard to push the gas and brake pedals, and know how to turn on your windshield wipers without taking your eyes and mind off the road. At first, it feels like you're juggling all these new skills at once, but **over time and practice they all merge into a mental model that enables you to drive without consciously thinking about each individual action.**

You can adapt your mental models to different situations—for example, applying your knowledge of driving a car to learn how to drive a bus or a big rig. Just like practicing a specific skill, when you *practice* your mental models in different contexts, you improve your ability to *apply* them in different situations.

Forming mental models is an essential step to achieving mastery in a skill or subject. People who become experts in their work—such as professional musicians or NBA players—practice thousands of hours until they've amassed an array of mental models for practically any possible situation. Then, when they're playing

a concert or a playoff game, they can agilely apply whichever mental model they need in any situation.

Exercise: Improve Your Comprehension

Use this exercise to practice identifying rules and build structures.

What was the last article or nonfiction book (or summary) you read?

What was the main takeaway of the text?

Consider whether your takeaway could apply in a completely different context. If not, how could you boil it down to a more fundamental rule?

Describe an experience you had—before or since that experience—in which that rule could apply.

3: Improve Retention: Retrieval Practice

You've extracted the key concepts from a lesson and used them to build a mental model. Now you need to remember the information.

The most effective way to improve retention of new information is through retrieval practice. **Retrieval is any exercise that requires you to recall the information or skill you've learned.** Retrieval practice can take the form of:

- A classroom quiz
- Self-testing with flashcards
- Making up your own questions about key concepts to test yourself later

Think of learning like stringing beads for a necklace: Every new fact, concept, and skill is a bead, and your memory is the string. The beads will simply slide off the other end of the string if you don't tie a knot to keep them in place. Retrieval is the knot at the end of the string that prevents you from forgetting what you learn. When you repeatedly practice retrieval, you're double- and triple-knotting the string to make sure the beads don't slip off.

The better you remember something, the more reflexively you can recall that information when you need it, which is a key aspect of mastery. For example, a quarterback practices movements and scenarios until they become second nature—because when it's game time, he won't have a spare second to stop and think about what he has to do.

Before we explain how to maximize the benefits of retrieval practice, let's go over the problems with the strategies most people use: Rereading and massed practice.

Why Rereading and Massed Practice Don't Work

You have a test or presentation in a few days. You have pages of notes you need to burn into your memory. What do you do?

If you're like most people, you read the material—and then read it again, and again, perhaps highlighting and annotating along the way.

Most people believe that rereading and massed practice (practicing one thing over and over in one sitting) are the most effective ways to learn and remember information. However, single-subject focus and endless repetition present three problems:

1) **They take a lot of time.** The time you spend rereading would be better spent using other, more effective strategies, which we'll get into later.

2) **They don't help you remember the information long term.** You may remember the material long enough to pass a test the following day, but you'll forget most of it by the time the midterm rolls around. In fact, research proves that retention quickly fades with these methods.

In a pair of identical experiments conducted at two different universities, one group of participants read the material once, and another group read it twice in one sitting. When both groups were tested right after reading, the group that read the material twice did slightly better. However, when the groups were tested later, there was no difference—the benefit of rereading was only temporary.

3) **They fool you into thinking you've mastered the material.** Rereading in succession makes you more familiar with the specific text and its wording, which tricks you into thinking you've mastered the concepts *behind* the text. **Mastery requires you to know the information, grasp the underlying ideas and concepts, and understand how to apply them to different situations.**

You may have understood a concept as it's described in a lecture or a textbook, but can you explain it to someone else in your own words? Can you come up with another example of it? Can you apply it to another context? Rereading alone doesn't illuminate where your gaps in understanding are.

Now, let's explore how to improve retention through retrieval practice.

Principle 1: More Difficult Retrieval Leads to Better Retention

There is a myth among some educators that learning and studying are more effective when they're presented in ways that are easy and enjoyable. If students are engaged and having fun, they must also be learning, right?

On the contrary, **the harder your brain has to work to retrieve the information, the better it cements it in your memory.** You can make retrieval more challenging in two ways:

1. By using generation, or generative learning, which requires you to *generate* the answer. Flashcards, short-answer questions, and essay prompts use generation, as opposed to true/false and multiple-choice questions, which offer possible answers.
2. By delaying the retrieval practice, which forces your brain to work harder to remember the material. **The delay should be long enough that your memory has gotten a little fuzzy, but not so long that you have to relearn the material.** The longer you wait before the first test, the more you'll forget in the interim. However, research shows that the rate of forgetting slows significantly after the first retrieval practice.

In one study, participants remembered pairs of words better when they had to use generation and first figure out one of the words in each pair and fill in missing letters. For example, participants were given the clue "foot-s__e" and had to determine that it should be "foot-shoe." Although the exercise was fairly simple, the additional effort of having to fill in the blanks—as opposed to simply reading the pairs—improved participants' retention.

