In far too many classrooms, the emphasis is on instructional strategies that teachers employ rather than on what students should be doing or thinking about as part of their learning. What's more, students' minds are something of a mysterious "black box" for most teachers, so when learning breaks down, they're not sure what went wrong or what to do differently to help students learn.

It doesn't have to be this way. Learning That Sticks helps you look inside that black box. Bryan Goodwin and his coauthors unpack the cognitive science underlying research-supported learning strategies so you can sequence them into experiences that challenge, inspire, and engage your students. As a result, you'll learn to teach with more intentionality—understanding not just what to do but also when and why to do it.

By way of an easy-to-use six-phase model of learning, this book

- Analyzes how the brain reacts to, stores, and retrieves new information.
- Helps you "zoom out" to understand the process of learning from beginning to end.
- Helps you "zoom in" to see what's going on in students' minds during each phase.

Learning may be complicated, but learning about learning doesn't have to be. And to that end, Learning That Sticks helps shine a light into all the black boxes in your classroom and make your practice the most powerful it can be.
If somebody offered you a thousand dollars to draw a reasonably accurate model of the human circulatory system, you'd probably be a thousand dollars richer a few minutes later—even if you're not a doctor. You know there’s the heart, veins carrying unoxygogenated blood back to the heart, and arteries carrying oxygenated blood to the muscles and organs of the body. Since oxygen is involved, you know the lungs must figure into it somehow. Given a few minutes of thinking, you'd likely to be able to sketch out a workable model, including labeling some of the key parts, and in the process use modestly technical vocabulary.

Basically, you can sort out how we breathe in oxygen and distribute it to our body’s cells and expel depleted carbon dioxide from our bodies. That’s because circulation ceased being a mystery several centuries ago, so we all learned about it in school. Even though it’s something we can’t observe with our own eyes (on a good day, anyway), all of us know the basics of it.

If you’re reading this book, however, odds are you’re a teacher rather than a cardiologist, so try this: See if you can draw a model of the human learning system—that is, how information enters our brains and gets converted into long-term memories we can retrieve later. In other words, how do our brains “breathe in” information to store and retrieve for later use? What’s the process? What are the key vocabulary terms?

I’ll give you some time.

It’s a bit of a stumper, isn’t it? Don’t feel bad if you struggled with this thought experiment. I’ve tried it with hundreds of teachers, principals, and administrators from across the United States and around the world over the last few years and found it’s a challenge for nearly everyone.

Nevertheless, there is a human learning system. Although its parts and processes may have remained concealed from science somewhat longer than blood vessels were, cognitive scientists have known for decades (a century or more...
when it comes to certain aspects) much about how the brain processes information into long-term memory. Therefore, this knowledge is something we should know, especially if we’re educators.

Think about it this way. Would you agree to undergo brain surgery from a doctor who did not know the anatomy of the brain or what impact various surgical techniques would have on it? Well, teaching is like performing noninvasive brain surgery on a classroom full of patients, 180 days a year. To do that well, we need to know a thing or two about how the brain works and be able to translate that understanding into designing learning experiences for students.

**Learning How to Make Learning Stick**

Many teachers, through no fault of their own, often know little about how learning actually works. Somehow, even though cognitive science—what we might call the science of learning—has been around for decades, it’s not adequately covered in many teacher preparation programs. In fact, a study of dozens of popular textbooks in preservice programs found that none of them accurately describe six key instructional strategies grounded in the science of learning (Greenberg, Pomerance & Walsh, 2016). As a result, according to the reports’ authors, new teachers are not learning “the most fundamental information needed to make learning ‘stick’” (p. v). They often enter classrooms with an incomplete toolkit, which can leave them frustrated and overwhelmed and leave students shortchanged.

This book aims to correct that by providing you with these research-based teaching strategies (and others) so you can deliver better learning for students. Instead of just spoon-feeding them to you, this book will unpack the cognitive science underlying these strategies so you can sequence them into learning experiences that challenge, inspire, and engage your students. As a result, you’ll learn to teach with more intentionality—understanding not just what to do but also when and why to do it. You’ll also know what to do when things go wrong or your students struggle to master new learning.

**Looking into the “Black Box” of Students’ Minds**

Now it’s time for true confessions. I knew very little of this stuff when I first entered the classroom. Sure, I had some best practices up my sleeve—asking higher-order questions, modeling processes for students, providing feedback, and the like. Admittedly, though, I knew little about why such things were best
Preface: Why a Learning Model?

practices—that is, how they supported student learning. Back then, I had little idea what was happening inside students’ minds while I was teaching. I just figured I needed to teach them something, have them practice it, test them on it, and hope it stuck.

If you’d visited my classroom in those days, you likely would’ve seen me doing many of the “right things.”
- Asking thought-provoking questions? Check!
- Forming cooperative groups? Check!
- Providing feedback? Check! And with a green pen to be nice. Double check!

Yet if you’d asked me why I was doing any of those things, such as putting kids in cooperative groups, I likely would have offered a blank stare. Maybe, on a good day, I might have said something like, “Well, I’ve been doing a lot of talking at the kids this week, so I figured they needed a break from that.”

That wouldn’t have been much of an answer, of course, yet it’s not a whole lot different from what I—and my colleagues, including Kris and Tonia—have heard some educators say when we ask them why they’re using certain practices in their classrooms. In many ways, it was hearing these things in so many places and so often that led me down the winding path to writing this book.

Why This Book

My colleagues’ and my journey began several years ago, when ASCD and McREL published two editions of Classroom Instruction That Works (Dean, Hubbell, Pitler, & Stone, 2012; Marzano, Pickering, & Pollock, 2001), which remains one of the most popular books on instruction ever printed. In these books, we identified several “high-leverage” teaching strategies. Following their publication, we spent countless hours in schools and classrooms helping teachers use the strategies. While visiting classrooms and watching educators in action, something began to trouble us.

