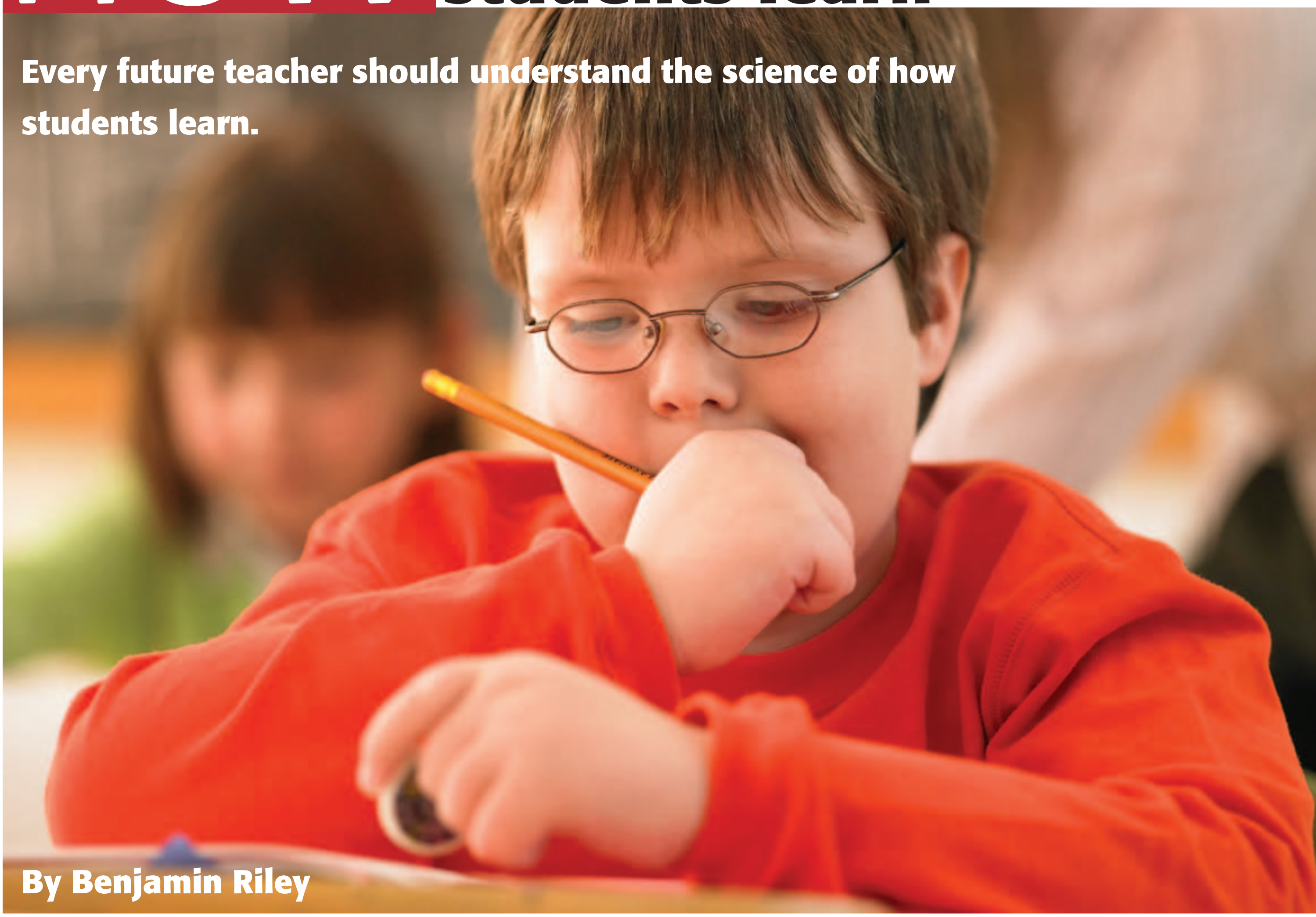
The value of knowing how students learn



Every future teacher should understand the science of how students learn.

By Benjamin Riley

I can remember the day that transformed my perspective on teaching and teacher preparation. I was sitting on my couch on a Sunday morning in Washington, D.C., reading a book written by Daisy Christodoulou, a teacher in England (2014). Three years into her teaching career, Christodoulou described a deep and surprising frustration:

> I was shocked to stumble across an entire field of educational and scientific research that completely disproved so many of the theories I'd been taught when training and teaching. I was not just shocked, I was angry. I had been working furiously for three years, teaching hundreds of lessons, and much information that would have made my life a whole lot easier and would have helped my pupils immeasurably had just never been introduced to me (p. 5).

