



Chapter 1

Discover the Power Behind Power Tools

Before we dive into all the powerful research and strategies in this book, I (Pooja) would like to tell you a story.

I was visiting family in Oakland, California, on Christmas Eve, 2017. I needed to write and so I asked my brother if he had a favorite coffee shop nearby. “Yes!” he said. “It’s only a few blocks away from the house, and it’s an easy walk.” Perfect, I thought – I can get some peace and quiet and write (while avoiding chaotic family time back at the house). He told me which streets to walk on and where to turn. It sounded pretty simple.

Except the next morning, when I wanted to walk to the coffee shop, I couldn’t remember where it was or how to get there. Thanks to my smartphone, I got directions and I took one last look at the map. After my five-minute walk, I arrived! It’s a good thing I found my way, too – it had great coffee, a cozy atmosphere, and very kind owners.

You may be thinking “Gee, I thought this was a book about learning.” It is! Learning is as complex as remembering and using directions to a coffee shop, even if we don’t think about it that way. To explore something so complex, cognitive scientists often refer to the three stages of learning: *encoding*, *storage*, and *retrieval*.¹

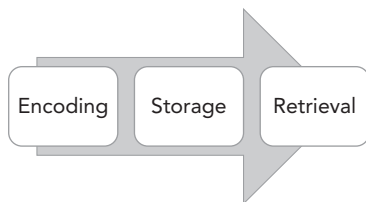
Figure 1.1 illustrates the three stages of learning:

- *Encoding* is when we get information in and absorb knowledge, almost like a sponge.
- *Storage* is where we hope that once we encode information, our knowledge sticks around.
- *Retrieval* is when we reach back and bring something we previously learned into mind.

Now, what do these three stages of learning have to do with my trip to a coffee shop? Let’s relive my journey, but this time through the lens of learning.

First, I asked my brother about a nearby coffee shop and he gave me the name of one down the street. At this point, I *encoded* or “inputted” the coffee shop details, but I was distracted by Christmas celebrations in the background. I expected that the coffee shop’s name would be *stored* in my memory until the next

Figure 1.1 A simplified three-stage model of learning: encoding (getting information *in*), storage (when information *sticks*), and retrieval (getting information *out*).



morning. When I woke up, however, I tried to *retrieve* the directions to the coffee shop, but I couldn't. *How could I forget something so simple?*

A few days later, I wanted to return to the same coffee shop. And yet again, I couldn't remember how to get there! It was literally four blocks away from my brother's house, but the directions had vanished from my head. This is a perfect example of a quirk when it comes to learning: *Just because you know something once doesn't mean you'll always remember it.*

One of the best ways to make sure something sticks and gets stored is to focus on the *retrieval* stage, not the encoding stage. In my situation, for example, if I had practiced *retrieving* the coffee shop directions before going to bed, I would have remembered them the next morning.

This brings us to the first *Power Tool* that will serve as the foundation for our book: *retrieval practice*. Retrieval practice is the same thing as the retrieval stage of the learning process: It's when we practice bringing information to mind. We tend to think that most learning occurs during the encoding stage, but a wealth of research demonstrates that learning is strengthened during retrieval.²

When I couldn't remember the directions, what did I do? I looked up the coffee shop on my phone, of course! Without even thinking about it, I gave myself *feedback*. It's second nature for us to seek more information, fill in the gaps, and check whether we're on the right track. First, I had to recognize I needed help, and then I gave myself feedback using my phone. This mental process is what's called *metacognition*, or, literally, "thinking about thinking." *Feedback-driven metacognition* is another Power Tool that significantly boosts learning. It isn't new and you probably give students feedback all the time; the difference is that *how* you give feedback has a large impact on encoding, storage, and retrieval.

Now, I can't help but re-retrieve the directions to the coffee shop. I'm 99% sure I'll remember them the next time I visit my

brother in Oakland! This act of retrieving something over time is another Power Tool called *spacing*, which strengthens long-term learning and decreases forgetting. Lastly, *interleaving* is a Power Tool where learning increases when we mix up what we need to learn – like learning the directions to multiple coffee shops and trying to keep them all straight. It might sound challenging, but as we’ll discuss in greater depth, challenges are a *good* thing for learning.

