UNDERSTANDING HOW WE LEARN

A VISUAL GUIDE

YANA WEINSTEIN AND MEGAN SUMERACKI
WITH OLIVER CAVIGLIOLI

A David Fulton Book

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Oliver would like to thank his wife, Lyn – now three years retired from teaching – who still has to put up with his incessant babblings about such and such a teaching strategy. Her support has often veered towards suffering.

Author profile

Dr. Megan Sumeracki *Dr. Yana Weinstein*

Who are you?

We are two cognitive psychologists who do applied research in education.

Yana first got hooked on "false memory."

Yana:
False memory is something I learned about in my first undergraduate research methods class: the idea that we sometimes remember things that did not occur, or differently to how they really occurred. I got stuck on the idea that surely there is an objectively "true" memory somewhere in our minds that we distinguish from this "false" memory. My dream was that you could take a person who claimed to have a particular memory, do some clever science on them, and come back with a "TRUE!" or "FALSE!" indicator for that particular memory. What can I say – I was young and naïve. I tried to research this in my PhD, but realized too late that it was, in fact,

more or less impossible to distinguish between true and false memories with a cognitive task. I then went on to join Henry (Roddy) Roediger's lab, where I learned all about how to apply memory research to education. Now my passion has shifted over to figuring out the best way for students to learn, based on advances in cognitive psychology and our understanding of how the mind processes and remembers information.

Megan got into cognitive research as an undergraduate student because she was interested in education.

Megan:
By the beginning of my junior year in college I was getting ready to apply for the research-focused honors program at Purdue University, and had started subbing K-12 on days when I didn't have classes – I went to great lengths to block them off so that I would have two full days off at a time. I loved being in the classroom and working with students, and I loved issues related to education. I applied to conduct my honors thesis in Jeff Karpicke's Learning Lab (http://learninglab.psych.purdue.edu/people/karpicke/), where I started conducting my own applied research on learning. I fell in love with the research, and continued to pursue training in cognitive psychology and applications to education. I had found my passion, and wanted to have a role in changing education.

What kind of research do you do?

Yana:
My research interests lie in improving the accuracy of memory performance and the judgments students make about their cognitive functions. I try to pose questions that have direct applied relevance, such as: How can we help students choose optimal study strategies? Why are test scores sometimes so surprising to students? And how does retrieval practice help students learn?

Megan:
My area of expertise is in human learning and memory, and applying the science of learning in educational contexts. My research program focuses on retrieval-based learning strategies, and the way activities promoting retrieval can improve meaningful learning in the classroom. I address empirical questions such as: What retrieval practice formats promote student learning? What retrieval practice activities work well for different types of learners? And, why does retrieval increase learning?

Why are you writing this book?

We are writing this book to continue the conversation about evidence-based learning

strategies that we *started on our website and blog, learningscientists.org, and our Twitter account, @AceThatTest. When we started the Learning Scientists, it was because we wanted to make the cognitive psychology research on learning more accessible, to increase its ability to have real positive impacts for students around the world. Essentially, we have aimed to break out of the typical walls of academic research and talk about research and education with many relevant parties, and not just our fellow researchers.*

How did you start the Learning Scientists project?

Yana:
One night in January 2016, I was feeling guilty about not doing enough to disseminate my research on learning to students — so I decided to see what I could do on Twitter. I searched "test tomorrow" and realized that many students tweet about how unprepared they feel for their upcoming exams or about how they can't concentrate enough to study. I began tweeting advice at these students.

Megan:
At the same time, I had started a new professional Twitter account and was trying to create an assignment for my students in cognitive psychology where they would find articles and tweet them. The assignment was a slight disaster, but in the process, Yana and I connected again (we had crossed over at Washington University in St. Louis, but had not worked together directly), and I saw what she was doing and started joining in. And then I realized if my account was flooded with all of this stuff, my students were going to get confused, so I suggested that maybe we should start our own Twitter handle just for this. That's when the Learning Scientists Twitter account (@AceThatTest) was born. At the time of writing, we now have over 10,000 followers, and the project has grown to so much more than just a Twitter account. We have a thriving blog, multiple funded research and science communication projects, a podcast, and now this book.