At first, we thought perhaps we were just seeing some earnest yet novice attempts to apply best practices. Some teachers, for example, seemed to think that if a little bit of cooperative learning was good, then a whole bunch of it ought to be even better—to the point that we’d see students in their classrooms sitting in small groups reading textbooks together (“to ask each other questions if they get stuck”), which hardly reflected effective cooperative learning. Yet their teachers seemed to think they were doing the right things—after all, research says cooperative learning works!
Meanwhile, we bumped into more than a few principals who were dogged in their pursuit of doing what works—to the point that they would hammer on teachers to use, say, similarities and differences ad nauseum regardless of whether teachers knew when or why to engage students in the mental exercise of comparing and contrasting. On one level, they were engaging in the “right” things, yet their reasons for doing so were often shallow or misguided.

It wasn’t all bad, though. We saw a lot of good things happening, too, especially when teachers and entire school teams became increasingly intentional with evidence-based teaching practices—that is, thinking about why they were using them. When that happened, student engagement and learning increased significantly.

In a subsequent ASCD/McREL book on teaching, *The 12 Touchstones of Good Teaching* (Goodwin & Hubbell, 2013), we highlighted the need for teachers to provide challenging, engaging, and intentional instruction and showed how the strategies in *Classroom Instruction That Works* supported student learning (i.e., pairing the what with the why). We hoped that revealing the why behind the what would help teachers connect the dots and select the appropriate teaching strategy for the learning task at hand.

However, we still found teachers often approached lesson planning solely in terms of their own moves and not what they wanted students to be doing or thinking about. They might follow a lesson plan template but not really consider what ought to happen in students’ minds at each step along the way. As a result, lessons were often a string of activities that didn’t engage or challenge students. In short, the focus was often on teaching, not learning.

**Teaching with Learning in Mind**

That’s when we knew something was missing for many teachers—namely, a deep understanding of what should be going on in students’ minds when they were engaging in learning activities. After all, that’s where the real “action” occurs in any classroom. For many teachers, though (ourselves included, before we dug more deeply into the science of learning), students’ minds have largely been something of a black box. As a result, when learning breaks down, we’re not really sure what went wrong or what to do differently to help students learn.

It doesn’t have to be that way.

This book will help you to peer inside that black box. It covers the basics of how the brain reacts to new information, how it stores memories away for later...
use, and how it retrieves memories and applies prior learning to new situations. Along the way, you may find you need to unlearn some of what you thought you knew about learning. As we'll see, what scientists have discovered over the years about learning often runs counter to some “tried and true” learning strategies most of us have used because we think they work—yet only have the illusion of working.

**Filling the Gap Between Research on Instruction and the Science of Learning**

In important ways, this book is unlike any others on your shelf or in your e-book reader.

Yes, you can find plenty of books that tell you what (hopefully research-based) instructional strategies to employ, but rarely do they ground their recommendations in the science of learning. As a result, they may help you solve a particular problem of practice but do little to help you consider what ought to be going on in your students’ minds to engage them in deep learning. You're unlikely to develop insights into why a particular strategy works, when you ought to use it, and when it might no longer work.

At the other end of the spectrum, you can find a burgeoning collection of books that provide insights on the science of learning and brain science. Such books have their place, too, especially for expert practitioners who are ready to dig into neuroscience—a fascinating field that's beginning to bear some fruit for educators. Yet it’s often a long walk back from neuropeptides to the realities of teaching a couple dozen youngsters in a classroom. As a result, brain science can be a bit overwhelming for teachers who have a lesson plan to prepare, papers to grade, and a faculty meeting at 3:30 p.m.

This book is designed with that reality in mind—that you have a lesson or unit plan to get ready by tomorrow. It’s not going to provide a postdoctorate-level deep dive into the brain's electrochemistry, synapses, and dendrites. Instead, it will summarize the big ideas that have emerged from cognitive psychology—the study of learning—over the past few decades and their implications for teaching and learning in your classroom.

On one level, this book will help you “zoom out” to get a better grasp of the process of learning from beginning to end. On a deeper level, it will also help you “zoom in” to see what's going on in students’ minds during each phase of the process, including what “blockages” or “leaks” may occur as students engage...
in learning so you can adjust your teaching strategies accordingly. In so doing, this book will demystify the process of learning and hopefully provide you with a number of a-ha moments about students’ learning along the way, helping you to set aside counterproductive practices that can get in the way of learning and ultimately making learning more productive and joyful in your classroom.

**Providing a Model for Learning**

What is perhaps most unique about this book is it offers a model for learning that draws from the most salient ideas from the science of learning you can apply in your classroom. As it turns out, providing such a model reflects a key insight from the science of learning itself—that we learn best when we “extract the key ideas from new material and organize them into a mental model” (Brown, Roediger, & McDaniel, 2014, p. 6). As you’ll see later in this book, to retain information, we must make sense of it, connecting dots and grouping ideas together. One of the best ways to do this is to develop a mental representation of the world around us—one that’s simple enough to allow us to zoom out and see how the parts fit together while being accurate and sophisticated enough to let us zoom in on key details.

Although researchers are still grappling with some of the finer details about how exactly the mind works, the processes described in this book reflect what cognitive scientists generally agree are the fundamental processes involved in translating information from our five senses into deep, long-term memories. Better teaching—teaching that supports deep learning—reflects the natural progression of knowledge through the stages of learning, which are shared in this book.

In summary, this book takes what we know from cognitive psychology, particularly what’s called the information processing model, and translates it into a model for classroom lesson and unit design. Having a solid, workable mental model of learning will help you plan better learning opportunities for your students, diagnose and solve their learning challenges, and adjust your instruction accordingly—much as doctors use proven models of the circulatory system to diagnose and solve cardiovascular diseases.