Finishing her book, I shared Christodoulou's outrage. More than that, I realized that I personally had promoted education policies and practices that were of dubious scientific merit. And I thought

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to myself, something should be done about this.

The science of learning

The body of research that Daisy Christodoulou was referring to is cognitive science — the empirical study of how the human mind works, including how knowledge is acquired, stored, and deployed. Cognitive science might be thought of as the science of learning.

We do **not** learn in discrete age-related stages dictated by biology. Instead, our learning is variable and often happens in fits and starts.

Deans for Impact, a nonprofit organization composed of leaders of teacher preparation programs throughout the U.S. (and where I serve as executive director), believes cognitive science is an important part of an evidence-based core of knowledge that preservice teachers should possess. We believe that cognitive science holds promise for improving learning and promoting the professionalization of teaching.

With that in mind, we have published a six-page white paper entitled *The Science of Learning*, which summarizes existing research on how students learn and connects this research to practical implications for teaching. *The Science of Learning*, which is free and available on the Deans for Impact web site (http://deansforimpact.org/pdfs/The_Science_of_Learning.pdf), was developed in close collaboration with cognitive scientist Dan Willingham and Paul Bruno, a former middle school science teacher.

The Science of Learning contains six key questions related to how students learn, with principles from cognitive science that help answer them, and lists some practical implications for teaching that follow from these scientific principles. The key questions:

1. How do students understand new ideas?
2. How do students learn and retain new information?
3. How do students solve problems?
4. How does learning transfer to new situations?
5. What motivates students to learn?
6. What are some common misconceptions about how students think and learn?

The Science of Learning is not intended to be a definitive, comprehensive overview of the field of cognitive science. Instead, the six questions were carefully selected for their general applicability to most education situations and for the robustness of the science underlying the answers to each of them. In this sense, the document serves as a short field guide to our best available scientific understanding of how learning happens. Other organizations such as the Institute for Education Sciences (Pashler et al., 2007) and the American Psychological Association (2015) have published documents of a similar nature that reflect many of the same scientific principles.

Principles to practice

The Science of Learning is unique because it not only identifies widely agreed-upon scientific principles but also connects them to specific practical tips for educators. Here's one example: Most teachers know from experience that students need to practice doing something in order to learn it. But not all practice is equivalent. To learn new content, it's helpful if students revisit and review information over a long term — weeks or even months — to ensure they truly remember it. Teachers also should alternate types of problems rather than presenting one type of problem set all at once and then moving on to the next set, and so on.

Another example relates to student motivation. Although having a growth mindset is often described as a noncognitive skill, in reality the pioneering work of Carol Dweck and others is grounded firmly in principles of cognitive science. Students are more motivated to learn if they believe that intelligence and ability can be improved through hard work. Teachers can contribute to this belief if they praise students' productive efforts — specific steps students undertake that lead to demonstrable learning, not just working hard.

For some, these principles and their practical implications may seem obvious. But *The Science of Learning* contains a handful of heresies that run counter to some of the prevailing winds of today's education enterprise. Here are four examples:

#1. To solve problems, students need to know facts.

Cognitive scientists have developed a robust mental model that distinguishes between working memory (the limited system where we consciously process new information) and long-term memory (the storage system that holds the vast majority of our knowledge). By committing certain facts to long-term memory, students free up their working memory, which leaves them better suited to grapple with complex problems. This is why it's still important for students to memorize multiplication tables — pulling out their smartphones in the middle of a complex math problem will slow their thought processes and often cause them to lose track of where they are.

#2. Tests can improve student learning.

The pitched debate over whether schools and teachers should be evaluated based on high-stakes tests threatens to obscure an important fact: Tests are useful drivers of learning. This is so because they require students to focus on specific material they need to remember. Low-stakes quizzes and student self-tests work well for this.

#3. Content should not be kept from students because it might be developmentally inappropriate.

All teachers have seen students have good and bad days in class. This seemingly simple insight reflects a larger principle of cognitive science that is not yet widely accepted in our education system: We do not learn in discrete age-related stages dictated by biology. Instead, learning is variable and often happens in fits and starts. Thus, when presenting new material to students, teachers should focus on whether students possess the existing knowledge they will need to understand the new content. This is one big advantage of using carefully sequenced curriculum.

#4. Students do not have different learning styles.

The notion that students have preferred learning styles, i.e., that they are visual, audio, or kinesthetic learners, is pervasive in education. While the theory sounds plausible enough, scientists have studied it time and again, and the data overwhelmingly suggest that students do not learn more when presented with information in their preferred style. This doesn't mean teachers shouldn't vary the ways in which they present material — not doing so would be boring — but it strongly suggests instructional approaches based on learning styles are unlikely to yield much fruit.