Additionally, when participants were tested later, their memory was better if they were first exposed to a word pair and then had to fill in 20 other word pairs before doing their first retrieval practice. Again, **the slight delay made the initial retrieval a little harder, and that effort improved retention.**

Use Generation for Learning as Well as Retrieval

When you're first learning a concept, use generation by attempting to solve a problem before you know how. **Even if you come up with the wrong answer, you'll gain a deeper understanding and better retention of the solution when you learn it.**

There are two aspects to this:

1. As you try to figure out the answer, you search your brain for prior knowledge that might help lead you to it. For example, if you're trying to figure out the capital of Texas, you start by listing the Texas cities you know and anything you know about them. When you do learn the correct answer, your

prior knowledge is already pulled up and primed to make connections with this new information, which is a critical aspect of learning and retention.

2. When you fail to come up with the right answer to a problem, you pay more attention to the solution when you learn it.

Principle 2: Frequent Testing Improves Retention

In addition to the *difficulty*, the *timing* of your retrieval practice also impacts its effectiveness. **The most effective approach is to test soon after you're exposed to the material**—after a slight delay, as we discussed in Principle 1—**and then follow up with additional tests at various intervals.**

After the first test, the longer you continue to practice retrieval at spaced-out intervals, the longer-lasting your retention will be. Additionally, regular testing deepens your level of understanding, which improves your ability to apply the knowledge in different contexts.

One study had students listen to a story and then try to recall the 60 objects that were mentioned in the story. Retention among different groups of students shows the impact of immediate and frequent retrieval:

- Students tested right after hearing the story remembered 53% of the objects, and they could still remember 39% a week later.
- Students who weren't tested immediately only remembered 28% of the objects a week later.
- Students who were tested three different times within the first week remembered 53% of the objects a week later. (Shortform note: The book doesn't specify at what intervals they took the three tests.)

We'll talk more about spaced practice in the next chapter.

Principle 3: Corrective Feedback Aids Retention

Challenging yourself during retrieval strengthens your retention, but some mistakes are inevitable. **Corrective feedback is crucial because it prevents students from remembering the wrong answer and reinforces the correct information.**

Furthermore, when corrective feedback is slightly delayed, it leads to better retention than immediate feedback. Think of immediate feedback like learning to ride a bike with training wheels: You're corrected automatically and begin to rely on that support, inhibiting your true learning and mastery of the material.

Strategy #1: Use Reflection to Improve Performance and Retention

Now that you know the principles of retrieval practice, how can you apply them? One way is through reflection.

You can reflect on a lesson from class by looking at your notes or the text and using a strategy called elaboration, in which you rephrase the main concepts and connect them with your existing knowledge and prior experiences. For example, if you're reading a book about the history of Mexico, think about everything you already know about Mexico's past and present and see how your knowledge connects with the information in the text.

Additionally, **each real-world situation that requires you to use your knowledge and skills offers an**

opportunity to improve your performance and retention through reflection. After you have an experience that uses certain knowledge, think about:

- How you approached the situation
- How successful you were
- How you could improve next time

As you reflect, mentally rehearse how to apply your knowledge, which deepens its imprint in your mind.

Strategy #2: Use Retrieval in the Classroom With Regular Quizzes

Frequent tests and quizzes are another key element of retrieval practice. In a classroom setting, **testing is often used and thought of as a *measure* of students' retention, but it's generally overlooked as a *tool* to aid retention.** However, small changes can make a big impact on students' learning.

Instead of having just a few big tests during a semester, students benefit from more frequent tests, such as unit tests and low-stakes quizzes. In addition to improving retention, the benefits of this approach include:

- Increasing students' attendance, focus during lessons, and at-home studying because they know they have an impending test on the material.
- Decreasing students' testing anxiety, because each test or quiz has a smaller impact on their overall grades than if their entire grades depended on just two big tests. (Shortform note: The book doesn't cite this reason, but the regularity of testing may also make students more accustomed to and comfortable with testing.)
- Helping students gauge what they know and which topics they need to study more.
- Helping teachers gauge what students know and what material needs to be reviewed.

4: Spaced Practice: Benefits and Methods

Now that we know that spacing out your retrieval practice improves retention, we'll discuss why it works and offer some methods for spacing your practice.

Why Does Spaced Practice Work?

As we talked about, when you learn something new, your brain undergoes a process of consolidation, which can take hours or days. **Spaced practice gives your brain the time it needs to strengthen the new knowledge and store it in your long-term memory through consolidation.**

Additionally, the effort of retrieving the knowledge from your last practice session triggers reconsolidation, further embedding the information.

Spaced practice develops your “underlying habit strength,” which prepares you to use that knowledge when you need it. **Spaced practice feels less productive than massed practice initially because you’ve forgotten some of the material and it feels like you don’t have a grasp of it—but that extra effort is precisely what makes the method effective.**

Many people resist spaced practice because it doesn’t give them the immediate gratification of seeing improvements as they practice that comes with massed practice, which scientists call “momentary strength.”

However, that feeling belies the fact that momentary strength quickly fades, because massed practice stores information in your short-term memory.

Two Methods of Spaced Practice

There are two methods that improve comprehension and retention while organically spacing your practice.

Interleaved Practice

One way to space out your practice and improve your retention is by interleaving, or mixing up your practice among multiple related topics or skills. Interleaving improves your comprehension and retention in two ways:

1. Switching among different topics naturally spaces out your practice in any one area.
2. Changing your focus among related topics helps you make connections among them, which deepens your understanding of each subject.