**Not Another Framework—A Model**

At this point, you might be thinking, “Wait, I think my school or district already has a districtwide instructional model. Is this the same thing?”

Most likely not.
That’s because what people often call instructional models aren’t models at all; at best, they’re frameworks of teaching practice. Yes, this may sound like splitting hairs, so let’s take a moment to parse the difference between these two terms that often get bandied about interchangeably but have decidedly different meanings.

Models explain abstract phenomena and provide mental representations of how things work by describing a process, cycle, or sequence. For example, the water cycle provides meteorologists with a shared understanding of how water evaporates from the ocean, condenses into clouds, and returns to Earth as precipitation. In film and theater, playwrights and screenwriters often follow a three-act model to sequence scenes into narratives with rising action, conflict, and resolution. Essentially, models help us to make sense of procedural (how-to) knowledge by showing how things work and fit together sequentially. In other words, they show how to do something and often provide basic templates to emulate.

By contrast, frameworks arrange and structure declarative (factual) knowledge into categories, taxonomies, or mental “buckets.” In literature, for example, we use frameworks to distinguish various genres of fiction (e.g., mystery, action, romance). In biology, we use a taxonomy first developed by Aristotle to categorize different types of living organisms (e.g., plants, mammals, reptiles, fish). With this in mind, most teacher evaluation systems and many so-called instructional models are actually frameworks—they categorize the myriad things we want teachers to attend to in their classrooms and professional lives (e.g., planning lessons, creating positive classroom climates, delivering instruction, engaging in collegial learning). In short, they clarify what to do yet not necessarily how to do it.

The how is where a model comes in.

As you dig into the model of learning described in this book, some astute readers may notice it has echoes of some popular instructional design models, such as Madeline Hunter, explicit direct instruction, and Robert Gagné’s nine events of instruction (to name but a few). This is, in fact, true. This model has many similarities to these older models (which are also similar to one another). That’s because most of them have shared roots in Benjamin Bloom’s efforts in the 1960s and 1970s to develop a model of mastery learning based on cognitive science.

You’ll notice, however, that unlike many of these earlier models, the Learning That Sticks model is not framed around steps teachers take to guide instruction (e.g., launch a lesson, check for understanding, create practice opportunities)
but, rather, steps students take to engage in deep learning. In so doing, this book aims to stretch your thinking, “flipping” it to consider what ought to happen in students’ minds as you’re teaching so you can map your instructional moves onto what you can do to guide and support learning. In short, what’s most important isn’t what you are teaching but what students are learning.

**How This Book Is Designed**

This book is based on the simple premise that learning may be complicated, but learning about learning doesn’t have to be. It takes big ideas from the science of learning and turns them into an easy-to-follow six-phase model of learning. Chapters 2–7 are named for what we’ve identified as the phases of learning, a progression we think you’ll find logical, easy to grasp, and eminently applicable to your classroom, regardless of subject or grade level.

Each chapter helps you zoom out to the big picture of learning from beginning to end as well as zoom in on the details and practical implications, including teaching strategies that support each phase of learning. As a result, you’ll be able to understand not only what to do but also when and why to use certain strategies.

After reading this book, you should be able to sketch out or explain a basic diagram of how the brain’s cognitive system functions and the various stages of memory formation. If that sounds a bit cerebral or theoretical, don’t worry. This book will also help you apply these insights to guide lesson and unit design in your classrooms along with plenty of practical tips you can use right away. At each step along the way, you’ll get a toolkit of research-based teaching strategies you can use to support each phase of the learning process. All the while, you’ll be able to draw a line of sight back to cognitive science to understand why a particular strategy is effective during a particular stage of learning.

**A Starting Point, Not a Final Destination**

Finally, keep in mind that this book isn’t intended to offer a lock-step checklist for teachers. In practice, you’ll likely find these phases of learning are not always linear; the process of learning in real life is often messier and more iterative. In short, this learning model is not intended to be a hard-and-fast script to follow but rather a springboard to more intentional and creative teaching.
Indeed, focusing on the science of learning is meant to encourage you to engage in deeper, more reflective professional practice as a teacher.

The point of this book is to help you design learning based on how your students’ brains work, so you provide them with learning experiences that are not only challenging but also engaging and joyful. By the way, there’s a word for this kind of engagement and joyful learning: curiosity. As you’ll see, curiosity is an important driver of deep learning. When it’s present, learning flourishes; when it’s absent, learning withers. Now that you are hopefully feeling curious about student learning, let’s dive into what’s long been a black box for educators but doesn’t need to be: our students’ minds.
Understanding the Science of Learning

What you’ll learn in this book isn’t new or faddish. It’s based on carefully designed studies of learning reported in peer-reviewed publications that have been around for many decades. Some of it, in fact, dates back to the 1870s when an amateur scientist in Germany, Hermann Ebbinghaus, began a series of unusual experiments on a singular subject—himself.

Each evening, at the same hour, Ebbinghaus would sit alone in a quiet room and pull from a box small sheets of paper with different nonsense syllables on each—drawn from a list of 2,300 nonsense syllables he carefully created (e.g., *mox*, *fim*, *tib*). After writing down each syllable in a notebook, he’d start a metronome and, following its rhythm, recite each syllable on the list in a monotone voice in equally spaced intervals. Afterward, he’d close his notebook and attempt to recall the list from memory, over and over, until he could recall them all.

From this lonely and tedious work, Ebbinghaus arrived at many important insights into the inner workings of our minds, including our “forgetting curve” (how quickly we forget new learning) and ways to strengthen memory (Boring, 1957). Perhaps most important, through his exacting and methodical experimentation, he began to turn what had previously been mostly just philosophical musings about the mind into a scientific pursuit, paving the way for study and exploration of how we learn.

