POWERFUL
TEACHING

UNLEASH THE SCIENCE OF LEARNING

POOJA K. AGARWAL, Ph.D. AND PATRICE M. BAIN, Ed.S.

Endorsements

In recent years, educators' understanding of how people learn has shifted in some big ways, but we haven't had a go-to manual for applying that research in the classroom. *Powerful Teaching* is that manual and so much more. With specific examples, actionable strategies, and tips for realistic implementation, Agarwal and Bain bridge the gap between cognitive science and education, showing us exactly how to put four key strategies into practice in any subject area and any grade level. Teachers who want to see dramatic improvement in student learning must read this book!

—*Jennifer Gonzalez, educator and director of Cult of Pedagogy*

Teachers need this book. Students need this book. It's as simple as that. This book will create a more efficient and effective classroom and improve learning. *Powerful Teaching* should be required reading for all teachers. If this book isn't in your school's professional development library, you're missing out. Our classrooms are in dire need of this information and I cannot wait to lead a book study on *Powerful Teaching*.

—*Blake Harvard, blogger and AP Psychology teacher,*
James Clemens High School

Powerful Teaching is an incredible book with a very powerful message for teachers as to how *we* can transform education. A practical read, explained clearly and explicitly, this book will impact and improve teaching and learning. I love the fusion of educational research with real-life practical classroom examples.

—*Kate Jones, author of* Love to Teach
and History Teacher, Abu Dhabi

In *Powerful Teaching*, educators at every level will find a treasure trove of new techniques they can put to use in their classrooms, all of which are grounded in the latest research on how students learn. Accessible prose, practical strategies, and solid scientific support—these elements combine to make this a book that will benefit all teachers and, more importantly, their students.

—*James M. Lang, author of* Small Teaching: Everyday Lessons from the Science of Learning

We've arguably learned more about the brain—how it works and more pressingly how it learns—in the last 20 years than we did in all of human history up to that point. Yet many educators have done precious little to adjust their teaching to what we now know. Fortunately this book provides a golden opportunity to do that. "Golden" because the authors have taken the science and distilled it into its most powerful form: a limited number of simple but powerful ideas with guidance on how to use them with insight and fidelity. They've made it easy to be smarter about how you—and your students—learn. Who doesn't want that?

—*Doug Lemov, author of* Teach Like a Champion 2.0, Practice Perfect, *and* Reading Reconsidered

Powerful Teaching shines a spotlight on the partnership between teachers and students in learning, by emphasizing student responsibility in the classroom. Using a set of clearly defined Power Tools, this book equips educators to empower students to take charge of their own learning.

—*Mandy Manning, 2018 National Teacher of the Year*

Powerful Teaching brings cognitive science and education together in one book! It's a digestible, evidence-based resource for educators (of all subject matter and age groups), parents, and students alike to easily implement for tremendous impact. I've already shared multiple ideas and activities with co-workers and I'll be asking all our staff to read it!

—Megan Nellis, program director of Imagine Scholar,
South Africa

Other books about learning draw on academic research or on experience in the classroom. In *Powerful Teaching*, Pooja Agarwal and Patrice Bain combine the best of both to offer teachers, parents, and others concerned with education the most accurate and most useful information on how students learn.

—Annie Murphy Paul, author of Origins
and The Cult of Personality

I have been anxiously awaiting *Powerful Teaching* and I am especially excited to put Chapter 4: Energize Learning with Spacing and Interleaving to work in my school. The data behind the science are visually presented so that teachers can instantly see why they should be using these strategies. The authors provide multiple practical applications that can be adapted to any educational setting—a book that will truly create powerful teachers and learners!

—Lisa A. Pulley, District Instructional &
Technology Coach and Social Studies teacher

Anxiety and fear of making mistakes was sometimes the culprit for failing to remember what I *really* knew at the right moment. Learning about retrieval strategies with *Powerful Teaching* not only clarified for me why I would get anxious in school about making mistakes, but also provided a toolbox of strategies to

truly make learning low-stakes and even fun for our students. From the creation of a welcoming community on day one to the day of the test, the ideas and resources offered in this book ensure that students succeed, take advantage of mistakes, and feel enthusiastic about learning.

—Oscar Ramírez, adult education principal,
The Next Step Public Charter School

This easy-to-read book makes the phrase "science of learning" real for anyone responsible for teaching students. It's chock full of practical tips (not fads) and, mercifully, devoid of academic mumbo jumbo. If you want to unlock the full power of students' minds, please read this!

—Benjamin Riley, founder of Deans for Impact

The authors have combined years of scientific expertise and practical experience to create a marvelous book about understanding and applying the science of learning in the classroom. This book is highly readable and a boon to all teachers who want to improve their students' learning.