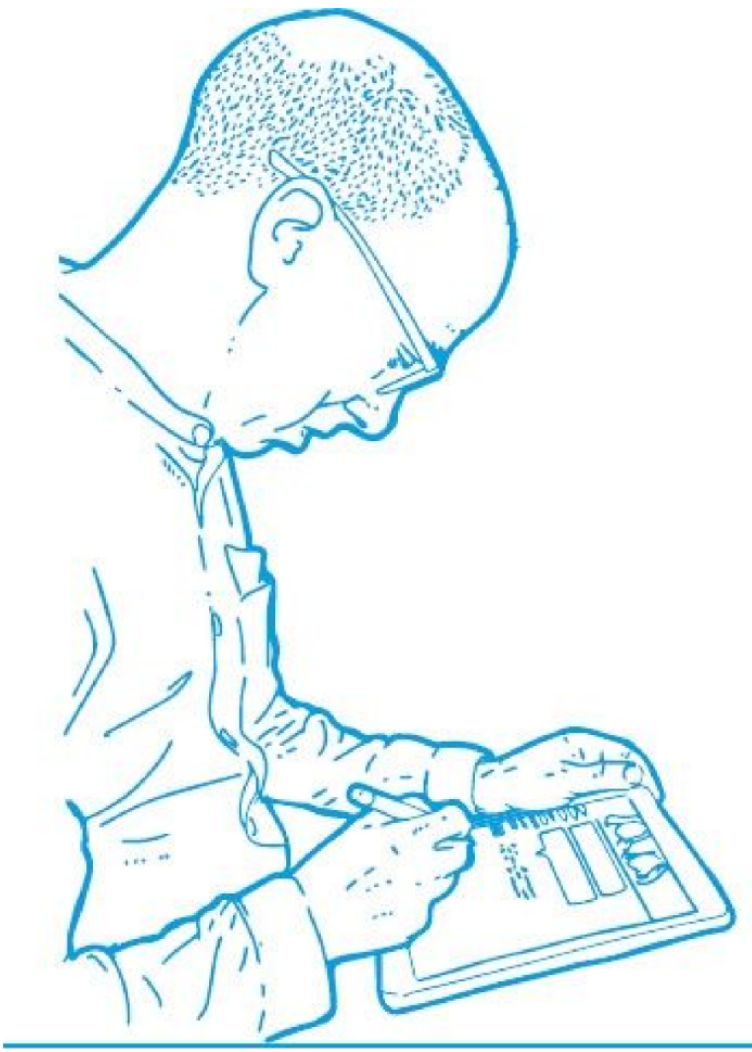
What drives you?

We're passionate about education and giving people tools to study and teach more effectively.

What might you hope the reader will do with the knowledge?

Apply it to their own lives – after all, everyone is trying to learn something!

Illustrator profile



Oliver Caviglioli

Who are you?

I'm a former special school principal who, from childhood, has been interested in visual communication. My architect father introduced me to diagrams, typography, and the fine arts in general. So when I became a special school teacher, this focus on visual depiction served me well, and by working with educational psychologists for a number of decades, I found an increasingly useful range of applications for my

growing set of skills.

How do you use your visuals to aid learning?

In addition to illustrating books, I also create posters and slide presentations, as well as designing documents. Then there's something called sketchnotes. These are live notes made of presentations at conferences. Or, alternatively – and rather less stressful – they can be hand-drawn summaries of book chapters, for example. Napkin sketches are similarly hand-drawn, but focus on depicting either the structure of concepts or stages of processes. They are immensely helpful in analyzing and depicting the steps involved in teaching techniques.

Have you worked with the Learning Scientists before?

Yes, last year we collaborated in the creation of a set of posters of the top six learning strategies as identified by cognitive psychology. The posters have now been translated into a dozen languages and can be found on classroom walls around the globe.

What do you get out of working with the Learning Scientists?

I end up getting the most marvelous education! As we discuss how best to visually explain some pieces of research, for example, I receive explanations that are personalised to my level of understanding. Being able to ask questions until you think you have established a good understanding is a treat, as well as being essential for creating the illustrations. And, of course, the illustrations become feedback to Yana and Megan on the effectiveness of their explanations. A perfect loop in which to learn!

