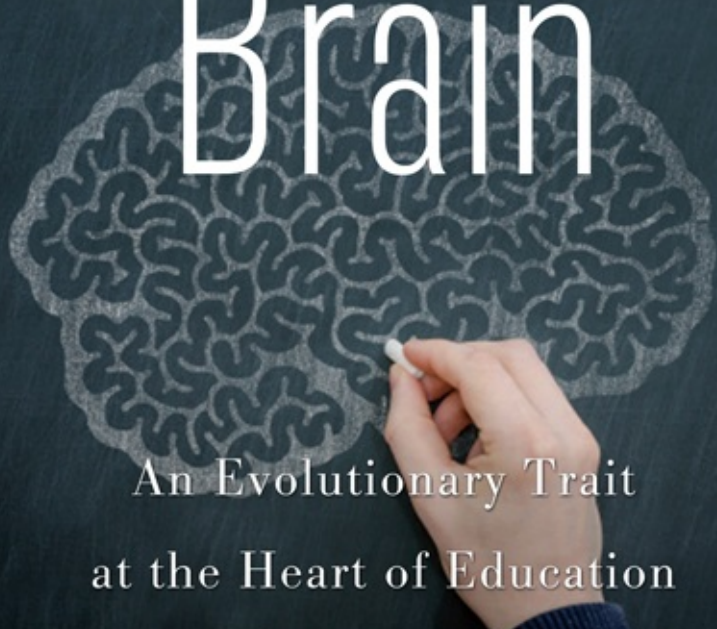


# THE Teaching Brain

A hand is shown in the lower right, holding a piece of white chalk and drawing a brain on a dark chalkboard. The brain is rendered in a light gray, textured style, with the word 'Brain' from the title overlaid on it.

An Evolutionary Trait  
at the Heart of Education

VANESSA RODRIGUEZ

WITH MICHELLE FITZPATRICK

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# THE TEACHING BRAIN

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AN EVOLUTIONARY TRAIT  
AT THE HEART OF EDUCATION

VANESSA RODRIGUEZ  
WITH MICHELLE FITZPATRICK



NEW YORK  
LONDON

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“It would be very strange for people to see someone without [a daemon]. It’d be just as strange as seeing someone without a head. Someone without a daemon would be considered horribly mutated—missing something essential.”

—Chris Weitz, director of *The Golden Compass*

*This book is dedicated to my daemon—without him none of this would be possible.*



“We have a lot of rocks in the classrooms . . . we study rocks. We’re learning about prehistory. We’re learning about the beginnings of the planet. We’re learning about patterns and cycles. [A visitor to our school] once said, ‘Why are there so many rocks in the school? What can you do with a rock? You can write a story about a rock. You can learn a little about rocks—then you’re done.’ And I thought, no. You can spend a lifetime with a rock. And that is the way I feel about teaching anything.”

—“Liz,” a fourth-grade teacher in New York

*This book is also dedicated to all the teachers who believe you can spend a lifetime with a rock.*

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# INTRODUCTION

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There's no shortage of complaints about the state of schooling today, no shortage of calls to reform our educational system, no shortage of opinions on how to fix what many (even those who fervently disagree on the particulars) agree amounts to a major social dilemma. The contemporary challenges facing formal education in the United States are vast, complicated, and emotionally charged. Educators, scientists, psychologists, government officials, and bestselling authors are all part of the mix of voices creating the conversation and, in part, prolonging the controversies, both warranted and not.

But it seems the biggest elephant in the proverbial room is how we think about teaching and our teachers. All sides of the teaching debate have sought to define "good teaching." However, this effort is as misguided as one that would label a student a "good learner." We need to keep the terms "good" and "teaching" forevermore apart. Indeed, the concept of a perfect teacher for all students is a complete myth. Instead we need to be asking new questions.

Our questions should begin with one in particular: What is teaching?

A five-year-old child, absent any formal training of the sort classroom teachers get, easily "teaches" a younger child how to construct a tower of blocks, could begin to read her two-year-old brother a story from her favorite book, or could show her friend how to make a tea party—although half of that party may be imaginary. As children grow, these social interactions develop, becoming multilayered and more complicated. A ten-year-old can show a teammate how to kick a soccer ball properly. A teenager might help his buddy understand the difference between adding and subtracting positive and negative numbers. To do that he might reach for a pencil and paper to write out an example, or go online to find a sample problem on a math website. Adding organization and pre-thought to teaching moments reflects a more complex form of thinking.