—Henry L. Roediger, III, co-author of Make it Stick:
The Science of Successful Learning

Powerful Teaching

Powerful Teaching

Unleash the Science of Learning

Pooja K. Agarwal, Ph.D. and
Patrice M. Bain, Ed.S.

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To the teacher who first asked me, "If you could build a school, what would it look like?" That single, simple question led to this book.
— Pooja Agarwal

To educators who create classrooms where students internalize success.
— Patrice Bain

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Introduction

Do you remember your first day teaching, with students eagerly (or not eagerly) awaiting your instruction? Perhaps you felt terrified. Elated. Cautious. Ready. Not ready. Almost ready?

In the days leading up to that first day, you may wonder, "What am I going to say? What am I going to teach? What are they going to think of me? What should I do when my lesson plans tank?"

But how often do you ask, "*How* am I going to teach?"

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Let's travel back in time to 2006. Patrice was starting her twelfth year teaching and Pooja had just graduated from college with a degree in elementary education. A veteran teacher and a newly minted teacher. Strikingly, the critical question on their minds was identical: What works best in education?

By this point, Patrice had noticed that her students were remembering what they learned years *after* her class – much more than what they remembered from other classes. Patrice also noticed that most teaching strategies were based on anecdotes, passed down from teacher to teacher. Year after year, teachers would come and go, but ineffective teaching methods would stay. *How* could there be such a disconnect between what was working in Patrice's classroom and ineffective fads permeating many other classrooms?

A few years earlier, Pooja had taken a course in cognitive science, without really knowing what that meant. She was astounded to realize that there is rigorous research on how humans learn and remember. *How* could there be such a disconnect between Pooja's education classes on one side of campus and her cognitive science classes on the other side of campus – both all about learning, but one based on anecdotes and the other based on science?

Suddenly, just like pieces in a puzzle, *it all came together*. Researchers at Washington University in St. Louis received grant funding to conduct cognitive science research in classrooms. Up until this point, most research within this specific field took place in laboratory settings with college students, using fairly simple materials to examine how students learn and remember information. Now, with this new grant, the long-overdue opportunity to bridge the gap between learning in the classroom and learning in the lab had arrived.

On a sunny Wednesday in August, Patrice and Pooja met for the first time – just inside the school's entrance, near the cafeteria, next to the principal's office. Shaking hands and walking up the stairs to Patrice's classroom, the energy was unmistakable; Patrice would be one of the first K–12 teachers to partner with cognitive scientists in her classroom, and Pooja would be one of the first cognitive scientists to conduct full-time research in an authentic school setting. This initial meeting of the minds became a teacher-scientist bond that continues today.

This book is the culmination of our extensive collaboration to understand what works best in education. Enter *the science of learning*. What, exactly, is the "science of learning?" It's so simple, and yet counterintuitive. Why can we remember scenes from our favorite movies but struggle to remember our students' names? Why is it easy to learn some things and hard to learn other things? Why can we read a book and feel we learned a lot, only to find that we've forgotten most of it a year later? Why can we think back and remember our first day of teaching, but not our tenth day of teaching?

Cognitive scientists conduct research on all of these things – how we learn stories, names, facts, important events, unimportant events, and more. Research on the science of learning dates back more than 100 years. Fads feel like they've persisted for 100 years, too. Sometimes we run into fads during pre-service programs and professional development, and other times through word of mouth or online blogs. We've all had the experience of being excited about a "new" teaching idea, only to file the materials away for a rainy day. Rarely are these new strategies utilized. Professional development programs often feel like a waste of time.

So why do we keep reinventing the wheel with teaching strategies based on the "fad of the semester," when scientifically based strategies are waiting to be unleashed? We feel there are two main reasons:

1. The science of learning sits dormant in academic journals, rather than easily accessible in pre-service textbooks and professional development materials.

2. The science of learning has recently been featured in newspapers, blogs, and social media, but it's hard to know if these are trusted sources or simply people concocting more fads.

For these reasons (and more), teachers are given the impossible challenge of finding time to seek out good research, make sense of it, and apply it in classrooms. We frequently get asked, "Why haven't I heard about this research before? Why didn't I learn about this in my pre-service program or professional development?" It's because this research isn't accessible – literally and figuratively. There is valuable research on the science of learning out there, but it's sitting behind lock and key.

Until now. For more than a decade, we have developed a rare partnership of scientist-and-teacher, research-into-practice – one that is true to the rigors of cognitive science and also practical with today's teachers in mind. In *Powerful Teaching: Unleash the Science of Learning*, we decipher cognitive science research, illustrate how we have applied the science of learning in our own teaching, and provide evidence-based recommendations to empower educators to unleash the science of learning in their classrooms.

> There is valuable research on the science of learning out there, sitting behind lock and key. Until now.