Part 1

Evidence-based Education and the Science of Learning

1
Communication breakdown between science and practice in education

Communication breakdown between

science and practice in education

Unfortunately, educational practice does not, for the most part, rely on research findings. Instead, we tend to rely on our intuitions about how to teach and learn – with detrimental consequences.

In 1928 Alexander Fleming came back from vacation and accidentally discovered a colony of mold that led to the development of penicillin, which can be used against bacterial infections (Ligon, 2004). This process then took several decades and involved clinical trials where this new drug was compared to other drugs that, at the time, were thought to help fight bacterial infections (Abraham *et al.*, 1941). The model that we, as cognitive psychologists, are striving for in education is similar to the one exemplified by this anecdote, and used broadly in mainstream Western medicine: a drug is proposed, tested by science, found to be better than a placebo, and put on the market.

Western medicine: a drug is proposed, tested by science, found to be better than a placebo and put on the market.

Of course, any one drug does not work all the time, and so doctors will prescribe different drugs at different doses for different circumstances, conditions, and individuals.

However, Henry L. (Roddy) Roediger III reported in 2013 that, unfortunately, educational practice does not, for the most part, rely on research findings (of course, this is not always how medicine works, either; see Haynes, Devereaux, & Guyatt [2002] about how "evidence does not make decisions, people do").

Henry Roediger
Henry L. (Roddy) Roediger III, James S. McDonnell Distinguished University Professor of Psychology, Washington University in St. Louis

Instead, somewhat dubious sources of evidence such as untested theories – or, even worse, marketing ploys by financially interested parties – drive educational fads. This concern is not new. For example, back in 1977, Fred Kerlinger (an American educational psychologist born in 1910) gave a presidential address at the American Educational Research Association conference on this issue. He argued in particular that education should pay more attention to *basic* research – the type of research that aims to figure out how and why people learn and behave the way they do. In this book, we review important basic processes – perception, attention, and memory – but we also focus on *applied* research – research that takes what we know about basic processes and applies them to real-life educational questions and settings.

How do we know whether a teaching or learning strategy is effective?

We advocate that teaching and learning strategies be put to the test, as in the medical field.

If evidence supports the effectiveness of a strategy, then we should by all means

adopt it, but continue to be flexible as the science evolves. After all, would you give your child a pill that had never been scientifically tested? Or worse, one that had been scientifically tested and was shown not to work? Would you bring your child to a doctor whose practice was based on opinion and intuition alone, rather than the most up-to-date science? We know we wouldn't. To use another example, think about the distinction between astrology and astronomy. Many of us know that one of those is science, and the other is … a fun pastime, at best.

Astronomy vs. astrology – one is science, the other is not.

However, when talking about something as broad as "learning," there are various different scientific fields that we can draw from. *In Chapter 2, we talk about different types of evidence about how we learn.* For the purposes of this book, we will be focusing on evidence from **cognitive psychology**, because that is our area of expertise. Cognitive psychology is usually defined as the study of the mind, including processes such as perception, attention, and memory (not to be confused with neuroscience, which focuses on how the brain functions). This field of research can help us understand learning by testing hypotheses about learning strategies that are developed based on what we already know about the mind.

A different type of evidence is our own intuition. Because often, our feelings about how we learn are more compelling than reality.

Alarmingly, our feelings about how we learn can often be more compelling than reality.