Or consider what parents do quite instinctively with their young children. The earliest forms of learning for any baby begin with the parent relationship. A mother talks to a toddler about what they see, hear, and sense around them: "Look at the birdie in the tree!" "Smell the yummy toast with butter." "Take my hand, and let's walk over to feed the ducks." Parents, without thinking, are constantly teaching their children about the world around them, talking to them so that they begin to develop their vocabulary, and interacting with them so that children begin to understand the simple concepts of sequence, procedural knowledge such as tying shoes and using a spoon, and more concrete knowledge about colors, numbers, or the sight and sound of letters.

So what, precisely, is teaching? This book answers that question in a new, transformative, and perhaps surprising way: teaching is a human, evolutionary skill. Although we may not all be in a classroom, we are all teachers.

Like learning, teaching is a skill (or set of skills) that develops over time. Social interactions of the sort mentioned above happen naturally all the time, yet most of us do not define them as teaching and learning moments that they are. Every social interaction does not involve teaching, but unlike moments in life when we are learning—every teaching moment is, in fact, a social interaction.

As much as the five-year-old, the ten-year-old, the teenager, and the parent are all teachers, we know instinctively, and through research, that each of them teaches differently. Certainly their age and

varied cognitive abilities contribute to the difference, as do a host of other factors that are explicitly and implicitly connected to the social nature of teaching. For example, if all of these teachers spent time about the task of showing another how to make a tea party, each of those interactions would look markedly different based on who is doing the teaching and who is doing the learning. The key, however, is that both actors—teacher *and* learner—are equally important to the transfer of understanding, and creation of knowledge and skills. Here is where things start to get sticky.

As the process and development of teaching become professionalized in more formal settings, suddenly the entire premise of the interaction ceases to be a natural interplay between the teacher and the learner. Inside school walls and pedagogical framing, teaching is often understood and practiced as if it were a one-way street, with a mostly unidirectional focus on the learner—the student. Who the teacher is and how she is processing these same moments become secondary, and in some cases irrelevant, to the needs and process of the student. And this is to say nothing of how any benefit to the teacher—either professional or personal—is almost always downplayed, if not overlooked entirely. This is why even thoughtful, well-intentioned efforts and policies that aim exclusively to be “student-centered” are incomplete. The process of teaching and learning is an inherently dynamic and social one, yet we press on in schools and in life with a harmfully imbalanced perspective. Everyone suffers when only the interests of the student seem to matter. Half of the equation is lost.

## HOW I CAME TO WRITE THIS BOOK

I spent more than a decade teaching in the classroom—science, history, and English. Truth be told, I was a combative teacher. I loved my students, taught to their individual needs, and was devoted to helping them learn. However, I was not good at being part of a system that often seemed at odds with their learning, and with my own teaching process. My methods often came into conflict with what the school’s goals—or more precisely, standards—expected of me. There was a lack of fit.

Most of the time, I resisted allowing this lack of fit to define my approach. Like many teachers know, I taught because I found it fascinating and rewarding, especially when I was in sync with my students. The principals I worked for would often say, “But in the end, Vanessa, you’re doing it for the children, right?” My answer was often silence. Dare I ever admit that I was a professional teacher because I found teaching so personally fulfilling? I taught because the act of teaching spurred growth within me; it meant something to me, and contributed to a more intelligent, informed, and connected world. It was not *just* about the children I was helping.

I know with confidence (though slight discomfort) that I never would have chosen to teach if it were purely an altruistic act. I certainly wouldn’t have taught for so long if that were the case. The moment I realized that my teaching methods and philosophy were no longer in line with major education reform efforts across the city where I was teaching, I knew it was time for me to move on. The balance had changed dramatically, and my vision for teaching no longer fit—even awkwardly—the school system I had been so committed to teaching in.

Still, I knew I had been a successful teacher. My students exhibited clear development in their learning—not just in measures that mattered little to me, such as standardized exams, but in qualitative measures such as their writing ability, sophisticated communication, debate skills, and, most important, their sense of identity. I was proud to facilitate and support their development. While each day was a challenge, it was also extremely rewarding to see students develop and even more so to form personal bonds with them. Their development was inextricably linked to my development as a teacher.