By drawing on empirical research by fellow cognitive scientists and practical strategies from educators around the world, *we focus on four powerful teaching strategies based on the science of learning*: retrieval practice, spaced practice, interleaving, and feedback-driven metacognition.

1. *Retrieval practice* boosts learning by pulling information *out* of students' heads (e.g., quizzes and flashcards), rather than cramming information into students heads (e.g., lectures). Retrieval practice is a no-stakes learning opportunity that increases student performance, beyond formative and summative assessments.

2. *Spaced practice* boosts learning by spreading lessons and retrieval opportunities out over time so learning is not

crammed all at once. By returning to content every so often, students' knowledge has had time to rest and be refreshed.

3. *Interleaving* boosts learning by mixing up closely related topics and encouraging discrimination. For example, learning increases when students practice addition, subtraction, multiplication, and division problems all mixed up, rather than one type of problem at a time.

4. *Feedback* boosts learning by providing the student the opportunity to know what they know, and know what they don't know. This increases students' *metacognition* or understanding about their own learning progress.

Critically, research demonstrates that these four powerful strategies:

• Raise student achievement by a letter grade, or even two – *from a C to an A*. Research we conducted in Patrice's classroom and additional classrooms demonstrated a consistent and reliable increase in students' grades, confidence, and engagement.

• Boost learning for diverse students and subject areas. Our book applies to all grade levels and disciplines (e.g., STEM, social studies, language arts, fine arts, special education, and foreign languages).

• Enhance higher-order learning and students' transfer of knowledge. We provide research and examples demonstrating that these strategies apply for basic fact knowledge, skill learning, and critical thinking.

When it comes to retrieval practice, spaced practice, interleaving, and feedback-driven metacognition, *the combination of being research-based and classroom-proven is paramount*. The rigor of science gives us confidence that these strategies aren't fads, and successful classroom implementation gives us

confidence that these strategies work in the real world, not just in the laboratory. In addition, the better you understand the research behind the strategies, the more effectively you can adapt them in *your* classroom – and you know your classroom best.

By this point, you may be thinking, "These strategies sound great, but they probably take a lot of time and effort to use them." Actually, they don't! The research-based strategies we describe in this book can be implemented *in less than a minute without additional prep or grading time*. In addition, as teachers, we already use many of these strategies: retrieving what we know, spacing it out over time, mixing it up, and giving our students feedback. The difference is that we share how to use these evidence-based strategies *purposefully, intentionally, and frequently*.

We start this book by sharing the research behind retrieval practice and why it's foundational for learning. Next, we share specific, actionable strategies to implement retrieval practice in the classroom. We continue with research and classroom strategies for spacing, interleaving, and metacognition, followed by recommendations on how to overcome potential challenges, engage in conversations with students and parents, and lead evidence-driven professional development at the school, district and university level.

We have even more activities, templates, and downloads available on our website, www.powerfulteaching.org. Lastly, we have intentionally embedded retrieval, spacing, interleaving, and feedback throughout this book. In other words, we practice what we preach, we model these strategies in each chapter, and we boost *your* learning from this book!

With *Powerful Teaching: Unleash the Science of Learning*, you will:

- Develop a deep understanding of powerful teaching strategies based on the science of learning, whether you are a past, present, or future educator.

- Go behind the scenes and explore key findings from cognitive science research.

- Gain insight into how scientifically-based strategies are effectively implemented in a variety of academic settings without additional preparation, classroom, or grading time.

- Think critically about your current teaching practices and classroom environment from a research-based perspective.

- Develop tools to share the science of learning with students and parents, ensuring success inside and outside the classroom.

- Identify next steps to transform teaching and unleash the science of learning in your classroom.

As educators, we must look forward – using evidence-based strategies – to propel and guide student learning. We must stop driving instruction with anecdotes and fads, we must stop reinventing the wheel, and we must stop riding in circles when it comes to classroom instruction.

Instead, it's our responsibility to *ask for evidence*. Evidence for which strategies are effective, not just which strategies are popular. Evidence for why we teach the way we teach, not just because we've always taught that way.

Most importantly, after reading this book, we hope that on the first day of the school year, you won't be asking, "What should I teach?" Instead, you'll be asking, "*How* should I teach? *How* can I turn my teaching into *powerful teaching*?"

The science of learning exists. *Now, it's time to unleash it*.

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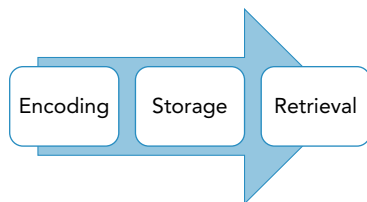
morning. When I woke up, however, I tried to *retrieve* the directions to the coffee shop, but I couldn't. *How could I forget something so simple?*

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.

- Yo*u 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!