For example, if students read and re-read a textbook, they will become more and

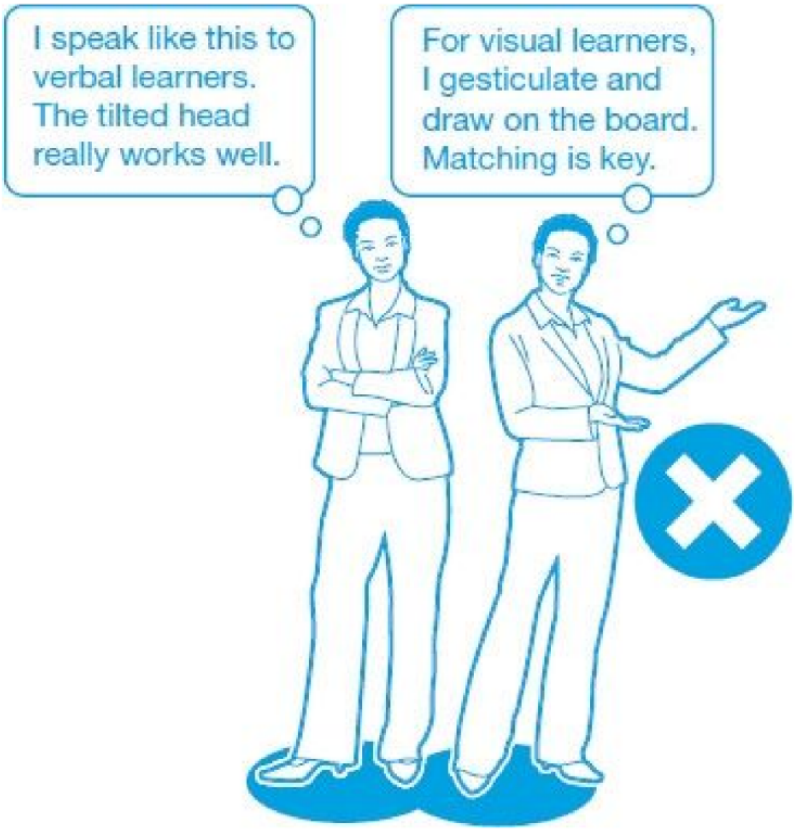
more confident that they will do well on a later test. If another group of students instead take practice tests, they will be less confident in their later performance – because these tests can feel hard. But in reality, those who took the practice tests will outperform those who re-read the textbook (see Chapter 9 for more about this technique). In this case, and in many others, going with our intuition about how we learn can be detrimental.

Relying upon intuition, rather than science, can also lead us to latch on to false positives. There are certainly times when we see a positive result just because of luck or chance. But, this positive result does not mean that a particular method will work consistently over time. For an example, think about sports. If you're an American football fan, then you can probably remember a time when the quarterback made a long-haul pass down the field that was successfully caught and run into the end zone for a touchdown. But, we know these "hail Mary'" passes certainly don't work every time, and it would be a mistake to attempt the long-haul pass on every play. This would likely lead to an increase in losses for that team in the long run.

In many cases, going with our intuition about how we learn can be detrimental.

We will cover this scenario, and other learning scenarios where intuition can mislead us, in Chapter 3 and throughout the book.

Not only does our intuition often mislead our own selves, but often, we can end up misleading others, too. The concept of "learning styles" is one example of time, money, and energy spent on a practice that is not particularly good at increasing learning, according to the evidence (Rohrer & Pashler, 2012). You may have heard of it: "learning styles" describe the idea that students learn best in different ways. The most popular of these "styles" are visual and verbal styles: the idea is that some people are visual learners, while others are verbal learners. Importantly, proponents of learning styles claim that in order to maximize student learning, we must "match" instruction to each individual's learning style (Flores, n.d.)



After a thorough review of the scientific literature, a group of leading researchers discovered that there was no evidence to support this view (Pashler, McDaniel, Rohrer, & Bjork, 2008). That is, there was not a single controlled experiment in the literature that demonstrated that matching instruction to learning styles overall helped students learn more. We talk more about this and other misunderstandings in Chapter 4. Above all, we do not want teachers and students finding themselves wasting time on strategies that are not particularly effective (see over).

Trying to implement these strategies may not be the best use of our time.

What do teachers and students learn about cognitive psychology?

We believe that researchers, teachers, and students should have an open dialogue about research related to learning. It is in everyone's best interest to talk to one another so that we can make the best use of recommendations from learning science in the classroom, and figure out what additional research would be most helpful for teachers and students. But how do those actually involved in teaching – and those involved in training teachers – feel about using cognitive psychology findings in their teaching practices?

Laski, Reeves, Ganley, and Mitchell (2013) asked trainers of elementary mathematics teachers across the US to what extent they found cognitive psychology to be important to teaching mathematics. While most found it important, very few of the respondents actually accessed the relevant primary sources (i.e., cognitive psychology journals). When asked how often teachers read cognitive journals to inform their teacher-training practice, the most frequent response was "Never." This response makes sense, as journal articles are dense, full of jargon, and often behind paywalls such that those outside of higher education do not typically have access.