I believe the reason many teachers leave the profession is not some amorphous burnout. I suspect (and to a modest extent, I know) that many teachers who move on do so for a similar reason: the perspective on teaching and that of the system within which they teach do not jibe. Even after years of trial and error, reaching synchrony with an administration or system—the kind of synchrony that effective, successful teachers find with their students—can still seem like a distant dream. Furthermore, the various other reasons teachers report feeling undervalued do nothing to help the situation.<sup>1</sup>

My own experiences teaching, the ups and the downs, prompted me to wonder about the drive to help others learn, the urge and the practice commonly referred to as teaching. What do we really mean by teaching? Do we all have the same thing in mind when we conceptualize teaching? Who should we trust to say what teaching is, and how does this play out in schools? How can we even begin to transform education policy or practice unless we all understand what teaching really means?

Four years ago, in the midst of my graduate-school research, I made a startling—and, it turns out, profound—connection between the cognitive psychology and neuroscience I had been studying and the practice of teaching: for all we know about the nature and science of learning, especially the discoveries in brain research, we have grown very little in our insight into the teaching process. I cannot understand that we all do it, this act we call teaching. But why do humans teach? How do we teach? And why has teaching, an interaction so integral to the foundation of education, been given such short shrift? Quite simply it is because, despite mountains of books and research on pedagogy (the practice of teaching), no one has ever truly bothered to understand specifically how the teaching process and its corollary, the teaching brain, are *separate and distinct* from the learning process and the learning brain.

This book illuminates how both past and current definitions of teaching are outdated and do not match the vast research in the learning sciences and the more fledgling area of neuroscience. Looking beyond the lab, commonly accepted definitions of teaching don't even match the actual practice of human teaching. It's time for that to change.

Starting with the premise that learning and teaching, while inextricably related, are indeed distinct processes, we can begin to develop a clearer picture of the teacher in all of us, whether we are in a classroom or a boardroom. New doors open up and everyone is better served when we demystify teaching based on a complete understanding of the cognitive, biological, and psychological processes of the brain. Through piecing together this puzzle, my goal is to unearth a new definition of teaching that is at once revolutionary and profoundly commonsense, one that builds on our understanding of learning yet has unique, individual properties. Part of a larger thrust in the learning sciences to explore and understand the human brain, the research that supports the model of the teaching brain connects the dots between what we have come to understand about the learning brain and how that relates to an analogous teaching brain. We know that learning is much more than memorizing content. It's about thinking skills and the ability to transfer knowledge to an array of situations. We don't expect learners to be expert learners right away; we know that becoming a resourceful, self-regulated, persistent learner happens over time. Learners develop. The same is true of teachers.

## **THE STRUCTURE, CONTEXT, AND PURPOSE OF *THE TEACHING BRAIN***

The pages that follow aim to shift how we see and understand teaching. This book is also designed to serve as a useful tool for teachers of all types, and will be particularly helpful to professional teachers.

looking to improve their skills. **Part One** starts by debunking older models of teaching in which knowledge is like water—something a teacher can simply pour into the mind of a student. This section also highlights misguided theories and policy reforms that wield a hefty amount of influence on both lay and professional perceptions of teaching. Beginning with an examination of the science behind the learning brain, **Part Two** lays out a revolutionary new framework for understanding the teaching brain as a dynamic, interactive system created by both teacher and student. The book then finishes with an exploration of how this new framework can help teachers and education reformers become more effective and successful, and includes a discussion of exciting neurobehavioral research that is using cutting edge imaging technology to observe interpersonal brain interactions (e.g., teaching) in real time.

Different from other brain-based educational advice that touts ways to train your brain or follows simple “rules” to enhance productivity and learning, *The Teaching Brain* is based on a carefully honed, research-driven understanding of teaching as a human-specific, natural ability, and a building block of the social fabric of humanity. There are those who will likely raise an eyebrow at the assertion that teaching is specific to humans. Yes, an ant can teach another ant how to find food, monkeys can teach their young how to use a stick to catch their prey, and cats and dogs pass on survival skills as well, but let’s take a step back and ask ourselves whether that is the extent of the type of teaching that we do as humans. I doubt it is the type of teaching that we anticipate our children will get in school. There’s plenty of room for debate on whether animals teach or whether teaching is human-specific. However, that argument, and any proposed resolutions to it, will not bring us any closer to understanding, in real and practical terms, what humans do when we teach. Regardless of whether and how human teaching is more sophisticated than that of animals, discovering the process of this complex cognitive skill in humans is essential.

Unfortunately, the current definitions and interpretations of teaching are inadequate; they are tied only to our understanding of learning. Until we clearly define and understand teaching, our efforts to reform education are doomed to fail. More important, once we recognize and embrace the teaching brain in all of us, we will be better equipped to comprehend the learning challenges that we all face at our homes, schools, and places of work. This book will enable any of us to find the teacher within, the teacher who knows best how to help others in our lives.

