The Science of Successful Learning: Applications to Physical Therapy Education

By Leda C. McDaniel, PT, DPT and Mark A. McDaniel, PhD

The Genesis of Make It Stick

Introduction by Mark A. McDaniel, PhD

Nearly 15 years ago, my graduate student (Aimee Calender) and I (Mark McDaniel) initiated a research study to examine the question of whether rereading an assigned textbook chapter would improve learning of the content. We did so despite the sense that the outcome was a foregone conclusion. After all, according to theories of text comprehension, rereading a didactic text should improve a student's understanding of the content[1] and students themselves reported favoring rereading over any other study strategy.[2] In a series of four experiments, we presented college students with a variety of chapters from psychology textbooks.[3] Some students were instructed to read the chapters once, and other students were instructed to reread the chapters. All students were told to expect a test on the chapters they read. The results were startling: Rereading the assigned chapter produced no gains in test performance—which included multiple choice, short answer, and summarization questions—relative to *a single reading* of the chapter.

How can we understand this result? The explanation is based on the faulty metacognitive processes that pervade human learning. When rereading text, the comprehension process is more *fluent* at many levels (ie, experienced as "easier" because it takes less cognitive effort for word decoding, syntactic parsing, extraction of ideas, etc.). Moreover, the content is *familiar* on the second reading. These two cues to the brain—fluency and familiarity—are misinterpreted by the reader as signaling good learning. Consequently, when rereading learners are misled into thinking that they *know* the material better and thus do not attempt to construct a more complete understanding (a better mental model) of the content.

AN EVIDENCE-BASED APPROACH TO LEARNING

The lesson here is broader than just this isolated finding. Students' intuitions about the study techniques that produce robust and durable learning are often sharply incorrect, and thereby encourage students to adopt inefficient study approaches that are largely wasted effort. Similarly, instructors' intuitions and common sense can lead them to adopt ineffective and ill-advised pedagogical practices (eg, the idea that

learning styles need to be accommodated by matched instruction).[4]

Countering these erroneous intuitions and common practices, decades of research derived from well-controlled experiments in diverse settings support an alternative, evidenced-based approach to learning. This evidence base is potentially transformative for teachers and students, much in the same way that evidence can greatly enhance the delivery of healthcare interventions. The frustrating barrier has been that the evidence base from the learning sciences is not overly accessible to the millions of students and instructors not expert in cognitive science. A similar theme arises in the healthcare professions, where examples of a "research-practice gap" abound such that clinical practice does not always reflect our "best available" research evidence. One example of this is the current overutilization of diagnostic imaging and surgical techniques for non-specific low back pain despite evidence that such techniques may be inappropriate at best and iatrogenic at the extreme.[5,6,7]

EVIDENCE-BASED LEARNING PRINCIPLES

This state of affairs was the genesis of *Make It Stick: The Science of Successful Learning*.[8] The goal of the co-authors (Brown, Roediger, and McDaniel) was to highlight the wrong ways in which people are going about learning (the myths of learning), and based on the research, to explain how learning and memory work, and can be optimized. The overarching objective was to provide an accessible account for students and teachers that would be built around a compelling narrative. As cognitive scientists, we (Roediger and McDaniel) were certain that we would not be able to find that voice; therefore, we enlisted a novelist (Peter C. Brown) to narrate the story. It worked. In the past 6 years since the book has been published, we have been inundated with testimonials from students and teachers who have successfully revised inefficient studying and teaching techniques with the evidence-based principles summarized in the book.

One shortcoming has become evident, however. From many conversations and e-mails with our readers, it is clear that for any particular discipline of study, these evidence-based principles must be translated into concrete techniques that align with the challenges and contents of that *specific* discipline.

To begin to remedy this shortcoming for students, clinical instructors, and practitioners of the rehabilitation sciences (including physical therapy), Leda C. McDaniel offers her insights in the main article of this issue. McDaniel is a physical therapist who has been applying and translating the principles in *Make It Stick* to her work: first as a student in a Doctor of Physical Therapy (DPT) program and now in her role as an instructor to physical therapy students. (It may be worth mentioning that she has a special vantage point in doing so, as she is also the daughter of the co-author Mark McDaniel.)