The key to interleaving is to switch to the next skill or concept before you’ve finished practicing one. It feels counterintuitive and frustrating to switch gears before you’re ready, which is why teachers and students often resist interleaving.

In fact, in contrast to the momentary strength you get from massed practice, interleaving actually hinders your performance while you’re learning the material. However, in the long term, this method still results in better retention.

In one study, college students learned how to calculate the volumes of four geometric shapes. One group of

students solved practice problems that were grouped by the shape, while the other group of students solved an interleaved set of practice problems. That day, students doing massed practice performed better, averaging 89% correct answers, compared to 60% among students who did interleaved practice. However, on a test the following week, the students who'd done interleaved practice averaged 63% correct, whereas the other group dropped to 20%.

(Shortform note: Although the interleaved group improved slightly, while the massed practice group dropped drastically, the interleaved group never performed at a level close to the massed practice group's initial work. The book doesn't address how the interleaved group could have raised its score overall—perhaps simply by doing more interleaved practice.)

Interleaving simulates and better prepares you for the final test—and real life—where you'll encounter situations that require a mix of different skills and knowledge.

Varied Practice

Varied practice involves practicing a skill in different contexts, which strengthens your ability to apply that skill to a variety of situations. **Varied practice strengthens your understanding of the underlying principles and makes you better at discerning among different contexts to determine the best way to approach a situation.**

One study illustrates the effectiveness of variation: Two groups of children practiced throwing bean bags into buckets. The first group practiced only with buckets that were three feet away, while the other group practiced with a mix of buckets that were two and four feet away. After a few months of practicing, everyone was tested on throwing bean bags into buckets three feet away—and the kids who'd practiced on the mix of buckets (none of which were three feet away) far outperformed the kids who'd *only* practiced on three-foot buckets.

Neuroimages of people learning new motor skills reveal that varied practice engages an area of the brain that deals with more difficult motor skills, while mass practice engages a part of the brain that deals with simpler tasks. This suggests that **learning a skill through varied practice produces a more complex mastery, which broadens its applicability.**

Similar results have been found in cognitive tasks. One experiment asked a group of students to solve the same anagram (word scramble) repeatedly, while another group of students solved different anagrams that made the same word. When all the students were tested on the anagram that the first group had solved—the only anagram that group worked on throughout the experiment—the students in the second group still outperformed them.

However, when varying your practice, be careful not to slip into blocked practice, which is doing variations in the same order. Blocked practice is like failing to shuffle your flashcards: You get a variety of topics and practice spaced-out retrieval, but encountering them in the same order every time limits the effectiveness.

Interleaved and Varied Practice Improve Your Discrimination

Interleaved and varied practice strengthen your conceptual knowledge of the underlying principles, as opposed to a simple surface-level understanding of facts and figures.

The conceptual knowledge you gain through **these methods improves your ability to discriminate, or determine what knowledge or which skill you need in various situations.** This is a crucial aspect of using what you learn in real-life situations.

In one experiment, researchers asked participants to study several artists' paintings so that they could look at a piece of art and be able to identify the painter. Some participants used massed practice, studying each artist extensively before moving onto the next, while others used interleaving and switched among different artists.

Interleaving helped participants see the *differences* among different artists' works, as opposed to the *commonalities* in each individual artist's works. That ability to discriminate helped them identify who'd painted not only the paintings they'd studied, but also paintings they'd never seen before.

Continue Practicing Mastered Skills

No matter how well you know something, you must continue spaced practice in order to maintain your mastery. Don't fall into the "familiarity trap," when you neglect a skill because you feel you've got it down pat. **The better you know something, the less frequently you need to practice it—but never stop practicing it altogether.**

For example, a basketball coach may spend the majority of practices on shooting drills, running plays, and playing scrimmages. But the coach must also regularly drill dribbling and passing, even though they're basic skills that are ingrained in the players' repertoire. The players can't perform the higher-level skills if they lose proficiency in the fundamentals.

Prioritize your practice with flashcards organized in the Leitner system, which naturally spaces your practice. Divide your flashcards into four sections in a box:

1. In the first section, put flashcards you struggle with the most. These are the cards you'll practice most often.
2. In the second section, put flashcards you're slightly better at. You'll practice these about half as often as the first section.
3. In the third section, put flashcards you're even better at. You'll practice these less often than the previous section.
4. In the fourth section, put flashcards you seldom get wrong. You'll practice these the least

When you have a wrong answer, move that flashcard up to the next section. When you get a right answer, move the flashcard back a section.

The goal of learning is to acquire and retain knowledge to use in real-world situations. **Spaced retrieval, varied practice, and interleaving simulate the randomness of practical experience**—whether you're a doctor seeing patients with a variety of different ailments or a football player encountering different situations in a game: Each patient and each play is a test in its own right.

5: Desirable Difficulties Enhance Learning

The learning strategies we've discussed improve comprehension and retention because **the more your brain has to work, the deeper it embeds the information**. In contrast to the belief that learning is effective when it's easy and enjoyable, these kinds of challenges—called “desirable difficulties”—improve long-term learning.