Furthermore, according to a recent report (Pomerance, Greenberg, & Walsh, 2016), very few teacher education courses and textbooks in the US cover principles from cognitive psychology related to effective learning.

Very few teacher education courses cover principles of cognitive psychology related to learning.

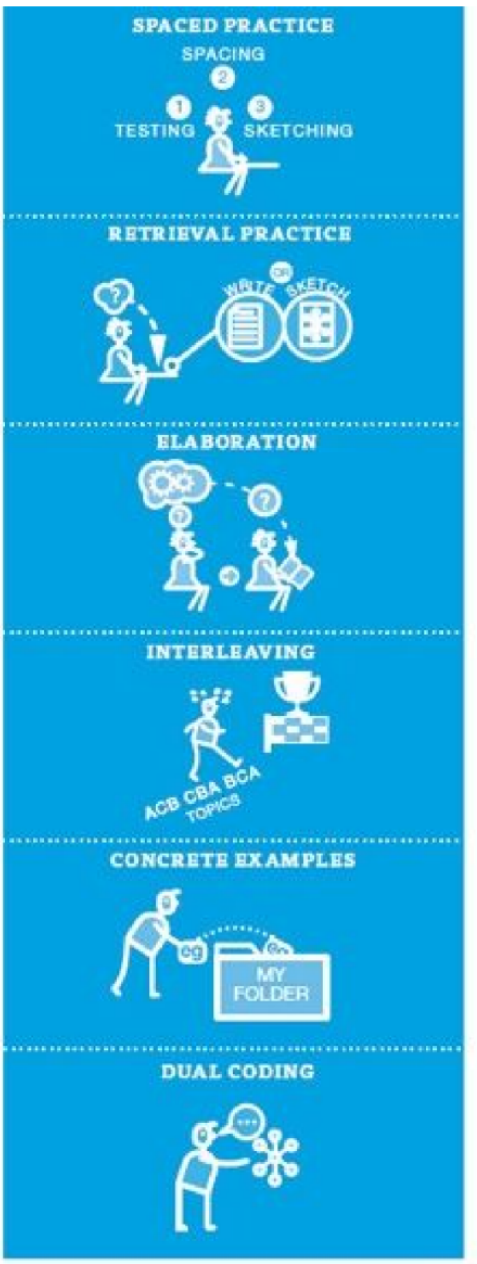
This suggests that the six strategies that have received the most evidence from cognitive psychology – which we will cover in Chapters 8 through 10 – are not systematically making their way into the learning experience in the classroom.

It turns out that these textbooks mostly gloss over, and often completely ignore, the learning strategies that have been most supported by evidence from cognitive psychology throughout the last century.

Alarmingly, on the other hand, these teacher-training textbooks and courses do sometimes propagate common misunderstandings about learning, which we will talk

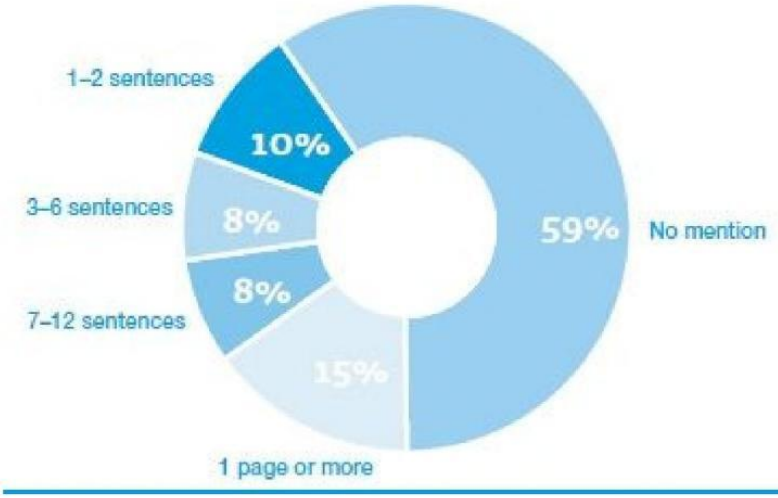
about in Chapter 4.