The Information Processing Model

Starting in the 1950s, cognitive scientists developed what’s commonly referred to as the *information processing model*, which uses the computer as an admittedly imperfect metaphor for what happens to information once it enters the
Learning That Sticks

brain. Basically, the information processing model attempts to map the long, perilous journey—full of twists, turns, and dead ends—that all new information must take before finding a home in our long-term memories. As you’ll discover, the human brain is both shockingly powerful and maddeningly inconsistent. Sometimes it forgets things that its owner wishes desperately to remember (What’s the name of my boss’s husband? Where did I park the getaway car?). Sometimes it remembers things that its owner wishes desperately to forget (an unkind word or an annoying jingle).

In many ways, the challenge of learning is rooted in a fundamental paradox of the human brain. Although it can learn and retain staggering amounts of information, it’s also incredibly adept at ignoring and forgetting information, which in many ways is a good thing. If we paid attention to every stimulus in our environment, we’d be nervous wrecks with our heads on a swivel, trying to pay attention to everything that’s happening around us. And if we couldn’t forget anything, we’d grow progressively unable to cope with the world as our brains clogged with useless information.

In fact, too much memory can be annoying—even lethal. Consider the curious case of Jill Price, who at first blush appears to possess what seems like a superpower: the ability to never forget. Now in her early 50s, she can recall events from her teens like they occurred yesterday. Ask her what she was doing on August 29, 1980, and she’ll tell you, “It was a Friday. I went to Palm Springs with my friends, twins Nina and Michelle, and their family for Labor Day weekend.”

The first time she heard Rick Springfield’s “Jessie’s Girl”? March 7, 1981. She was driving in a car with her mother yelling at her. The third time she drove a car? January 10, 1981. It was a Saturday. She was at “Teen Auto. That’s where we used to get our driving lessons from” (McRobbie, 2017).

Price is among a group of rare people who have been clinically tested and found to have hyperthymesia or HSAM (highly superior autobiographical memory): the ability to recall abnormally vast details from their lives. They can remember minutiae from years earlier, such as every meal they’ve eaten, every phone number they’ve written down, and every song they’ve heard on the radio. Sounds awesome, yes? But in reality, not so much. Price will tell you that having “total recall” memory creates a swirling mess in her head and leaves her teetering on the edge of sanity.

My memory has ruled my life. Whenever I see a date flash on the television (or anywhere else for that matter), I automatically go back to that day and remember where I was, what I was doing, what day it fell on,
and on and on and on and on. It is nonstop, uncontrollable and totally exhausting. . . . Most have called it a gift, but I call it a burden. I run my entire life through my head every day and it drives me crazy! (Parker, Cahill, & McGaugh, 2006, p. 35)

The Stages of Memory

Recent studies in neuroscience are finding that our brains appear actively and purposefully to forget most of what we learn—continually pruning and clearing out old and unneeded memories (often as we sleep) to allow us to focus on more important information. As it turns out, forgetting is as important to our memory systems as remembering (Richards & Frankland, 2017). Forgetting extraneous information simplifies our memories, decreasing the static hiss of the noisy, information-rich worlds in which we live and allowing us to focus on the pertinent details needed to make better decisions.

So, for the sake of our mental health and happiness, it’s good that most of us ignore and forget the vast majority of what we experience. For learning, though? Not so great. As educators, we are locked in a constant battle with our students’ brains, which by design are programmed to ignore or forget most of what’s in their environment, including what we attempt to share with them in our classrooms. Therefore, let’s take a look at the stages of memory, followed by the phases of learning with which they intersect, to build a mental model of the learning system.

Sensory Register: Finding a Signal in the Noise

Before memories can be created, we must notice some initial information with one or more of our five senses—sight, hearing, touch, taste, smell—or our related senses of movement and balance. Our nerves convert these stimuli into electrical signals that travel along our body’s nerve fibers in milliseconds, racing with incredible urgency to arrive in our brains where—surprise!—the vast majority of stimuli are promptly discarded in less than a second.

Why does this happen? Well, there’s simply too much going on around us every second of the day for our minds to remember it all in full detail. Our bodies are designed for survival in a hostile environment, and to survive, our early ancestors primarily needed to pay attention to and remember the really important
stuff—things that kept us safe from predators, nourished, and sheltered. For example, it was important to be able to ignore our hunting companion prattling on about his digestive issues and narrow our focus down to a tiny pinhole of stimuli: a lion making its way toward us through the savannah grass while licking its chops. The ability to filter distractions down to a pinhole was a good thing—it was the difference between living to tell the tale and being a lion's lunch.

Even now, hundreds of thousands of years later, most of what we sense throughout our day can be simply ignored. In fact, our brains' ability to filter out distractions (which I’m doing right now as I write this paragraph on my laptop while sitting outdoors at my daughters’ swim meet, surrounded by screaming kids, loud music, towels flapping in the breeze, and people walking by, to name but a few stimuli) is often essential in helping us focus on the stimuli that are most important to us at the moment. Yet as teachers, it means we must ensure students focus their “pinholes” on what we want them to learn.

The next time you walk into your school or office, try to observe and remember everything you’re seeing, hearing, and feeling for as long as you can: the color and shape of every car in the parking lot, the conversations of people you pass by, the feeling of a light breeze or sun on your face, the clothes and facial expressions worn by every person you see. This is the sensory register, and it’s impossible to hold on to every single input all at once and for any length of time. Only a tiny fraction of what registers gets retained. And as we’ll see, “rules” in our brains form something of a pecking order for which information we pay attention to and which we ignore.