It may seem strange that we don’t really understand teaching, since most of us probably think that we know it when we see it and that this is good enough. In some sense we believe that teaching is simply a service, a duty to children that, like parenting, therefore requires no further definition. If we consider the role of teachers the way we consider the role of parents, teaching is cast as an obligation that cannot be dissected, and teachers simply must give everything they can. This mode of thinking helps neither teachers nor students. As modern psychology and other behavioral research shows, there are indeed more and less effective modes of parenting.<sup>2</sup> There are endless approaches that can be tailored to the nuances of each individual family situation. The time has come for a similar evolution in our thinking about teaching.

Problems abound in today’s education system—from dismal graduation rates and a lack of school financing to “bad” teachers and “underperforming” kids. Reformers of every sort have matched solutions to these problems: more after-school programming, more money, more testing of kids, and better teachers. Yet if we don’t see any problem with our definition of teaching, we are missing out on the most important solutions. Without accurately defining teaching, how it works, its processes, and its systems, we don’t have a clear understanding of the cornerstone of our education system—a system that so many work tirelessly to improve. Just as we cannot suggest how to build a better parent, it

not possible to simply outline how we can “build a better teacher.”<sup>3</sup> We can build machines, but we can’t build humans. To improve human behavior, we must understand it. Observation is crucial, but only if we come to understand behavior on a deeper level through studying the brain. The key to unlocking the mystery of teaching is to understand the teaching brain.

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**THE  
TEACHING  
BRAIN**

WHAT IS WRONG WITH OUR DEFINITION OF  
TEACHING?

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## THE THEORIES THAT HAVE LED US ASTRAY

My first teaching position was in a very affluent neighborhood in the suburbs outside New York City. Typically teachers roughed it out for years in urban public schools, trying to gain enough credentials to land such a position. For me this was the result of a mistake. I hadn't realized that, after graduating with a teaching degree, I should have gone into the Board of Education pool with other new teachers seeking jobs within New York City. Had I done so, I would have been "matched" and placed in a vacant position at a random public school. Instead I scoured through the education section of the *New York Times* every Wednesday and applied to every English position I found listed.

So there I was, standing in my brand-new classroom with a crisp, clean copy of the new teacher manual. During the first English department meeting I attended, I was given a tried-and-true curriculum guide, compiled by the department head over years of teaching high school students. All I had to do, I was told, was choose from an approved list the books that I would read with my class, then pull those books from the department storage room.

Upon entering the storage room, I was greeted with rows and rows of shiny new books. I quickly envisioned myself standing in the front of my classroom, book in hand, reciting line after line from Shakespeare as students absorbed every word. I would be like a conductor bringing forth and organizing the beautiful music created by past masters. The results would be magical: as my audience, the students, heard this masterpiece, their minds would travel to previously unknown worlds for them to explore. I wanted nothing more than to share with students the way I understood Shakespeare. I was certain that I could get them to love the works by seeing them the way that I did. Surely, I thought, their apathy was the result of disinterested grown-ups. I wanted them to really learn, as opposed to just regurgitating facts.

The senior teachers cautioned me against using too much passion in my classroom: "Just read the books, ask them questions of comprehension, and have them write essays to prove that they've learned the appropriate theme of the book." If I could do that while also convincing students to love the literature, I thought, then I was being a great teacher. After all, I was the one holding all the knowledge, right? I just needed to ignite my students' passions to free them of the shackles affixed by past teachers and experiences. My goal was to give all of my knowledge to my not-yet-hungry students. I was sure the key to success was simply to motivate them to a point where they were excited to receive the knowledge that they would ask for it—thirst for it, even.

I often try to make myself feel better by remembering that this definition of teaching has been around for at least fifty years. These erroneous assumptions of best teaching practices have led us astray when we train our teachers, establish expectations, and design schools, testing, and curriculum. To be blunt, our current models of teaching are outdated and unsophisticated. Their deterministic and rigid criteria stand in the way of fully integrating current research from the learning sciences and what we know of how the brain works.

As counterintuitive as it may seem, there is quite a bit of evidence that we have structured our system of education on animal behavior experiments, utilizing definitions of how animals teach.