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The Science of Successful Learning: Applications to Physical Therapy Education

By Leda C. McDaniel, PT, DPT

When I first read *Make It Stick: The Science of Successful Learning*—a book for the general public written by Peter C. Brown, Henry L. Roediger III, and my father, Mark A. McDaniel[1]—I did not realize the significant impact it would have on me. It not only greatly influenced my own study habits as a student, but it also shaped how I went about developing effective teaching methods and course materials in my role as an educator. The book was especially impactful for me because my reading of it and application of its principles coincided almost identically with my entry into a Doctor of Physical Therapy (DPT) program as a graduate student.

My re-entry into academics posed challenges. It had been nearly six years since I had graduated with a Bachelor of Arts in Psychology, and my study habits were rusty at best. Furthermore, the fact that I had never taken any natural science classes meant that virtually all of the subjects I was trying to learn were brand new to me. I was also tasked with figuring out optimum techniques of *how* to learn; this is where *Make It Stick* became crucial.

I am now in my first year of practice as a physical therapist, which reflects my success in meeting those challenges as a student. I have also had the opportunity to teach, first as a teaching assistant while obtaining my DPT and now as a Physical Therapy Orthopedic Resident, and have done so in various settings. During these experiences, I have consistently utilized principles from *Make It Stick*.

The following are three key techniques from the book that I have successfully applied to my own learning, and to teaching others to learn more effectively within doctorate-level physical therapy education.

TECHNIQUE 1:

RETRIEVAL PRACTICE

Retrieval practice, such as trying to recall key points from a recently-read passage, involves retrieving information from memory and is experienced as much more difficult than a simple rereading of information. However, retrieval practice is the best way to ensure durable learning.

It feels good to reread, because the fluency and familiarity gives one the sense of having "learned" the material, which provides a pleasant experience. Retrieval practice, such as trying to recall specific details from a recently-read passage, takes more effortful attention and is experienced as much more difficult. However, retrieval strengthens memory for the retrieved information,[2] and helps guide subsequent study (eg, by identifying gaps in one's knowledge).[3] Therefore, it is important as a learner and an instructor to craft opportunities for retrieval practice.

A number of study techniques can emphasize retrieval.

For example, students can structure retrieval practice with methods such as flashcards, free online programs such as "Quizlet" (where students can create digital flashcards or quizzes), and using study time to draw pictures of anatomy or biomechanical concepts from memory or with minimal cueing (eg, drawing diagrams of the brachial plexus to learn nervous-system anatomy or drawing force diagrams for movement-analysis problems).

Memory techniques such as mnemonics and "chunking" can also be helpful. There are a plethora of medical mnemonics such as those for remembering muscle groups based on common insertion sites (eg, Pes Anserine attachment muscle group as: "**S**ar**G**en**T**": **S**artorius, **G**racilis, semi**T**endinosis muscles). These techniques can improve recall of information and facilitate remembering.

As indicated in *Make It Stick*, part of the tendency to eschew retrieval practice is because it is *harder* than rereading or "recognition" practice. However, this difficulty is often necessary and desirable. We can think of this similarly to how we advise our patients that they need to push just a little bit past their comfort zone or experience symptoms of discomfort (eg, muscle soreness, joint stiffness, or mild symptoms of vertigo) in order to see improvements in muscle strength or to reduce symptoms such as dizziness or imbalance that may indicate vestibular dysfunction. Just as our patients require these minor stresses to promote positive adaptations, as physical therapy students and physical therapists, we can optimize learning with some necessary amount of struggle.

TECHNIQUE 2: TEACHING AS A MEANS OF BUILDING DEEPER UNDERSTANDING

Along with retrieval practice, there is also a need to integrate target information into a coherent mental model (an organized representation of how the information is interrelated). Such deep understanding facilitates retention much more than memorization. One superb way to encourage this deep encoding is via the practice of teaching. There is great power and utility in teaching as a part of medical (and physical therapy) education (eg, "See one, Do one, Teach One").[4] Teaching stimulates retrieval practice, requires the learner to reach for a deeper understanding of information, and provides a "learning check" for the student.