Stimuli that make it through the filters of our sensory registers and are deemed important enough can begin moving along a journey through three phases of memory: immediate, working, and long-term. This is true regardless of the type of memory in play, declarative or procedural, although the area of the brain that leaps into action varies. Declarative memory, which is the recall of facts, information, and personal experiences, is stored across the neocortex—the large, gray, wrinkly outer part of the brain—and deeper down, inside the hippocampus and the amygdala near the center of your brain. It is further divided into episodic memory (recollections of events we personally experience) and semantic memory (facts and information we have learned).

Procedural memory refers to the memories that allow us to repeat physical actions and skills, such as how to ride a bicycle or draw a portrait. These performance-based memories are stored in the basal ganglia and cerebellum, which coordinate our movement, balance, and equilibrium (Queensland Brain
Experiments by neuroscientists have found that our procedural memories, once established, are very strong and far less likely to fade over time than our declarative memories, which is why we can remember how to ride a bicycle years after our last pedal around the block (Suchan, 2018).

**Immediate Memory: The First 30 Seconds**

Those lucky few sensory inputs that make it through our initial filters are carried along by electrical signals to neurons that then produce a biochemical charge that records, or encodes, the impression of that stimulus. Then it passes along this code to a thousand other neurons to which it is connected; each neuron can then help store and recall multiple memories (Reber, 2010). Later, when you try to recall a particular memory, that group of neurons fires the same biochemical code associated with it, re-creating the memory in your mind (Mastin, n.d.).

Our initial, immediate memory is short term, lasting only about 30 seconds. It also has limited capacity, as Harvard psychologist and researcher George Miller discovered in the 1950s. Through a series of experiments, he found that our brains can actively focus on and work with approximately seven bits of information at a time (Miller, 1956). The bits of information for what Miller called the Magic Number 7 range from small singular items such as a letter of the alphabet or a single number to chunks of information that the brain is able to group together because of some connection, such as words or mathematical functions.

Try juggling more than seven of these bits at a time, and most of us will begin to mentally stumble and forget some data points, letting some of the information fall to the floor, so to speak (Harvard University Department of Psychology, n.d.). We can thank Miller for our relatively short phone numbers, as it was his research that persuaded phone companies around the world to limit local phone numbers to seven digits. A reexamination of Miller’s research (University of South Wales, 2012), however, suggests the magic number may be closer to four, because what we really seem to be doing when we encode a seven-digit number, such as 6458937, is break it into four shorter chunks, such as 64, 58, 93, and 7.

Between four and seven items at a time in our immediate memory—doesn’t sound like much, does it? But think about the student activities taking place in your classroom on a daily basis, and you’ll see students must constantly employ immediate memory when they are

- Reading a book, a website, or text on a smartboard display and their eyes travel across words in rows. To make sense of the meaning of the
sentences, they have to keep an immediate memory of the previous words they’ve just read.
• Listening to you or their peers. They use immediate memory to keep track of what’s just been said and mentally prepare their responses.
• Working on a math addition or subtraction problem. They have to briefly keep track of place values and carryovers as they solve the calculation.

These initial memories can’t get too comfy—this stage lasts only about 30 seconds because, again, the brain must weed out some information. It can’t store everything. But if the stimulus is deemed important enough, it can be retained long enough to advance into the next stage, working memory.

Short-Term Working Memory: Up to 20 Minutes

Here’s where volition comes in. If we consciously focus on what’s in our immediate memory (by listening to someone as they’re talking or making marginal notes in a book, for example), we cause our neurons to repeat their chemical and electrical exchanges, which in turn increases the efficiency and strength of their communication (Queensland Brain Institute, n.d.). It’s akin to creating a new path through a forest; as your feet press down on the soil and vegetation, it makes the path more visible and easier to follow.

Short-Term Memory Versus Working Memory

For simplicity’s sake, this book merges two overlapping yet arguably distinct concepts: short-term memory and working memory. Although cognitive scientists still debate the exact relationship between these ideas (Aben, Stapert, & Bickland, 2012), we might think of the difference like this.

Short-term memory is our stream of consciousness—the sensory events (e.g., listening to a lecture, reading a book) and information (e.g., names, words, numbers) we hold in our attention at any given moment. When we apply mental effort to what’s in our short-term memory—for example, manipulating, clustering, or connecting it with stored memories—we employ working memory.

Through brain imaging, scientists have found we appear to activate different parts of our brains when we shift from simply rehashing what’s in our short-term memory (e.g., repeating a string of letters) to manipulating what’s in short-term memory (e.g., alphabetizing that same string of letters). So we might think of working memory as short-term memory plus mental effort. As we’ll see throughout this book, the key to learning almost anything is focusing mental energy on what’s in short-term memory—that is, employing working memory. Rather than bouncing back and forth between these two similar ideas, we’ll simply use the single, blended term *short-term working memory.*
But it takes more than just one or two walks along the same route in the forest to create an easily seen, easily followed path. Similarly, the pathways in our working memory don’t last long, holding on to a recollection roughly 5–20 minutes before the memory either decays or continues its journey to long-term memory.

Although this book mainly focuses on the brain’s processing of new information, neuroscientists say that our working memory is also used when we activate old memories and bring them front of mind, so to speak. As with the creation of new memories, the more often we recall and think about these existing memories, including combining them with new sensory inputs and information being learned, the more efficient our neural pathways become, strengthening the memories in our minds a bit more each time.

**Long-Term Memory: Potentially a Lifetime**

If we decide to revisit the information often enough through repetition, rehearsal, contextualization, or application, we can usher it into its ultimate destination. The brain creates more, and larger, dendrites (extensions of the nerve cell) to store these memories (Young, 2015).

Not only that, but activating neurons using different sensory inputs related to the same concepts can strengthen memories and make more connections and pathways between related memories to build broader understanding. In other words, memory and knowledge about a subject—say, civil rights—can be strengthened by reading about civil rights and then also listening to or watching interviews with activists and historians describing what took place and visiting museums or places connected with the civil rights movement.