# PAVLOV, PIED BABBLERS, AND PUNISHMENT

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One of the most common assumptions about teaching comes out of behaviorist research on learning. The behaviorist view of learning is one in which learners are seen as empty vessels, ready to be filled with knowledge. In their view learning is an additive process where information is *held* by experts and *given* to naive learners who are otherwise a blank slate. Pavlov is perhaps most notable for his contribution to the foundation upon which behaviorist learning theories are built. His studies detailed how animals react to stimuli in response to the environment around them. We all know of the classic experiment involving Pavlov's dogs, who learned to expect food every time they heard the sound of a bell ring. Once the dogs learned that the bell meant food, Pavlov could watch the dogs salivate each time he rang the bell.

Psychologist John B. Watson saw great potential in Pavlov's design and decided that this method of stimulus response could tell him quite a bit about human learning. He believed that people learned due to continued experience with different stimuli in their environment. Learning was considered a conditioned response, and in his view anyone could be conditioned to have a certain response. Once behavior was learned, it could be adapted based on changes in the environment. Watson believed that understanding the range of human behaviors was the key to understanding learning.

To be clear, it's quite possible for a person to be trained to react a certain way. Even if you know you'll be sorely disappointed with the outcome, you might still feel compelled to buy a Subway sandwich when you get a whiff of that bread aroma while walking down the street. This reaction is not mediated by logic flowing through your mind. It's just a reaction that you've been trained to follow—your free will basically takes a step back.

B.F. Skinner drew on this concept to design a system that he felt would guarantee preferred behavior. He believed that one could use rewards and punishment to influence behavior and learning, and his model of operant conditioning claimed that the mind, or one's thoughts and beliefs, were not relevant factors in decision making. All processes, he argued, were the result of either a reward or punishment received at the end of a task, not the product of free will.

These concepts were an important influence in the way behaviorists viewed teaching. The definition of teaching was based on what could be observed. In the behaviorist view, teaching is an act where the teacher changes his or her behavior to aid a naive student in acquiring knowledge or skills. Let's take a common example from the animal kingdom.

Pied babblers are birds who use special calls to lure their young away from danger. The training begins young, when the birds are first learning to eat. The mother bird makes this special call, and each time she calls, she then feeds her baby.<sup>2</sup> It's very Pavlovian: over time the young bird learns that when he hears the call, he gets food. When they are old enough to leave the nest, the mother bird can use this special call to keep her young away from dangerous situations. Granted, she ends up expending a lot of energy and food to solidify these life lessons, but the outcome can be lifesaving.

This definition of teaching makes perfect sense in conjunction with the behaviorist view of learning. Throughout the interaction the teacher is providing the student with feedback, and as a result the students have learned the knowledge or skill more effectively than they would have had they not had the interaction. *Note that this type of interaction yields no direct benefit to the teacher.*<sup>3</sup> In fact, the mother bird could very well go hungry for a few days while her offspring are first learning the call. However, think of the benefit that does exist. This is how humans and animals learn to catch food, locate watering holes, and in general survive. This logic, if oversimplified or misapplied, could easily lead to the conclusion that being a selfless teacher is just something we all have to do. This bi-



example is actually quite popular among biologists, who argue that animals, just like humans, can teach and that they do so in the same way as we humans. Some researchers argue that teaching in fact evolved independently of learning and is therefore able to be observed and quantitatively tested.<sup>4</sup>

In this frame, teaching looks something like this: the mother bird and baby bird are cooperating and we can see from their behavior that the payoff is dependent on the response. That is, in order to receive food, the baby must come running (or flying) when it hears the special call, otherwise it will starve. And the mother must issue the appropriate call when there is food to be had. The whole interaction functions purely to facilitate learning in the young bird. The donor (the mother bird, who has absolute knowledge and power) gives information to the receiver. The mother bird gathers the food and chooses when and where to release it. The sole beneficiary of the teaching is the baby bird, for presumably this is the only way the baby will learn how to eat and to be part of the pied babbler community. This is how adults within a community teach the young both to survive and to participate in the culture. It's a necessary part of building organized societies.

## A CLOSER LOOK AT BEHAVIORIST VIEWS OF TEACHING

Skinner's suggestions for improving teaching followed this animal model. Skinner believed that humans and animals were cut from the same cloth. He thought that teaching could be completely utilized by utilizing a stimulus response, meaning that teachers could input or transmit information to students, not unlike pouring juice into a glass or filling up a bowl with rice, and the students would learn the information, supposedly because they were being given positive rewards to do so. To prove his theory, Skinner designed a teaching machine, which modeled how he thought the interaction should occur. The machine was programmed to give students a list of questions to respond to and to reward correct answers. The machine provided students with immediate personalized feedback and new questions based on their responses, led students through correcting their errors, and automatically adjusted the pace and level of assistance required by the learner.<sup>6</sup> Skinner believed this individualized instruction guaranteed that students would pay attention and remain motivated. Teaching machines were thought to be useful in teaching actual content, self-management, and decision making.<sup>7</sup> In the ensuing decades, computer-assisted instruction such as this became a driving force in the programmed-instruction movement.<sup>8</sup> Companies such as IBM partnered with universities including Stanford to design computer-assisted instructional systems to teach an entire class of students.<sup>9</sup>