In this brief, everyday situation, I engaged in the three stages of learning. Even when we try to remember names, birthdates, or our favorite recipe, we engage in encoding, storage, and retrieval. But what does this mean when it comes to your classroom? Students encode, store, and retrieve, too! In this book, you’ll learn quick, simple, everyday tools that transform learning. Each Power Tool we share has been supported by decades of scientific research *and* decades of classroom implementation. You probably use many of these strategies already; the difference is that when you understand how learning works, you can harness these evidence-based strategies and increase student achievement even more.

Get ready to move beyond the coffee shop and on to unleashing the science of learning. *Let Powerful Teaching begin!*

HOW DID PATRICE’S TEACHING EVOLVE INTO POWERFUL TEACHING?

I (Patrice) made a discovery at the end of my first year working with Pooja.

In my sixth-grade history class, Pooja and I gave a “pop” final exam. The students were not told in advance, so there was no opportunity to study or “cram.” Students’ exam scores were not recorded in the grade book, so test anxiety was minimal.

My discovery occurred when, after the pop final exam, I looked at the score of my top GPA (grade point average) student. She had done well on all homework, quizzes, and tests

throughout the year. However, she was not number one on this pop final exam. In fact, although she did well, she was only in the top *half* of the class. Why?

Indeed, I had several questions to ponder. Why didn't my highest-GPA student score higher at the end of the year? Knowing exactly what I had taught, why would I get confused looks upon bringing up something from earlier in the year? How could students get a 100% on homework and not be able to discuss it in class a day or two later? Why do I prioritize grading homework and having it returned 24 hours later, when none of this seems to increase learning?

A summer of pondering allowed me to realize the solution to all of my questions was *retrieval practice*. Digging into research and applying my own years of teaching experience helped me make changes the following year. It took me, however, a few more years to perfect my tools.

My own essential question turned into, "How can I support my students to become more accountable for learning?" I realized that many of my students, including my top GPA student, had mastered the system of doing homework. Look for the correct answer, copy it down, next question. Their homework grades were 100%. But learning was negligible. And, to be honest, some papers looked surprisingly similar – copying from friends? Copying from the book? A little too much parental involvement? I was also extremely frustrated at the hours I had spent grading those "A" papers when my students lacked the breadth and depth to answer essential questions. What could I do differently? How could I evolve my teaching into *powerful teaching*?

THE FOUR POWER TOOLS: RESEARCH-BASED AND CLASSROOM-PROVEN

As we all know, we could fill warehouses with all the books, blogs, and worksheets out there promising to transform classrooms.

Powerful Teaching is more than just another promise. *Powerful Teaching* is different. How?

- It's based on rigorous research by cognitive scientists.
- It's based on decades of experience by classroom teachers.

In *Powerful Teaching*, we show you how to harness four evidence-based strategies, which we call *Power Tools*:



Retrieval Practice

Retrieval practice boosts learning by pulling information out of students' heads, rather than cramming information into students heads.



Spacing

Spaced practice boosts learning by spreading lessons and retrieval opportunities out over time so learning is not crammed all at once.



Interleaving

Interleaving boosts learning by mixing up closely related topics, encouraging discrimination between similarities and differences.



Feedback-Driven Metacognition

Feedback-driven metacognition boosts learning by providing the opportunity for students to know what they know and know what they don't know.

When it comes to Power Tools, we're all about being practical. No need to revamp what you're already doing! Here's why:

- *You already use Power Tools.* Retrieving what we know, spacing it out over time, mixing it up, and giving our students feedback are no-brainers! They're intuitive strategies, and that's what makes them so simple and flexible. And they're not new – *100 years of research* demonstrate they significantly

improve learning. You can harness these evidence-based strategies that have stood the test of time and make them a regular part of your classroom practice.