Although *The Science of Learning* is primarily aimed at influencing teacher educators and others who prepare future teachers, our hope is that educators at any point in their careers will find it useful. One hallmark of a true profession is that it coheres around a well-understood and specialized body of knowledge that practitioners learn as part of their training. Cognitive science does not comprise the entirety of that body of knowledge, but it should at least be part of it.

Teachers need to know how students learn

For many, the simple question of whether teachers should understand learning science is enough to answer it. If the job of teaching requires imparting knowledge to children, then surely the task of teachers will be made easier if they understand the conditions that make learning more likely to occur. This scientific knowledge combined with practical insights gleaned from classroom experience should empower teachers to be more effective.

Research evidence suggests that teachers employ mental models of how students learn when they teach (Beijaard & Verloop, 1996). In this sense, every teacher — implicitly or explicitly — employs a theory of learning as they make instructional decisions. It seems logical for the mental model to be based on our best available scientific understanding of how learning occurs. Similarly, emerging evidence suggests these models influence how teachers teach (Lohse-Bossenz et al., 2015). Research related to developing expert practice in the medical profession suggests that doctors who have accurate mental representations in mind when performing procedures are more effective than those who don't (Ericsson, 2015). Outcomes improve when theory is in harmony with practice.

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But we don't yet have definitive evidence that proves such understanding will lead to specific and measurable learning outcomes. For this reason, Deans for Impact is working with some of the programs led by our member deans to investigate this claim. We plan to test our own hypotheses.

Unfortunately, we *do* know that many teachers hold beliefs at odds with cognitive science. Sample surveys of teachers in the U.K. and the Netherlands found they overwhelmingly believe that students learn best when "they receive information in their preferred learning style" (Dekker et al., 2012). We lack comparable data for teachers in the U.S., but current research is under way, and data from an initial small pilot study conducted by a researcher at the University of Hawaii suggest these same neuromyths are prevalent here too.

Room for improvement

A separate objection to the relevance of cognitive science to teaching is that it conflates *learning* with *teaching*. I sometimes think of this as the Lionel Messi counterargument. Lionel Messi is generally considered to be the best professional soccer player in the world, capable of delivering deft passes and jaw-dropping strikes on goal at the highest level of international competition. Yet it seems unlikely that he understands the physics of how soccer balls travel. Indeed, it seems reasonable to assume he developed his skills in blissful ignorance of the underlying physical laws that control a ball's movement.

Perhaps the same holds true for educators. Perhaps teachers need not understand the science of learning to be effective. Perhaps they, like Messi, can acquire the skills they need *without* understanding the underlying theory of learning implicit in their actions.

Cognitive science is an important part of an evidence-based core of knowledge that preservice teachers should possess.

As noted above, there is already evidence against the Messi counterargument that suggests a teacher's mental model of how students learn is important. But even absent this evidence, there is something impoverished in viewing teaching as no more than a set of enacted behaviors unconnected to any deeper theory. We hold doctors, engineers, and even lawyers in esteem because they possess special knowledge relevant to their fields, and this knowledge is woven together by theory. If we agree that cognitive science is one form — not the only form but one form — of specialized knowledge relevant to teaching, then ensuring that teachers understand it may be one way of improving the esteem of the education profession. Teachers are so much more than soccer players.

Defending against knowledge nihilism

There's one final reason that it's important for educators to understand cognitive science. In my view, understanding this science may be our best defense against the growing danger posed by what I call knowledge nihilism. The proponents of knowledge nihilism believe knowledge itself is overrated. In an era of proliferating technology that lets us access information at speeds unimaginable even a few years ago, they believe students no longer need to know facts or understand procedures. After all, why teach it when they can Google it?

There's a scientific answer to that question that all educators should be ready to offer. We should teach it — whatever it may be — because students understand new ideas by reference to ideas they already know. Thinking well requires knowing facts that help us make sense of new information. If this weren't true, you wouldn't be able to read this essay, or it would be no more difficult for you to read if it were written in Slovak, the vocabulary and grammar of which, after all, you can find with Google.

Teachers should be the first line of defense against knowledge nihilism. Through exposure to both cognitive science and their own experiences as educators, they should push back against those who deny their relevance to the education system. Knowledge isn't overrated, and teachers are critical to ensuring we transmit it across generations. Understanding the science of learning should be part of the knowledge that all educators possess as they begin their careers. K

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