To be clear, there are also *undesirable* difficulties that don't benefit your learning. A difficulty is undesirable if:

1. You don't have the prior knowledge to overcome and learn from the difficulty
2. The difficulty doesn't target skills you need

Fear of Failure Inhibits Learning

If you push yourself, take risks, and engage in learning that incorporates desirable difficulties, you'll inevitably fail sometimes. **Failure is not only a critical aspect of learning because it's an invaluable opportunity to learn from your mistake.**

People who understand that mistakes and failures are critical to learning are more inclined to:

- Try challenging problems
- Persevere in their effort, undeterred by mistakes
- Advance further in their learning

Research proves the benefits of desirable difficulties in learning, but negative attitudes toward failure still persist from outdated theories.

In the mid-20th century, psychologist B.F. Skinner suggested that wrong answers inhibit learning and reflect poor teaching. Skinner pushed for “errorless learning” methods, in which teachers introduced new material bit by bit to make it easily digestible, and then tested students while the lesson was still fresh.

Most classrooms still don't embrace errors. As a result, **many students develop a fear of failure that impedes their learning** in two ways: First, their fear inhibits them from trying challenging lessons.

Second, fear of failure produces anxiety in high-pressure situations, such as tests. Anxiety taxes your working memory, which is your capacity to keep information in your head while solving a problem. When performance anxiety strains your working memory, you have less mental bandwidth to actually figure out the problem in front of you.

Exercise: Embrace Failure

Failure is a valuable aspect of the learning process. Rework your feelings about failure.

Describe a recent situation in which you made a major mistake or outright failed.

How did you react?

What lesson can you glean from that experience?

How can you avoid a mistake/failure like that in the future?

6: Illusions and Myths that Impede Your Learning

The strategies we've discussed give you the tools for effective learning, but the tools alone aren't enough—you must clear away the illusions and myths that impede your drive to learn.

Misperceptions about your competence and myths about your ability to learn can both inhibit you from pursuing greater levels of knowledge.

Balancing Intuition With Reason

Continued learning requires you to consistently strengthen and build upon your skills and knowledge. **In order to expand your learning, you need to know what you know, what you don't know, and what you need to work on.**

The problem is that most people are poor judges of their own competencies. Humans are naturally prone to illusions and cognitive biases that make us blind to our shortcomings.

Humans are wired with two complementary processing systems.

1. **The automatic, unconscious system that's responsible for your intuitions and knee-jerk reactions.** This system is critical for situations that require split-second decisions and reflexive action, whether you're getting away from a dangerous situation or defending against another player on the basketball court.
2. **The controlled, conscious system that's responsible for logic and reason.** This system works a little more slowly, helps you analyze problems, and balances the impulsivity of the first system. For example, your unconscious system notices a snake and makes you bolt away, but a few seconds later your second system kicks in and makes you realize that it's not a snake, after all—it's simply a garden hose.

(Shortform note: Learn more about these two systems in our summaries of [Thinking, Fast and Slow](#) and [Blink](#).)

When your conscious system fails to correct a misperception by your unconscious system, you can end up believing illusions that make you misjudge your ability, such as:

1. **Perceptual illusions:** Perceptual illusions distort your senses and make you misinterpret images, sounds, or other sensations. For example, pilots can encounter optical illusions or, in extreme situations, illusions that make them think the plane is flying level when it's actually tilted.
2. **Cognitive biases:** Cognitive biases are caused by systematic problems with your way of thinking that impact your judgment and decision making. For example, the bandwagon effect is a cognitive bias that makes people more likely to think or do something if other people think or do it.

Hunger for Narrative

Paradoxically, people sometimes unwittingly create their own illusions in an attempt to make sense of the world. **People naturally want to find order and reason, so they unconsciously create narratives that explain why something is the way it is.**

People also create narratives that explain events in their own lives, including circumstances they've faced and actions they've taken. For example, someone may say that no one in her family has attended college because they're not "academic" types, which reflects the narrative she and her family have created.

Narratives are a stronger influence than objective facts, yet people fail to recognize or vastly underestimate this influence.

Don't Be Constrained by Learning Styles

A common narrative in educational settings is the belief that everyone has a preferred learning style, though everyone has some ability in each area.

There are many learning styles theories and models, each defining different types of learning styles based on different criteria. A common model defines three learning styles:

1. Auditory: students who learn best through oral presentations, such as lectures
2. Kinesthetic: students who thrive with movement and hands-on learning
3. Visual: students who gain the most from graphs and images

Many people also believe that students learn best when they're taught according to their learning styles, but **focusing on learning styles tends to limit a student's views of her own abilities and potential**. For example, if a student self-identifies as a kinesthetic learner, she's less likely to put as much effort into a reading assignment because it supposedly doesn't play to her strengths.

In fact, while it may be true that people have distinct *preferences* about the way they learn, learning isn't *inhibited* if the style of teaching doesn't match the learning style. Researchers found that the few studies that had adequately tested the theory either failed to affirm it or debunked it outright. The takeaway was that **all students learn best when the instruction style matches the subject of the lesson**—such as using visual means to teach geometry, audio to teach foreign language, or kinesthetic to teach physics principles on motion.