With this principle in mind, I have sought out teaching opportunities for myself that encourage learning, and have also created opportunities for students to teach within the courses that I have helped to instruct. One example is to set up a teaching and learning exchange in gross anatomy or neuroanatomy labs in which students are tasked with preparing and then teaching on different body area sections within groups. Each student can present on a body area for 15 minutes and discuss all of the muscles, nerves, and blood supply to that body area including details such as muscle actions and attachments. I have used various iterations on this basic theme. First-year DPT students (as part of their final exam review) can teach third-year DPT students (as a study review for the National Physical Therapy Examination [NPTE]) in neuroanatomy labs, third-year DPT students can teach physical therapists as part of continuing education courses on anatomy, and first-year DPT students can teach within their own lab groups. Feedback from students participating in these various teaching exercises has been overwhelmingly positive.

TECHNIQUE 3: LOW-STAKES TESTING: 'PRACTICE HOW YOU WANT TO PLAY'

"Practice how you want to play" is the best representation I know to explain why practice quizzes and tests are so valuable: we are replicating performance conditions. Whether the performance is for a physical therapy student taking an exam to demonstrate knowledge (eg, on the NPTE) or whether we are trying to replicate patient care situations, simulating these conditions can be useful in successful learning. I believe we can set up all sorts of quizzing and testing conditions to support learning, as long as we remember that the testing is a learning exercise ("low-stakes"), not a summative assessment. For example, as a student learning how to perform physical therapy evaluations, I would regularly study with classmates by acting out patient cases and performing evaluations on "mock patients" (ie, fellow classmates). In pairs, one of us would role-play the physical therapist and one of us would role-play the patient.

As a teacher, I have led and structured similar exercises for students—creating patient cases for students to act out and helping other students practice their evaluation skills by interviewing these simulated patients. Other ways in which practice quizzes can be effective are in anatomy and neuroanatomy labs, where I have participated in and organized practice "pin exams," in which students identify anatomical structures and functions based on colored pushpins fastened to these structures; in orthopedic labs by providing assessment and feedback during "skill checks," in which students are asked to perform hands-on techniques for assessment and treatment; and by writing and discussing "knowledge review," quizzes and practice test problems from a variety of subjects found in DPT curricula (eg, biomechanics, orthopedic examination techniques, and nervous system physiology).

TOOLS FOR OVERCOMING LEARNING CHALLENGES

I have found the three evidence-based learning techniques reviewed above to be especially useful for the learning challenges I experienced as a graduate student and for assisting my students with similar challenges in acquiring foundational knowledge and skills needed for PT practice. Of course, these learning techniques are not exhaustive, and others may also be potently applied within DPT education settings. For a more comprehensive overview of evidence-based learning principles, please consult the full text of *Make It Stick: the Science of Successful Learning*.

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Dr. Leda McDaniel is a practicing Physical Therapist in Atlanta, GA. She earned her Doctorate of Physical Therapy in 2019 from Ohio University and went on to complete Emory University's Orthopedic Physical Therapy Residency program in July 2020. During her residency, Leda served as a guest lecturer and teaching assistant within select courses in Emory's Doctor of Physical Therapy (DPT) program. Leda's passion for physical therapy is paralleled by an interest in teaching and education and her clinical practice interests include persistent pain management, tendinopathy rehabilitation, and leveraging neuroplasticity principles in orthopedic physical therapy settings. She is also fortunate to be the daughter of Dr. Mark McDaniel, the prominent educational psychologist and author of Make it Stick: The Science of Successful Learning (2014). Leda greatly values the inclusion of compassion and humanity within the rehabilitation sciences and clinical practice and believes that her undergraduate studies in psychology coupled with her teaching experiences have provided a depth to her clinical care that otherwise would be lacking.

Mark McDaniel is a Professor of Psychological and Brain Sciences and the Director of the Center for Integrative Research on Cognition, Learning, and Education (CIRCLE) at Washington University in St. Louis. McDaniel is known for his work in the application of cognitive psychological principles to education. He has published numerous papers related to cognition and education, including topics such as individual differences in concept representations, discovery learning, mental models, analogical learning, and classroom studies on testing effects. To facilitate dissemination of research literatures pertinent to learning and education, with Peter Brown and Roddy Roediger, he co-authored a book published by Harvard University Press entitled Make it Stick: The Science of Successful Learning (2014).