Teacher-training textbooks and courses sometimes propagate misunderstandings about learning.



Six strategies for effective learning based on cognitive psychology research.

The National Council on Teacher Quality (NCTQ), which created the Pomerance and colleagues (2016) report, has been in the process of creating teacher training programs that are based on evidence from cognitive research. Other organizations, such as Deans for Impact, have also been vocal about the need for such evidence-based teacher training programs. Unfortunately, programs like that of the NCTQ seem to be few and far between.



This figure demonstrates the amount of space dedicated to any of the six strategies for effective learning in the 48 teacher-training textbooks commonly used in the US. If every strategy of the six had been mentioned in every textbook, there would be 288 mentions (48 textbooks x 6 strategies) in total. However, most of these mentioned (59 percent) did not exist, and the ones that did tended to be very short. Figure adapted from Pomerance *et al.* (2016).

Is our research inaccessible to teachers?

The research-to-classroom pipeline is not straightforward. As we've learned over the past two years of engaging in public outreach about learning science, the discrepancy between research and practice in education is a lot more complex than just a communication breakdown.

There are a number of reasons why teachers may not be inclined to engage in "evidence-based practice." For example, Alabama high-school psychology teacher Blake Harvard (2017) lists three different reasons on his blog "The Effortful Educator": lack of time, lack of access to academic journals, and the difficulty of interpreting technical writing (though interestingly, Laski *et al.* did not find a strong relationship between how difficult teacher educators found cognitive psychological articles, and how (un)likely they were to consult them).

The discrepancy between research and practice is a lot more than just a communication breakdown.

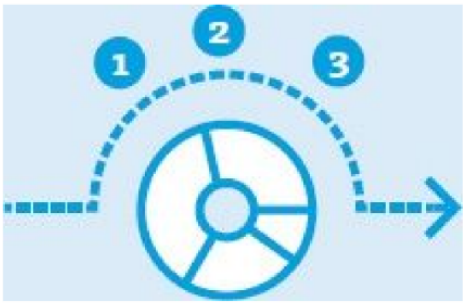
Teachers and students deserve access to this research and time to read through and discuss ways to apply it in the classroom. (2017)

Religious education teacher Dawn Cox in the UK provides some additional suggestions for why teachers may not engage with researchers, including discomfort with change, uncertain findings, and reluctance to accept findings that disagree with one's intuition (Cox, 2017; see Chapter 3 about the problem with using intuition to make decisions about teaching and learning).

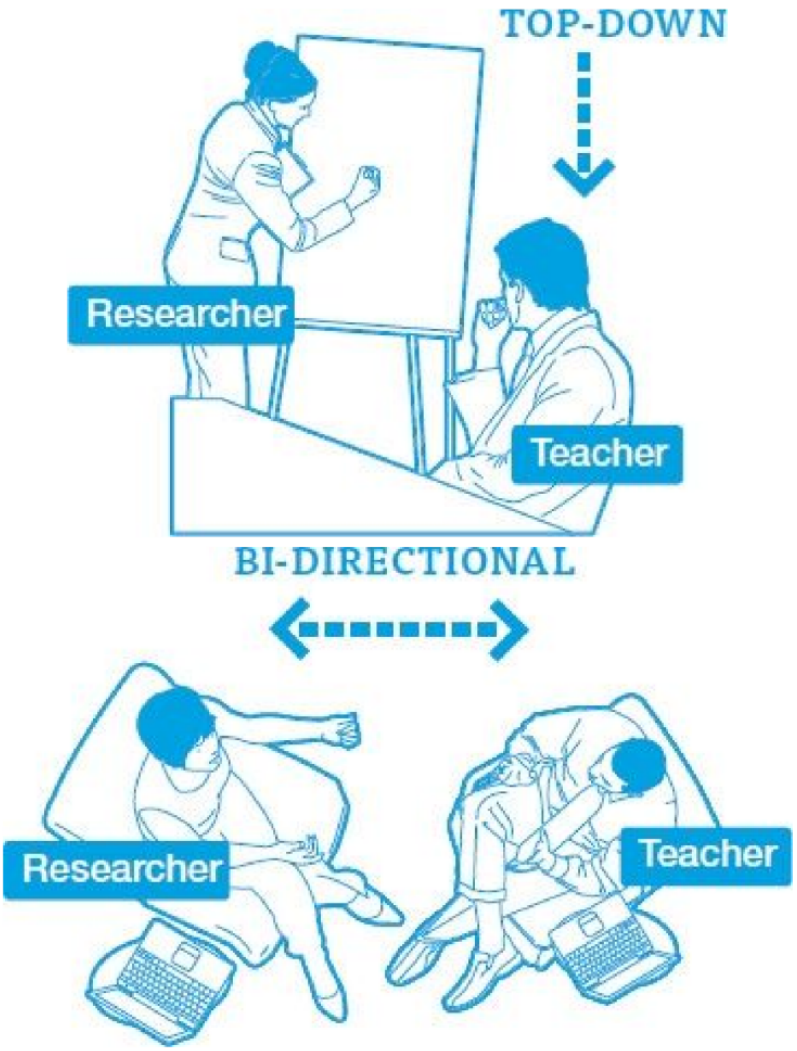
We like to teach in a way that we know, even if it isn't hugely successful; we are reluctant to change. (2017)