While it turns out your learning style isn't a big factor in your ability to learn, the way you see yourself and your potential is. This is part of your narrative, which shapes how you interpret your experiences and actions. **Your narrative affects your confidence to try new things, how much effort you put forth, and your perseverance in the face of obstacles.**

Memory Distortions

Narratives are so strong that they shape how you interpret and remember your experiences. In other words, your memory is inherently moldable.

On one hand, your memory's pliability is critical to your ability to learn: **Everything you learn becomes a memory, and every time you recall that lesson you're making new connections and creating new cues for that information, which further embeds it in your memory.** The ability to add to your memory in this way allows you to deepen your understanding and better retain the information.

On the other hand, your tendency to create distorted memories—and fail to realize that they're distorted—can be problematic.

Illusions of Memory

Memories are mere representations of events—not accurate recordings—and thus they easily become distorted. There's no way you can remember every detail of an experience. Instead, you remember certain aspects, and when you call up the memory, you unconsciously fill in the details.

This lends itself to memory illusions, such as:

- **Flashbulb Memories:** You tend to believe that there's no way you'd forget or mistake any detail of major, emotional events because you have a "flashbulb memory" of the experience—you recall where you were, what you did, and how you felt. However, research shows that although people tend to have the highest confidence in their most emotional memories, these are the memories that become altered the most over time.
- **Hindsight Bias, or the Knew-It-All-Along Effect:** When you're reflecting on an event, you're likely to inflate how predictable it was, even though you couldn't have actually predicted it before it happened.
- **Interference:** If you're exposed to something right before or after an experience, it can distort the memory of that experience. For example, if a witness to a crime views photos of suspects and then subsequently looks at a lineup, she's more likely to falsely accuse someone in the lineup if she's already seen his photo.
- **Mistaking Implications for Fact:** As you naturally fill in the details of your memory, you're likely to remember things that you understood to be implied and assumed to be fact, but which may not be. For example, when you recall a meeting with your boss about your new promotion, you probably assumed that a pay raise was implied, and thus you may falsely remember your boss stating that you'd receive a raise with your new title, but that's not the case.
- **Power of Suggestion:** Other people's suggestions can heavily influence and alter your memories. For example, study participants watched a video of a car running a stop sign and hitting another car. Those who were asked how fast the car was going when it "smashed" into the second car guessed 41 miles per hour, while those who were asked how fast the car was going when it "contacted" the second car guessed 32 miles per hour. By simply changing the language of the question, researchers changed participants' memories of the video.
- **Social Contagion of Memory, or Memory Conformity:** If you and a friend are recalling a joint experience, you're likely to merge her memories with your own—even if she supposedly remembers something that didn't actually happen. In other words, other people's errors can contaminate your memory.

Furthermore, you can entirely fabricate memories under certain circumstances, such as:

- **Feeling of Knowing:** When something is familiar, you're more likely to believe it's true. This means that if you hear the same lie enough times, you eventually believe it's the truth.
- **Imagination Inflation:** If you imagine something vividly enough, you can start to believe it happened and mistake your visualization for an actual memory.

False Perceptions

There are still more ways our minds trick us into misjudging our knowledge and abilities. These include:

- **Curse of Knowledge:** The more proficient you are in a particular skill or subject area, the more ingrained your mental models become. The more ingrained your mental models, the harder it is to break them down into individual steps in order to teach someone else, and the more likely you are to underestimate how long it will take someone to learn the skill.

- **False Consensus Effect:** You're inclined to assume that other people think the way you do because you underestimate how much your individual paradigms influence the way you interpret the world. If you mistakenly assume you're on the same page with people around you, you may fail to see the shortcomings in your performance.
- **Fluency Illusions:** If you easily follow a text or lecture about a topic, you may mistakenly think that your *fluency* with the content means you have *mastery* of the concepts—but, in reality, you may have just read or heard a simplified presentation of the topic.
- **Misdiagnosing Problems:** Sometimes, your mental models lead you astray when you encounter a problem that you think is familiar and apply your tried-and-true solution, only to find out that it's a different kind of problem and requires a different approach. For example, brain surgeons typically have to perform surgery slowly and steadily, but if certain conditions create pressure in the brain, their patients' lives depend on them doing the opposite and working as quickly as possible.
- **Oblivious Incompetence:** People who are the least competent in a given skill are often the most oblivious to their shortcomings and, thus, don't think they need to improve. However, they can counteract this by learning how to more accurately judge their knowledge and skills.

Correct Your Faulty Competence Gauge

You're not the best judge of your own competence, and that makes it difficult to effectively improve your knowledge and skills. But **you can improve—if you know which cues to trust, which cues *not* to trust, and the tools to more accurately gauge your competence.**

Don't rely on these cues to judge your proficiency:

- How familiar you feel with your notes or a text
- How easily you recall information you just learned

Do use these cues to judge your proficiency:

- How easily you recall information a day or more after you learn the information
- How easily you can explain a concept or lesson in your own words

Here are some learning strategies that help you keep an accurate view of your competence:

- **Apprenticeship:** Learning alongside a seasoned veteran gives you a clearer view of your skill level compared to an expert's.
- **Peer Instruction:** Collaborative learning with your peers helps you to avoid the kinds of misconceptions you can have when you study by yourself. An example of peer instruction is if students first read a lesson, then listen to a class lecture, which is punctuated with questions about the concepts. After spending a couple minutes on each question, students gather in small groups to discuss the answers they reached.
- **Peer Review:** Your fellow students or professionals can tell if you're doing a good job or not, and if they give you honest feedback, you can adjust and improve as needed.
- **Team Learning:** When you work in a team of people who have complementary skills, each member of the team has an opportunity to learn from the others. Additionally, each person's strengths are on display, and it's often apparent if someone is falling short.
- **Real-World Simulations:** Training under conditions that resemble what you will face in real-life situations is the best way to hone your skills and see any gaps between conceptual learning and application.