The history of the behaviorist view of learning matters because it developed into a widely accepted view of teaching that, along with other threads in the history of learning and teaching, still holds considerable sway over how we make educational decisions today, even as our understanding of learning has undergone a profound shift over time, from a unidimensional view of a learner being filled with knowledge to a recognition of the learner's brain as a dynamic, context-dependent system.<sup>10</sup> The transmission model of learning takes many forms. It is most easily viewed by looking at behaviorist frameworks, most significant among them the work of Pavlov, Watson, and Skinner. In a nutshell, these behaviorists argued that learning was the product of either positive or negative reinforcement of a response to a stimulus. Skinner took the concept of tabula rasa one step further to create the doctrine of the empty organism, which postulates that a person is like "a vessel to be filled by carefully designed experiences."<sup>11</sup>

In contrast to the behaviorists, cognitive theorists viewed learning as the acquisition and reorganization of mental structures through which humans process and store information. Piaget w



the first to systematically study and develop principles of human cognitive development and learning. Founded on these principles was the belief that learners construct knowledge from their experiences. Adding to this foundation, Vygotsky's theory of social cognition further argued that learners develop while interacting with their world. Utilizing these principles as well as those of the constructivists including Dewey, Montessori, and Kolb, who believed that children learn most effectively when they are given opportunities to co-create knowledge, Kurt Fischer and others drew inspiration from dynamic systems and extended cognitive theories by developing a flexible model of how the learning brain develops from birth through adulthood.<sup>13</sup> This theory posited that the learner's brain is a complex, dynamic system. Therefore the development of learning does not follow a linear pattern. Instead, there are learning spurts that are due to shifts in context and level of support.

This concept of cognitive development is called dynamic skill theory (which you will read more about in [chapter 3](#)) and is increasingly being substantiated on a neurologic level by new studies of the learning brain that use brain imaging and other technologies to identify the neural processes and pathways through which learning develops over time. This integrated approach of complex, dynamic cognitive theoretical frameworks and neurologic mapping of learning pathways is the foundation of the popular modern view of brain-based learning.<sup>14</sup>

Still, behaviorist principles are alive and well in our everyday educational lives—they drive state-mandated exams, charter schools that rely on “no excuse” cultures, incentivized teaching models, and several other current education reform policies. While the next chapter will go into greater detail on how this model plays out in classrooms today, let's review quickly what behaviorist theory, drawing primarily from animal behavior studies, sees as the three main aspects of teaching:<sup>15</sup>

1. **A cooperative donor-receiver behavior.** The teacher purposely alters his or her behavior in the presence of the student in order to facilitate learning.
2. **Teaching is a selfless act.** It comes at a cost to the teacher, who does not directly benefit from the interaction.
3. **The interaction allows a student to learn efficiently.** A student learning on his or her own would learn less efficiently.

There are a number of problematic repercussions to the underlying assumptions inherent in the three characteristics of behaviorist teaching. This definition of teaching is firmly rooted in animal studies on learning, and no proven, obvious, or sensible reason exists for applying it to humans, let alone for using it to design entire school systems. And humans' ability to read and respond to the body language of others, which is something that takes place in a teaching interaction, is beyond the capabilities of other animals that have been seen to teach.

Even though the behaviorist model of input-output comes up short in describing the broad range of the teaching skill, that's not to say that it is entirely wrong. I am not so bold as to fly in the face of the wealth of significant research in this area. The point is that these Skinner-esque models of teaching are a mere sliver of the range of teaching that is capable by humans. The cognitive processing required to produce the teaching output we see in behaviorist models is quite low.

Yet many researchers, economists, and policy makers continue their attachment to this basic definition, which makes teaching into a largely functional endeavor. They do so primarily because it provides testable criteria by which to measure learning and therefore (by their estimation) teaching.

While this input-output model offers a clean and linear framework to understand and assess teaching and learning, it is harmfully oversimplified.