Effort is everything at this stage; the more we think about and experience a topic, the stronger the memories we create will be. As noted earlier, our brains actively weed out most memories. Researchers think sleep is critical to this process. While we slumber, the subconscious mind sorts and organizes the day’s events, embedding the important bits and pieces as best it can and building connections among other related bits and pieces. It also prunes what it regards as useless memories—in particular, memories we haven’t stored strongly or connected with other learning. In the morning, we wake up refreshed, ready to load up with a new day’s sensory inputs.
Think back to my initial question in the Preface. Can you now sketch out the basics of how memory works—how knowledge enters our brains and is saved for future use?

- **Sensory input:** We sense something new and our neurons send electrical pulses to our brain.
- **Sensory register:** Our brain makes a near-instantaneous decision that the sensory data are either important or not important.
- **Immediate memory:** Important data are processed by the neuron cells in our brains, which create biochemical codes that can re-create the experience later. These codes are shared from neuron to neuron in different parts of the brain, depending on what type of memory is being stored.
- **Short-term working memory:** If we focus on our immediate memories (or recall prior memories), we can create stronger pathways between our neurons, which increases the likelihood of being able to recall the information later.
- **Long-term memory:** If we revisit memories to keep the pathways active and add to them by connecting them with other sensory inputs and related memories, we can strengthen our ability to apply old learning to new situations (and vice versa).

This is, of course, a summary of memory formation, and a brief one at that—the equivalent of waterskiing over something we could easily scuba dive into.

**Applying Memory Science to a Model for Learning**

As we noted earlier, sometimes “brain science” can become too granular and impractical to help educators. We don’t really need to know about neuropeptides to be good teachers, but we do need to have solid mental models of how learning occurs so we can use tactics to help our students better seize control of information at just the right time and in the right manner to give that new knowledge the best possible chance for moving through the phases of memory.

So how can we as educators use our knowledge of these phases of information processing to ensure that our lesson planning and instructional delivery help our students’ learning stick? By following a learning model, which arranges strategies for teaching and learning into a larger process for helping new knowledge travel through the three types of memory in our students.

**Sensory Register and Immediate Memory**

We must trigger these two key phases of learning in students’ minds for new information to pass through the filters of their sensory registers and enter their immediate memories.
**Become interested.** The external stimuli that make it past the brain’s mental filters tend to be of two varieties: those that stir emotions and those that arouse curiosity (typically in that order). Our brains default to ignoring almost everything else. What this means is that to start the learning process—to get information past our students’ mental filters—we need to help them feel comfortable in their learning environment and then attach some form of emotion (e.g., excitement, indignation, passion) and/or intellectual stimulation to what they’re learning that leaves them scratching their heads in wonder. For example, we might pose a mystery to them—for example, “Thousands of years ago, the wooly mammoth was the dominant creature in North America. So what happened? How could such a massive creature just up and disappear?”

**Commit to learning.** Being interested is vital but only gets us so far; to go beyond learning mere tidbits of information or discrete skills, we must take the next step and commit to learning more. As teachers, we can help students do this by presenting new knowledge and skills as part of a big picture that affects their lives and helps them set clear, challenging, yet attainable goals for their learning. In short, when it comes to learning, we need to help students answer the simple question “What’s in it for me?” For example, we might help students see how learning why the mammoth went extinct connects to a modern crisis (e.g., the mass extinction of species around the world).

**Working Memory**

Once information begins tumbling around students’ working memories, students must engage in these two phases of learning to begin encoding information, preparing it for long-term memory storage.

**Focus on new learning.** Once students are “thirsty” for new knowledge, they must acquire it by actively thinking about what they’re learning. For example, they might participate in a question-and-answer session, engage in close reading of text, follow a process as it’s modeled, visualize what they’re learning by creating nonlinguistic representations of concepts, or take notes during a lecture. All these active learning processes, especially when used in combination, help knowledge soak deeper into the brain.

**Make sense of learning.** Due to the limitations of working memory, we must “chunk” learning into bite-size segments interspersed with opportunities to connect new learning with prior knowledge and cluster ideas together, which is how our brains store knowledge—as webs of ideas and memories. Even though knowledge remains in our working memory, we must “make sense” of it before
the details fade. For example, we might help students group various scientific facts, details, and insights into how the wooly mammoth went extinct into three big scientific theories of over-kill, over-ill, and over-chill.

**Long-Term Memory**

At this point in the process, new learning is still at a crossroads; students’ brains are primed to prune the information, discarding it onto a mental trash heap unless they engage in these final two phases of learning.

**Practice new learning.** To store learning into long-term memory, we must go on more than one date with it, so to speak. As it turns out, cramming seldom works. Rather, we’re more apt to remember what we learn when we engage in distributed practice (engaging in practice sessions a few days apart) and retrieval practice (being quizzed on or quizzing ourselves on new knowledge). Learning science shows that searching our memories for knowledge that’s begun to fade rekindles those waning neural networks and strengthens memory. Therefore, giving students multiple opportunities to repeat, rehearse, and retrieve new knowledge and skills makes them more apt to commit new learning to memory.

**Extend, apply, and find meaning.** We’ve all likely experienced the frustration of struggling to jog our memory for an important bit of information. Often, what’s going on in our brains when this happens is that we’ve stored the information but have too few neural pathways to retrieve it. This “use it or lose it” principle of learning suggests that students more readily retrieve knowledge when they develop multiple connections to it by, for example, associating it with multiple other pieces of information, digging more deeply into it, or using it to solve real-world problems. For example, we might encourage students to delve into the science and ethics of using DNA to bring the wooly mammoth back to life or investigate whether the forces that led to its extinction might now be causing the collapse of global honeybee populations.