Exercise: Are Illusions Deceiving You?

Use this exercise to try to identify when illusions are making you misjudge your competency.

What's a topic you feel very familiar with and/or what skill do you feel very confident performing?

Why do you feel so confident?

How might "fluency illusions," "oblivious incompetence," or another cognitive bias be influencing your feeling of competence?

How can you determine whether or not you're truly competent?

Exercise: Do You Play to Your Learning Style?

Use this exercise to reflect on if and how you play to your learning style, and what the results have been.

What's your learning style—visual, auditory, or kinesthetic?

How do you approach work differently when it's designed for a different learning style?

What have you noticed about your performance on work that fits your learning style versus work that doesn't?

Describe something you learned recently that you were successful at despite it being taught in a different learning style.

7: How Do You Measure Intelligence?

If the purpose of learning is to move through life more effectively, the measure of your intelligence should be how well you navigate each day. But, for many reasons, people want a way to quantify cumulative intelligence.

Modern psychologists largely agree that there are at least two kinds of intelligence:

1. **Fluid intelligence is your capacity to think both logically and abstractly**, understand how things relate, and keep relevant information front-of-mind while solving a problem.
2. **Crystallized intelligence is your library of knowledge** about how the world works as well as the mental models you've created from your experiences.

Models of Intelligence

Historically, scientists have struggled to develop an objective measure of intelligence.

Various psychologists have theories that expand upon the different areas of intelligence. One example is Howard Gardner's model that lists eight kinds of intelligence:

1. **Logical-mathematical**: critical thinking, abstract thinking, and mathematical thinking
2. **Spatial**: the ability to visualize things in your mind and to gauge three-dimensional spaces
3. **Linguistic**: words and language
4. **Kinesthetic**: body control
5. **Musical**: sounds, tones, rhythms, and music
6. **Interpersonal**: the ability to pick up on people's mental and emotional states and work with them
7. **Intrapersonal**: self-awareness and the ability to accurately judge your own knowledge and competence
8. **Naturalistic**: the ability to relate to your natural surroundings (such as a hunter or gardener does)

Another example is Robert J. Sternberg's three types of intelligence:

1. **Analytical**: Solving the types of problems you find on an academic test
2. **Creative**: Thinking outside the box to use what you know to create new ideas and solutions
3. **Practical**: Adapting and applying new ideas and solutions in the varied contexts of daily life (street smarts)

In contrast to other theories, Sternberg's model is supported by empirical research.

Sternberg did a study of children in Kenya that tested their practical knowledge of herbal medicines, which would help them in daily life, as well as their analytical knowledge, which helps them in school. Children who knew more about herbal medicines tended to perform worse at school, and vice versa. Sternberg reached the conclusion that the difference depended upon whether a child's family valued and emphasized practical knowledge or academic (analytical) knowledge.

Sternberg's study produced two important takeaways about traditional intelligence tests:

1. They don't factor in differences in environment. **A student's lack of exposure or support in a certain area of information doesn't reflect a lack of ability.**

2. They measure what people know at the time they take the test. **People learn continually throughout their lives, and intelligence tests indicate nothing about test-takers' ability or potential to learn more.**

Sternberg's Dynamic Testing

In order to improve upon the shortcomings of traditional tests, Sternberg and Elena Grigorenko developed dynamic testing. The premise of dynamic testing is that **people constantly learn and raise their competence, so dynamic testing accounts for and contributes to that continual improvement.**

Dynamic testing is a multistep process that involves:

- Testing to measure your level of ability
- Redoubling efforts to improve in the areas where you performed poorly on the test
- Retesting to measure improvement
- Repeating the process

Instead of interpreting low test scores as inability, dynamic testing frames them as areas that simply need more attention. Additionally, **dynamic testing is a better indicator of students' *potential* to learn, rather than their *past* learning.**

Your IQ Isn't Fixed

When it comes to gauging intelligence, many people default to the IQ test, which measures logical and verbal ability.

Contrary to what many people think, **your IQ isn't predetermined.** In fact, Americans' average IQ has risen over time, likely because of changes in nutrition, schools, and culture.

Several factors affect IQ scores, including:

1. **Genes**
2. **Environment:** A small genetic advantage can be multiplied in an environment that supports learning. For example, if two students are comparably intelligent but one is part of a family that has a home library and goes to a school that offers many types of classes and clubs, her learning will be nurtured and her intelligence will expand exponentially.
3. **Socioeconomic status:** In more affluent families, the parents tend to have higher levels of education as well as jobs that give them more resources to support their children's learning.
4. **Nutrition:** Certain vitamins and nutrients support the brain's health and boost its capacity for learning. Specifically, fatty acids aid nerve cell development and the formation of new synapses. Studies showed babies' IQ scores were 3.5 to 6.5 points higher if they were exposed to fatty acid supplements directly or through their pregnant or breastfeeding mothers.