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## THE PROBLEM WITH THE EMPTY-VESSEL THEORY OF LEARNING

Indeed, there is a problem with treating learners as mere empty vessels. Pouring knowledge into the passively receptive head of a student leaves the student to conceive of knowledge as something that already exists, rather than something that is created or co-constructed. In this scenario, the teacher is little more than a learning tool, transferring knowledge from one vessel (the teacher) to another (the student). This is precisely why Skinner believed that a teaching machine could do the job of a classroom teacher. The machine was programmed to enact the behavior of a knowledge expert by transmitting information to the naive student and offering feedback in the form of rewards and punishment on the student's answers, voilà!—a ready-made teacher. Recall that Skinner was one of the first to suggest that a teacher could be something other than a human. In his model and that of other behaviorist believers, a teacher could be a television, a computer program, or even an ant. A teacher is anything that *causes* you to learn. This is of course a summarized explanation, but that's the gist.

The behaviorists are not the only researchers who hold an empty-vessel view of learning. Over the years, many pedagogical approaches—that is, theories of teaching—have been premised on a similar view: that novice learners obtain knowledge through interaction with their expert teachers. If teachers are merely learning tools, then it follows that they too just need to be filled with any information necessary for the learner to acquire knowledge. It is this definition that ignited the current excitement for new modes of technology-based “teaching” (via the Internet, computers, and TV). Learning tools that are programmable, and ostensibly more reliable because of their lack of human error, are in many cases cheaper knowledge transmitters. Initially that might seem like a great relief—we don't need more money or more teachers to improve schools; we just need machines. Unfortunately, any definition of teaching that is premised on learners being empty vessels and teachers being mere transmitters of knowledge and information fails to take account of the latest discoveries in the learning sciences.

In stark contrast to the empty-vessel theory, it turns out that learning is a dynamic and complex behavior (more to come on this in [chapter 3](#)). When we unravel the complexity of learning, we see why so many well-intentioned approaches to supporting teaching and learning have not worked. As we work to build this new definition of teaching, it's useful to take a look at some other commonly held misconceptions about teaching and learning.

## THEORY OF MIND: TEACHING AS INNATELY HUMAN

More recently, another attempt to define teaching emerged from cognitive psychology, best exemplified by the work of David Premack and Sidney Strauss, who noted that teachers, like all humans, demonstrate a theory of mind (ToM). *Theory of mind* refers to a person's ability to understand what is going on in the mind of another human. Young children have an emerging ToM: at one and two years old, they mostly believe that the world revolves around them; the thoughts and emotions of another are not experienced as separate from themselves. Around the ages of three and four years, children begin to show an awareness that others do in fact have thoughts or feelings.

different from their own. This growing awareness represents important developmental milestones—social, emotional, and cognitive.

Adults utilize ToM all the time. Theory of mind is what we all use when we are trying to understand what makes another person tick, so that we know how to engage and react. It's what you might do on a first date in trying to figure out how to impress the person you're with and get a second date. We do it when we're negotiating with a sales clerk, hoping to get a better deal on an item. You are even doing it right now as you read this book: you are trying to follow my train of thought as I introduce you to the concept of the teaching brain.

Premack has defined ToM as a necessary characteristic of human teaching.<sup>16</sup> Developmental psychologists assert that ToM enables teachers to take into account the needs of the learner as they plan, evaluate, and reorganize their teaching.<sup>17</sup> In his seminal work Strauss notes that teaching is a natural human cognitive ability because only humans have ToM.<sup>18</sup> Animals do not have ToM; they do not modify their teaching based on the learner's ability and progress.<sup>19</sup> Teaching among animals involves simple responses to behavioral cues; animals do not adapt to individual variation.<sup>20</sup>

Allen Pearson has described teaching among humans as the teacher's intention to help the learner attain knowledge.<sup>21</sup> This human-specific intention to teach goes well beyond survival instinct; it has goals uniting individuals and closing the "knowledge gap" between them.<sup>22</sup> In order to achieve these goals, humans adapt their teaching based on learner variation. In this perspective, understanding how teachers think is necessary if we are to grasp an understanding of the human cognitive skill of teaching.

At first glance, ToM seems to present a revolutionary new way of understanding teaching, casting it as an innate intellectual and psychological skill. Indeed, the constructivists have utilized ToM to develop and design curricula that emphasize co-creation of knowledge between learner and teacher. And while ToM gets us one step closer—it offers valuable insight into teaching as a process—it too is incomplete as an explanation of teaching as an interaction.