**Bringing It All Together**

In sum, we might visualize this entire process of learning as looking something like Figure 1.1. Together, the steps provide a simple six-phase model for student learning. Figure 1.2 provides more detail about these six phases, along with a practical toolkit for bringing them to life in your classroom that includes
many evidence-based teaching practices from *Classroom Instruction That Works* (Dean et al., 2011) and *The 12 Touchstones of Good Teaching* (Goodwin & Hubbell, 2013). Bear in mind, you needn’t use every tool with every lesson but, rather, should use your professional judgment to draw on them to design learning opportunities for your students.

As noted earlier, the labels for each phase of the learning model reflect not what you’re doing as a teacher but, rather, what’s happening inside students’ minds as they learn. Though this may seem like a slight mental and semantic shift, it carries profound significance for how we plan lessons and reflect on and respond to student successes and struggles, which is the essence of professionalism—being able to apply expert knowledge to diagnose and solve problems.
### Figure 1.2

**Phases of Learning and Classroom Toolkit**

|------------------------|----------------|-------------------|-------------------------------------|---------------------------|-----------------------|
| Stimuli in our sensory register catch our attention. | Become interested | Why should students care? | **Emotional valence.** Our brains have a “pecking order” for stimuli; we first pay attention to stimuli with emotional valence. | Prime emotion | • **Show them you care.** Students are more likely to learn if they feel emotionally safe and supported by teachers.  
• **Connect learning with positive emotions.** Help students connect positive emotions to learning, such as joy, pride, eagerness, and enthusiasm. |
| | | What will spark student interest? | **Curiosity.** After emotionally laden stimuli, our brains attend next to novel stimuli—the unexpected, incomplete, controversial, mysterious, or gaps in our knowledge. | Spark curiosity | • **Spark curiosity.** Use mystery, suspense, or cognitive conflict to hook and hold student interest.  
• **Activate prior knowledge and reveal knowledge gaps.** Prepare students for learning by helping them recall background knowledge and see gaps in their knowledge.  
• **Structure academic controversy.** Engage students in debate about content that challenges them cognitively and, as appropriate, emotionally.  
• **Switch it up.** Infuse learning with novelty and the unexpected to hold students’ attention. |
| | Commit to learning | What meaning will students find? | **Meaning and purpose.** Our limbic (emotional) system is more powerful than our prefrontal (logical) cortex; thus, we must “feel” like learning. | Give a why | • **Give a WIIFM (What’s in it for me?).** Students must see why something is important to learn. How will they use it later in life? How do people use it in the real world?  
• **Frame learning around big ideas/questions.** Students must see the big picture of where learning is headed, so use big ideas/essential questions to guide learning. |

*We determine whether stimuli are worthy of further attention.*
What will motivate students to learn? What will connect them to the learning?

Connecting to personal interests and goals. Connecting learning to our own lives motivates and deepens learning. Students are more motivated to learn— and recall later what they've learned— when they set personal goals for learning.

- Set learning goals
  - Provide learning objectives and success criteria. Help students see what's expected and what they're committing to learning.
  - Show students the path to mastery. Help students develop an internal locus of control by tracking effort, anticipating roadblocks, and considering how to overcome them.

- Encourage personal learning goals. Ensure goals are mastery-, not performance-, oriented.
- Help students commit to effort. Help students develop an internal locus of control by tracking effort, anticipating roadblocks, and considering how to overcome them.

- Model steps to mastery with direct instruction. Show students the steps for new processes so they see what mastery looks like (the "I do" phase).
- Slow and tell. Illustrating abstract ideas with concrete examples and extracting abstract patterns from concrete examples support learning.
- Use nonlinguistic representations. Most of us are visual learners, so visual aids (photos, diagrams, models) support learning, especially if students create them.
- Engage in thoughtful learning
  - Engage students in active note taking. Writing things down (by hand) and drawing pictures enhances memory. Guided notes (filling in blanks) are also effective.
  - Teach self-questioning and close reading. Showing students how to quiz themselves while learning boosts comprehension and retention.
  - Alternate worked problems with problems students must solve. Weaving worked examples into students' own productive struggle boosts processing of new learning (the "we do" phase).
  - Use nonlinguistic representations. Most of us are visual learners, so visual aids (photos, diagrams, models) support learning, especially if students create them.

Focus on new learning.

We focus on new knowledge and skills while they're in our working memory.
While new knowledge is in our working memory, we begin to cluster it and link it to prior learning. How will I chunk learning and support information processing?

- Make sense of learning

Pausing and processing: Our working memories are limited in how much information they can hold at once (7 ± 2 items) and how long they go before “timing out” (5–20 minutes) and needing to process learning.

- Provide time to process

- “Chunk” learning into segments to support processing. We must periodically pause during learning to build neural connections.
- Ask probing questions. Higher-order questions prompt students to think about their learning, apply it, and connect dots with new learning.
- Provide wait time after questions. Pausing after asking questions and student responses engages more students in thinking about learning and classroom dialogue.
- Use cooperative groups to support processing. Effective cooperative learning strategies (e.g., reciprocal teaching, classroom dialogue) support processing.

What themes, categories, sequences, or links to prior learning do students need to make with this learning?

Categorizing and clustering: Memories form in our brains as neural networks—as complex webs connecting ideas; in short, we learn by connecting new learning to prior learning.

- Help students categorize knowledge

- Help students identify similarities and differences. The heart of learning is connecting new ideas to old ones, so comparing, contrasting, and categorizing new learning is essential for making sense of learning.
- Invite students to summarize their learning. Students are more likely to retain learning when they synthesize and paraphrase what they’ve learned into big ideas, guiding principles, and key concepts they put into their own words.

Practice and reflect

What knowledge and skills must students commit to memory or automate?