- *You don't have to spend more time grading.* Will Power Tools increase grading time? No! In fact, keeping these strategies as grade-free as possible lowers the stakes and increases learning. In fact, we'll talk about how to remove grades all together. There's no need to collect papers, assign points, or enter anything into the gradebook.
- *You'll save time, not spend it.* Engaging students in Power Tools might take a tiny amount of class time (one minute or less, we promise). But in the long term, students will remember *more* and you can re-teach *less*. In fact, just a few quick quizzes in K–12 classrooms have raised students' grades from a C to an A. You'll learn more about small strategies that make a big difference for students.
- *You can use Power Tools your way, in your classroom.* From preschool through medical school, and biology to sign language, these strategies increase learning for diverse students, grade levels, and subject areas. There are multiple ways to use these strategies to boost students' learning, making them flexible in *your* classroom, not just any classroom.
- *You can use Power Tools for free.* Yes, free. There are many great technology websites, tools, and apps available that take advantage of these strategies, but old-fashioned paper and pencil are perfect, too.

Evidence-based strategies that are simple, quick, flexible, and free – too good to be true? Definitely not! By the end of this book, we hope to convince you that these strategies answer a number of today's challenges when it comes to teaching and learning – precisely because they're research-based *and* classroom-proven.

Even if you're already using Power Tools, how learning works isn't always intuitive. Consider these myths about learning, which you'll read more about throughout the book:

Myth: When students learn something easily, they will remember it well.

Myth: Forgetting should be prevented as much as possible.

Myth: It's better for learning if we give feedback *before* students make errors.

In this book, we focus on *how* students learn, not *what* students learn. While we give examples from teachers in a variety of content areas, we don't focus on content-specific knowledge because research demonstrates that Power Tools are effective for *all content areas*.

Unleash these four Power Tools your way, with your content, in your classroom.

Because you know your classroom best, we will help you take these flexible research-based strategies and unleash them your way, with your content, in your classroom.

When it comes to *Powerful Teaching* and Power Tools, one teacher put it best:

I do this all the time, but it's nice to have a name *and* know why it works.

POWER TOOLS IMPROVE MORE THAN MEMORIZATION

In the following chapters, we dive into each Power Tool, the research behind it, and how to unleash it in your classroom. Before we do, we want to address the single most frequent question we are asked: "Do these strategies improve *more* than just memorization?" Here's our answer, based on years of cognitive science research and classroom practice:

Yes!

These four Power Tools improve students' higher-order learning, ranging from a deep understanding of mitosis to effectively resuscitating someone using CPR.³ As educators, we know that boosting learning beyond the memorization of facts is critical. And that's why we advocate for the use of these strategies – because decades of research demonstrates that they improve much more than just memorization. We share specific research studies and teaching tips to emphasize that retrieval practice, spacing, interleaving, and feedback-driven metacognition boost students' basic understanding of information, and students' higher-order learning and transfer of knowledge, too.

Power Up

Earlier, we talked about three stages of learning in the context of going to a coffee shop.

Challenge yourself: Describe the three stages of learning in a situation from your everyday life!

POWER TOOLS ARE *DESIRABLE DIFFICULTIES* THAT ARE GOOD FOR LEARNING

When it comes to teaching, we might lecture, show videos, and encourage note-taking during class. When it comes to studying, students might re-read their textbooks, highlight information, and review their notes before an exam. We've all had the experience of feeling like these teaching and studying methods work. So what's the problem?

The problem is that these methods only lead to *short-term* learning. Have you ever asked students about material you covered months earlier, only to find that they've forgotten everything? This common situation arises because of an assumption we make about learning. We assume that when information comes to mind easily and it feels *fluent*, we'll remember it.

In contrast, researchers have demonstrated that the *opposite* is true: When information feels fluent, we forget it. In other words, *just because we learn something easily does not guarantee we'll remember it*. As Anne Agostinelli, a math teacher from Illinois, put

When it comes to learning, easier isn't better.

it, "I thought my students learned it, but then they forgot it. Which makes me wonder: Did they ever really know it in the first place?"