Can You Improve Your Fluid Intelligence?

IQ measures fluid and crystallized intelligence. The methods we've discussed—including consistent and spaced retrieval practice—improve your crystallized intelligence. But **science hasn't proven that you can improve your fluid intelligence.**

Working memory is a key aspect of fluid intelligence, and that's what brain training games, videos, and exercises aim to improve. Brain training methods are largely based on a 2008 Swiss study in which participants had to remember two different kinds of information—a number sequence and the location of a small light—for increasingly longer intervals while they viewed other lights and number sequences.

All the participants improved on this task by the end of the experiment, and those who'd done the exercise the most had the biggest improvements. This was the first time research suggested people could improve their fluid intelligence. However, there were several issues with the study.

1. Participants did just one task, which makes it impossible to know whether the participants improved their working memories or merely improved their performance on *this task*. Improving one skill doesn't affect other skills; a professional pianist's superior dexterity on the keys has no impact on her dexterity when crocheting a scarf.
2. There's no data about whether the improvement was long-term.
3. The sample size was small (35 people) and not diverse.
4. No other experiment has been able to replicate the results.

Although the participants may not have actually improved their fluid intelligence, they left the study *feeling* like they'd strengthened their mental capacity. This effect was merely the participants' perception, but higher confidence does correlate with more perseverance. In other words, when the participants encounter a problem, their chance of success will be higher—not because they've made mental improvements, but because their confidence will make them try harder to solve it.

8: Make the Most of Your Intelligence

Aside from *raising* your IQ score, there are strategies you can use to *make the most* of your intelligence with diligence, practice, and tools to help you remember information.

Strategy #1: Growth Mindset

Grit and perseverance are far more important ingredients for success than intelligence. **People who have a “growth mindset” are empowered to take their success into their own hands because they understand that effort and discipline are critical to their learning potential.** These people work harder, take more risks, and view failures as learning opportunities.

On the other hand, people who have a “fixed mindset” have no sense of control over their own destinies because they believe that intelligence is the bottom-line determiner of success: They were either born with it or they weren’t. These people become helpless when they encounter failure because they attribute it to their lack of intelligence and ability.

Psychologist Carol Dweck studied this phenomenon and found several other characteristics associated with growth and fixed mindsets.

People with growth mindsets:

- Create *learning* goals, which focus on gaining information and skills. **They set increasingly challenging goals in order to continually expand their knowledge.**
- Tend to receive praise for their *effort*, which encourages them to continue to work hard and persevere.

People with fixed mindsets:

- Create *performance* goals, which focus on measurable achievements that validate their skills. They set more conservative goals to ensure they can achieve them and receive the validation they seek.
- Tend to receive praise for their *intelligence*, which discourages them from taking risks, for fear of blowing their image as an intelligent person.

(Shortform note: Read more about the growth mindset in our [summary of Mindset](#), and about the value and the building blocks of grit in our [summary of Grit](#).)

Strategy #2: Deliberate Practice

Mastery requires thousands of hours of deliberate practice. Deliberate practice is more than mere repetition—it has several distinct characteristics, including:

- Being solitary
- Being goal-oriented
- Pushing past current ability

(Shortform note: [Read more about the power of deliberate practice in our summary of Peak](#).)

Pushing yourself, failing, troubleshooting, and trying again are necessary for building the skills and creating the mental models that lead to mastery. Through deliberate practice, you gradually develop a repertoire of increasingly high-level skills that you can then apply in a wide variety of situations.

Although deliberate practice is generally most effective when it's solitary, coaches and trainers can play pivotal roles in helping you to see your areas of weakness, providing corrective feedback, and pushing you to redouble your efforts on the areas where you're struggling most.

Strategy #3: Memory Cues

Memory cues are tools for shorthanding information that you need to remember. **Memory cues can help you remember facts on a surface level, but they're most valuable as a way of organizing and retaining information that you've already mastered.** For example, you can use a mnemonic device to remember names and dates for a history test, but you won't ace the test if you don't understand the *significance* of those names and dates.

Mnemonic devices are tools that range from simple to complex to remember various types of information. For example, the acronym ROY G BIV is a mnemonic device for remembering the colors of the rainbow. **In order for a mnemonic device to be useful, it needs to tether reminders to something very familiar,** so that the things you need to remember are all tied to something nearly impossible to forget.

One type of mnemonic device that helps you recall larger amounts of information is a memory palace. Memory palaces capitalize on the idea that it's easier to remember images than words.

To create a memory palace, follow these steps:

1. Choose a physical space or route that you're very familiar with, such as your home or your commute to work.
2. Choose objects or features that stand out in that physical space, such as your couch or a major intersection.
3. Make a mental link between each object and something you want to remember. For example, imagine yourself sitting on your couch with a friend who you need to remember to call.

When you need to recall the information, take a mental tour of the space. As you imagine yourself passing by each object, its associated reminder should pop up in your mind.

Another type of mnemonic device is a rhyme scheme, in which you create rhymes that associate your reminders with concrete images.