Spaced and interleaved practice: New learning is more likely to be retained when practice is spaced and reflects “desirable difficulties.”

- Design and guide deep practice

- Observe and guide initial practice. Guidance during initial efforts to apply knowledge or skills ensures students correctly learn procedures and avoid misconceptions.
- Check for understanding. Identify learning gaps before they become bad habits or misconceptions.
- Provide formative feedback. Give students nonevaluative descriptive feedback as they learn, helping them reflect on their learning and identify next steps toward mastery.
### Understanding the Science of Learning

#### What feedback will I provide to guide deep learning?
- **Reflecting on gaps in learning or skills.** Repetition that adds new connections to learning along with “discrepancy reduction” enhances storage and retrieval.
- Help students reflect on their learning
  - **Interleave and space independent practice.** Practicing different skills and spacing out practice sessions support better recall of learning.
  - **Support frequent retrieval practice.** Straining to recall learning builds retrieval pathways, so ungraded quizzes and other testing devices boost retention of new learning.
  - **Teach students how to practice.** Show students how to target knowledge and skills they have not yet mastered with interleaving and distributed practice.

#### Applying new learning in novel, meaningful ways supports retrieval.
- **Transferring and applying.** Memory storage and retrieval are two different functions: we better retrieve learning when we transfer it to new ways and are more apt to transfer knowledge when we make our thinking visible.
- Help students apply learning to new challenges
  - **Provide challenging learning tasks.** Help students develop deeper knowledge by engaging them in challenging work that ensures they think about their learning.
  - **Support inquiry-based learning.** Give students opportunities to explore essential questions via investigations, analyses, and syntheses; without these opportunities, learning quickly fades.
  - **Make thinking visible.** Thinking aloud when solving problems and explaining their reasoning helps students transfer learning to new situations.

#### How will I (and my students) know they’ve mastered learning?
- **Building mental models for critical thinking.** Mental models that integrate declarative and procedural knowledge are essential for deep learning and critical thinking skills. Assessments should engage students in applying mental models and demonstrating critical thinking.
- Help students develop mental models and demonstrate deep learning
  - **Teach critical thinking.** Contemplating evaluative questions about what they’ve learned helps students more deeply encode learning.
  - **Sharpen student thinking with writing.** Writing about learning—in all subject areas—supports deep learning, creating mental models, making meaning, and transferring learning to new situations.
  - **Anchor learning in performance assessments.** Classrooms assessments often measure only declarative knowledge. Performance assessments ask students to demonstrate both declarative and procedural knowledge while motivating with choice.
We imagine some readers, especially those familiar with *Classroom Instruction That Works*, may wonder how the research-based instructional strategies in that book map onto these phases of learning. Figure 1.3 provides such a link, aligning the 26 strategies from *Classroom Instruction That Works* with the six phases of the learning model offered here. You may note that some strategies, such as questions, align with multiple phases of the model—that’s because when skillfully applied, they serve different roles in advancing learning.

Figure 1.3  
Mapping *Classroom Instruction That Works* (CITW) onto the Phases of Learning

<table>
<thead>
<tr>
<th>Learning Phase</th>
<th>Teacher Support</th>
<th>CITW Strategies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Become interested</td>
<td>• Hook interest</td>
<td>• Cues</td>
</tr>
<tr>
<td></td>
<td>• Activate prior knowledge</td>
<td>• Advance organizers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Questions</td>
</tr>
<tr>
<td>Commit to learning</td>
<td>Help students set goals</td>
<td>• Setting objectives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Reinforcing effort</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Providing recognition</td>
</tr>
<tr>
<td>Focus on new learning</td>
<td>Provide information</td>
<td>• Pictures and pictographs</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Mental images</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Note taking</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Graphic organizers</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Models and manipulatives</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Kinesthetic movement</td>
</tr>
<tr>
<td>Make sense of learning</td>
<td>Support deeper processing</td>
<td>• Comparing</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Classifying</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Cooperative learning</td>
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<tr>
<td></td>
<td></td>
<td>• Summarizing</td>
</tr>
<tr>
<td>Practice and reflect</td>
<td>Support reflective practice</td>
<td>• Assigning homework</td>
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<td></td>
<td></td>
<td>• Providing practice</td>
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<td></td>
<td>• Providing feedback</td>
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<tr>
<td></td>
<td></td>
<td>• Reinforcing effort</td>
</tr>
<tr>
<td>Extend and apply</td>
<td>Support deeper learning and application</td>
<td>• Questions</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Problem solving</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Experimental inquiry</td>
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<tr>
<td></td>
<td></td>
<td>• Systems analysis</td>
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<tr>
<td></td>
<td></td>
<td>• Investigation</td>
</tr>
</tbody>
</table>
As you'll soon discover, these six phases are also based on the assumption that intrinsic motivation—not external punishments and rewards—is the true key to deeper learning. After all, when you think about it, all learning (with the possible exceptions of brainwashing or subliminal advertising) requires the learner to be a willing participant in the process. Although we can cajole, bribe, or bird-dog, we really cannot force anyone to learn anything. In the end, learning only occurs when the learner decides (or relents) to learning something.

Most of the meaningful things we learn in life, in fact—whether it’s our native tongue, a hobby, or the lyrics of our favorite song—we learned because we saw the value of learning and often experienced joy in doing so. With that in mind, a key idea that runs through all six phases of learning is that intellectual curiosity—the need to explore, answer questions, and encounter new experiences—is the best companion to learning.

We'll start the next chapter with this idea—how curiosity can spark learning—and return to it repeatedly, showing you how to design learning experiences for your students that tap into what lies deep inside them: an innate desire to learn. In so doing, you'll be able to create learning experiences for your students that tap into and unleash their curiosity, making the entire process of learning easier and more joyful for both you and your students.
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Learning That Sticks


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