Why do retrieval practice, spacing, interleaving, and feedback-driven metacognition boost learning? It's because they *challenge* learning. This is what's called a *desirable difficulty*, a term coined by cognitive scientist Robert Bjork in 1994.⁴ Power Tools are challeng-

Power Tools are desirable difficulties. They challenge learning, and that's a good thing!

ing, and that's a good thing! Decades of research have shown that fast, easy strategies lead to short-term learning, whereas slower effortful strategies lead to long-term learning.

Power Up

When it comes to your teaching, ask yourself: Are you supporting *short-term* learning or *long-term* learning?

There's a second component to unleashing powerful, challenging strategies: Students can be resistant because of the added struggle. Remember Patrice's top GPA student from earlier? Sometimes students who have done really well up to this point are the most resistant to desirable difficulties. In addition, students who struggle most can be even more reluctant to engage in challenging strategies like retrieval practice and spacing.

In other words, desirable difficulties are good for learning, but they can be tough for us and also for our students. In the first half of this book, we highlight how retrieval practice, spacing,

interleaving, and feedback-driven metacognition challenge learning, which is why they improve learning. In the second half of this book, we discuss how to make desirable difficulties a regular part of your classroom, how to foster buy-in with students, and how to engage in conversations with parents about this shift from short-term learning to long-term learning.

*From here on out,
if a student says,
"My brain hurts,"
you'll say, "That's a
good thing!"*

WHAT EXACTLY IS THE SCIENCE OF LEARNING AND COGNITIVE SCIENCE?

In the next chapters, we dive into the four Power Tools and specific research-based teaching strategies. Before we do, we want to answer this common question: What exactly is “the science of learning” and “cognitive science?”

Fundamentally, because learning is an incredibly complex behavior, *the science of learning* is actually an umbrella term that spans many research fields including psychology, computer science, and neuroscience.

Our research sits in the field of cognitive science or, more specifically, *cognitive psychology*. In cognitive psychology, we typically examine mental operations, or “behind the scenes” behaviors occurring *inside* our heads, like perceiving, attending, remembering, thinking, and decision making. One way to think about it is that the word *cognition* comes from the Latin word for “to know,” similar to the word *cognizant*, which means “to be aware.”

Cognitive psychologists examine “invisible” everyday behaviors we rarely stop to reflect on. For example, have you ever talked on a cellphone while driving a car? There’s a lot that goes into being able to multi-task and do both things at once: We have to pay attention to a lot of information, we need to react quickly, and we’re talking while moving our hands and arms – all pretty seamlessly. (Or so we think! Based on cognitive science research,

talking on a cellphone while driving is much more dangerous than we realize.⁵⁾

Here's another example: You meet someone at a party and later you remember details about your new friend – where she lives, where she works, and so on – but you struggle to remember her name. Strategies from cognitive psychology can help you remember names, concepts, and much more – just like learning in the classroom!

In contrast to cognitive psychology, research on social-emotional learning (e.g., growth mindsets and character development) investigates how we interact with the world around us; in other words, what happens *outside* our heads. This field is typically referred to as social and personality psychology, and social psychologists examine behaviors such as how we develop relationships, how we're affected by culture, and why we form stereotypes. Of course, how we learn and how we interact with our environment are intertwined, and learning doesn't happen in a vacuum (especially not in education!). Even so, think of cognitive psychology and social psychology as looking at the same human behavior – learning – but using different approaches.

While research on learning – arguably the most complex cognitive process – can be based on observations, surveys, or correlations, most of our research in cognitive psychology is experimental. We use experiments to examine how students learn everything from basic facts and vocabulary words to how students apply their knowledge using complex higher-order materials. Or we might compare popular study methods, such as re-reading or highlighting, to see which ones lead to longer-lasting learning. In this book, we focus on cognitive psychology or the “inside” behaviors of how learning works, in order to emphasize specific, practical teaching strategies for the classroom.