An example of a rhyme scheme is the peg method, which is a memory aid for lists of items. The peg method assigns an image to each number, from 1 to 20; the images always remain the same, no matter what you need to remember. Then you associate a reminder with each image. Say you assign "shoe" to 2, and you associate shoe with a reminder to go for a run.

Exercise: Maximize Your Intelligence

What's important isn't just what you know—it's how you use it.

Think of a challenge you faced recently, and how you navigated it. Did your actions exhibit a growth mindset or a fixed mindset?

Think of a skill you're trying to master. How can you alter your approach or schedule to make your practice more deliberate, which entails being solitary, goal-oriented, and pushing past your current ability?

What strategies do you normally use to remember things?

What is one area of your life—such as your list of errands—where you could try using a mnemonic device? Which one?

9: Put These Strategies Into Practice

Now that you understand the principles of effective learning, let's look at how to apply them to your life.

Suggestions For Learners

Think of your intelligence as a work in progress and remember that you're constantly learning.

Take an active approach to your learning. Reading this summary is a good first step. Follow up with these strategies:

- Pause regularly to ask yourself questions about the material you're learning. These questions may include:
 - What are the main concepts?
 - How would I explain these to someone else?
 - What concepts and information am I encountering for the first time?
 - What connections can I draw to my existing knowledge?
- **Think of a metaphor or image that demonstrates the principle you're learning** (for example, thinking of how the movement of a bowling ball illustrates a law of physics).
- Engage with your reading by anticipating what the main concepts will be and trying to define them before you've found the definition in the text. As you read, see if you were right.
- Similarly, **try to solve math and science problems before you learn the formula**. Once you learn the formula, go back and see how close you were.
- As you study, create questions to quiz yourself later.
- Schedule time to regularly spend a few minutes quizzing yourself on new and past material, interleaving multiple subjects. Check your answers and review the topics of the questions you get wrong.

To get the most out of a conference or professional development training, use these strategies:

- Using a copy of the schedule or presentation materials, test yourself about the main concepts.
- Schedule monthly emails to yourself with questions about the material to continue regular self-testing.

Suggestions for Teachers

Teachers play an important role in teaching their students how to learn and designing instruction that incorporates effective learning and studying strategies.

First, help your students understand the principles of effective learning, including:

- Desirable difficulties are important for deep understanding and long-term retention
- The only way to achieve mastery is to consistently reach beyond your current ability level
- Failures are not only inevitable but also provide invaluable learning opportunities

Second, incorporate desirable difficulties in your teaching by:

- Using the principles of spacing, interleaving, and variation in the way you present information
- **Giving frequent, low-stakes quizzes and being transparent about the quiz schedule.** Students generally react and perform better when they know when to expect quizzes, and the anticipation doesn't reduce the quizzes' effectiveness.
- Incorporating past lessons and material in quizzes and exercises
- Providing study aids that use retrieval practice, elaboration, and generation—such as practice tests, reflection writing exercises, short answer retrieval exercises, and problems assigned before a lesson is reviewed in class
- **Explaining the methods to students, and acknowledging the initial frustrations that these can cause to prevent students from getting discouraged and distrusting the strategies**

Additionally, consider using some of these strategies to integrate the principles of effective learning:

- **Bloom's Taxonomy Answer Keys:** For each test, create an answer key that includes multiple answers for every question—an answer for each level of Bloom's taxonomy of learning. Bloom's taxonomy describes the different levels of comprehension: remembering, understanding, applying, analyzing, evaluating, creating (creating may not be relevant for many test questions). When students get their tests back, provide the answer key and ask them to consider at what level they answered each question and how they can reach a higher level. For example, did they merely recall the three branches of government (remember)? Did they explain how the branches interact through checks and balances (understand)? Did they illustrate how the three branches work to pass a piece of legislation (apply)?
- **Free Recall:** At the end of class, students spend 10 minutes writing everything they remember from the day's lessons. Even if they feel stuck after just a couple minutes, they must spend the entire 10 minutes trying to recall anything they can. After 10 minutes, they revisit their notes from the day, check that what they've recalled is correct, and—most importantly—see what they've forgotten. Then they know they must study the information they forgot.
- **High-Structure Class Design:** Create a high-structure class, which includes daily and weekly retrieval exercises that are low-stakes but still count toward students' grades.
- **Learning Paragraphs:** At the end of the week, students write a paragraph answering a question that reflects on something from that week—it may be about a main concept from the material, or how the student would improve her performance on the next test.
- **Role Playing:** For practice skills, have students role play, which allows them to use generative learning, get feedback, and reflect on how they could improve their approach.
- **Small Groups:** Students work in small groups during class to answer a high-level conceptual question the teacher poses. After a while, one student from each group explains her group's answer to the rest of the class, and the class critiques the group's conclusions.
- **Summary Sheets:** At the start of each week, students turn in a summary sheet of the previous week's lessons, preferably through illustrations (if the subject allows) with notations pointing out key concepts.
- **Testing Groups:** Replace study groups with testing groups. Without referring to their textbooks, students gather in groups to discuss questions they're struggling with and collaborate to find the answers. Each student typically knows different aspects of the answer, and together they can piece together the entire concept.