Dawn Cox

Another reason that has been cited for teachers' reluctance to adopt practices described in research studies as effective, is a lack of trust in researchers: teachers may feel that researchers are out of touch and unaware of the reality of the classroom, and make irrelevant recommendations. This lack of trust is understandable, given the power dynamic (perceived or otherwise) of researchers "creating" and "disseminating" knowledge in a top-down manner (Gore & Gitlin, 2004). The resulting situation is a lack of two-way dialogue between teachers and researchers – and that's something we're passionate about changing.



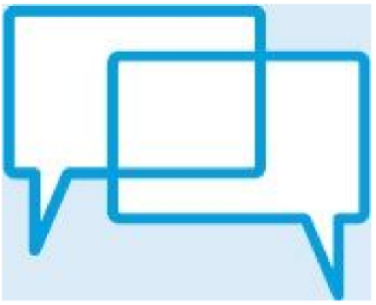
There are a number of reasons why teachers may not be inclined to engage in evidence-based practice.



In top-down communication, the researcher passes on their knowledge. In bi-directional communication, the teacher and the researcher have a conversation and learn from each other.

Teachers face the gargantuan task of integrating information from a myriad of sources in order to best help their students learn. So, we all need to do our part to make sure research is accessible to educators, and that educators are open to research findings. We also need to make it possible for teachers to openly communicate with researchers, so that the most important questions are tackled and, hopefully, answered. That is the main reason we are writing this book: we want to help open up the lines of communication between researchers, teachers, and students. This book is just one of the many ways we are attempting to connect with different groups of people invested in education through our Learning Scientists project. We started this project in January 2016 with the goal of making scientific research on learning more accessible to students, teachers, and other educators. Our outreach efforts so far include a frequently updated blog, downloadable posters and PowerPoints about effective learning strategies in many languages, a podcast, an active social media presence, and many formal and informal collaborations with schools.

In the next chapter, we talk about different types of research evidence about learning, and how it evolves from the lab to the classroom (Chapter 2). We then go on to talk about why using one's own intuition about how we (and others) learn can be problematic (Chapter 3). Finally, the last chapter of Part 1 deals with pervasive misunderstandings in education, where they come from, and how we might be able to overcome them (Chapter 4).



We want to open up the lines of communication between researchers, teachers, and students.

Whether you are a teacher, a parent, a student, or simply a person interested in how human learning works – there's something for you in this book.

Chapter summary

The goal of cognitive psychologists who are applying their work to the educational domain is to encourage the stakeholders (teachers, students, parents, policy makers, and more) to do what has been scientifically demonstrated as most effective. Instead, somewhat dubious sources such as untested theories or – even worse – marketing ploys by financially interested parties, create fads in education. The goal of our outreach efforts in general and of this book in particular is to make research from cognitive psychology more accessible to teachers, students, parents, and other educators.

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