While cognitive psychology is probably the most appropriate term for the field of research we describe in this book, we rarely use the term *psychology* to avoid confusion due to many

misconceptions and myths about the field of psychology.⁶ For example, clinical psychologists examine behaviors related to clinical populations and provide therapy for mental health conditions. Cognitive psychologists, by contrast, conduct experiments in laboratories (and classrooms more recently!) on everyday learning and memory in typical human populations.

To describe our research, we've chosen to use the phrases *cognitive science* and *the science of learning* interchangeably. These fields are more comprehensive when it comes to learning, and they help emphasize the *science* of learning, not the fads or anecdotes of learning. We are thrilled to share the science behind how learning works *and* share how to put it into action in your classroom.

WE PRACTICE WHAT WE PREACH AND MODEL BEST PRACTICES

Finally, we wanted to mention that in *Powerful Teaching*, we practice what we preach: We engage you in frequent retrieval practice! If you are going to make teaching powerful by getting information out, then you should get information out while reading this book, too.

Boxes, like the one earlier in this chapter, are called Power Ups! When you see a Power Up, you should literally pause and complete our retrieval, spacing, interleaving, and metacognition exercises. In the first Power Up, for example, we asked you to *retrieve* a situation from your life and apply it to a *spaced* concept, which were the three stages of learning we described earlier.

With these exercises, we:

- Improve your long-term learning and remembering from this book.
- Provide you with the experience of desirable difficulties.
- Model what Power Tools look like – quick, simple, and no-stakes whatsoever.

- Give you the opportunity to put on your “teacher hat” *and* your “learner hat!”

For example, we’ll keep you on your toes with spaced exercises (e.g., we may ask you to retrieve information from three chapters prior!), metacognition prompts (e.g., questions to help you reflect on your own learning), and key information about scientific research. We use a mix of question types, too: basic, complex, short-answer, multiple-choice – all research-based best practices, of course.

We also have a wealth of downloads, resources, templates, retrieval exercises, and more at our website, www.powerfulteaching.org. Visit our website and explore more strategies, spark ideas, and connect with powerful teachers all over the world.

Finally, we provide additional retrieval exercises in your own *Do It Yourself Retrieval Guide* in Chapter 12, to solidify what you’ve learned and also to use as a reference in the future. We don’t provide chapter summaries; we all have a tendency to flip straight to them

Evidence-based strategies that are simple, quick, flexible, and free – too good to be true? Definitely not!

rather than challenging our own learning! Instead, experience powerful teaching as you read and challenge yourself to pull information *out* of your head, rather than cramming information *into* your head.

NOTES

1. Melton, A. W. (1963). Implications of short-term memory for a general theory of memory. *Journal of Verbal Learning and Verbal Behavior* 2: 1–21.
2. Brown, P. C., Roediger, H. L., and McDaniel, M. A. (2014). *Make It Stick: The Science of Successful Learning*. Cambridge, MA: Harvard University Press.

3. Dunlosky, J., Rawson, K. A., Marsh, E. J., et al. (2013). Improving students' learning with effective learning techniques: Promising directions from cognitive and educational psychology. *Psychological Science in the Public Interest* 14: 4–58.
4. Bjork, R. A. (1994). Memory and metamemory considerations in the training of human beings. In: *Metacognition: Knowing about Knowing* (ed. J. Metcalfe and A. Shimamura), 185–205. Cambridge, MA: MIT Press.
5. For research on attention, multi-tasking, and more, we recommend the book *The Invisible Gorilla: And Other Ways Our Intuitions Deceive Us* by Christopher Chabris and Daniel Simons (Crown Publishing, 2009).
6. For more about myths and misconceptions in psychology, we recommend the book *50 Great Myths of Popular Psychology: Shattering Widespread Misconceptions about Human Behavior* by Scott O. Lilienfeld, Steven Jay Lynn, John Ruscio, and Barry L. Beyerstein (Wiley-Blackwell, 2010).