Let's start with what we know about infants and teaching. In a study of one-year-old nonverbal children, researchers found evidence that they freely gave information to aid the experimenter.<sup>23</sup> The experimenter intentionally pushed an object off the table in plain sight and then feigned looking for it before telling the child that he or she had lost the object and asking whether the child had seen it. The child offered up information by pointing to it on the floor.

Is this teaching? It's easy to argue that it is not, but think for a moment about what the point of teaching is. When someone—anyone, not only a trained teacher in a classroom—decides to teach a learner, it's because the teacher perceives a knowledge gap and is trying to close it by offering information. This attempt suggests that the teacher has formed a ToM of the learner.

Another example of this very early stage of teaching can be seen in a study that was done with one-year-old infants but included children up to twenty-three months as well. The resulting behaviors were evaluated across three age groups: twelve to fifteen months, sixteen to nineteen months, and twenty to twenty-three months. The experimenter sat with the child in the comfort of the child's nursery school and played a fairly common game of placing a shape (triangle, circle, square) in an appropriately shaped hole. After the child became familiar with the game, the experimenter would feign an inability to place the shape in the corresponding hole and would exclaim, "Oh, I can't."

Each session was videotaped so that researchers could evaluate the child's response. The child's behavior was assigned to one of four categories: putting the shape in the correct hole, pointing to the correct hole, staring and doing nothing, or showing no interest of any kind. They found that all of the

children between twelve and fifteen months put the shape in the correct hole for the adult experimenter, as did 80 percent of the children between sixteen and nineteen months. These results are similar to the previous study except that these children were not prompted by the experimenter to help close the knowledge gap (recall that in the previous example the experimenter asked the child if he or she had seen the “lost” object). In this study, children between twelve and nineteen months completed the action on their own and did not need the experimenter to offer a hint such as pointing at the correct hole. Without prompting, children performed a very basic level of teaching. They did not teach through demonstration, which would have required a higher level of sophistication, but their actions were suggesting a hint or even a general display of ToM.

The next age level showed a more sophisticated type of teaching. The children between twenty and twenty-three months pointed and uttered something in response. We can assume that they were uttering some type of direction even though their language was not yet developed. When a toddler was asked a question such as “Have you seen my pen?” and the child points to the pen and utters something, it’s likely the child is responding about the pen, although he or she may not yet have the vocabulary for adults to understand what is being said.

In both of these studies, very young children were teaching! They knew where the object was and should have been placed, and the experimenter did not. By offering information and giving the experimenter this knowledge, they positioned themselves as teachers. Simple as it may seem, it is actually quite sophisticated. The little ones made a decision to close the knowledge gap between themselves and the experimenter. But *why* did they do this? The children were offered no reward. They did not know the experimenter. And children of this age are certainly not professional teachers.

A large body of research exists suggesting that children this age did so simply because they are human, implying that *teaching is an innate and natural human cognitive ability*.<sup>24</sup> If we can all teach, even very young children, the distinction between one person’s teaching ability and that of another—that of a grad student compared to that of a preschooler, or a professional classroom teacher compared to a bank teller’s—becomes muddled. When and why, then, should we treat the classroom teacher like a professional on any level? Armed only with this understanding, it might even seem feasible that a few weeks in a fast-track program—perhaps one that trains young people to modify the behaviors of their soon-to-be students—could transform anyone into a teacher. Yet when parents think about the experience they want or expect for their child in school, few if any would settle for the child being taught by someone whose teaching skills consist of pointing to the necessary information in the manner of a helpful two-year-old. Without a doubt, a computer could fill that role more reliably and at a lower cost than any human.

But when very young children demonstrate an awareness that other people have thoughts different from their own, they are expressing a necessary and fundamental cognitive skill, one that only humans seem to have. This skill changes and becomes slightly more sophisticated as children develop, as demonstrated by differences in how each age group teaches. All around us, every day, we see that humans can and do teach at almost any age. Still, what a two-year-old can teach and what a fifty-year-old can teach are significantly different, though not simply because inevitably they have different content knowledge.

Our innate ability to teach develops over time, just as our learning skills develop over time. Whereas infants exhibit a basic, concrete level of teaching (what Strauss refers to as proto-teaching), older toddlers do something more complex. One study, which was subsequently replicated, found a developmental trajectory reflecting different levels of teaching by children ranging from three to five years of age. The study began by teaching children how to play a board game. Once they learned how

to play the game, they were then asked to teach a friend. The purpose of the game was to collect three flowers of different colors. There were four different colors of flowers available. Children would roll the die and pick up from the center of the board a flower that corresponded with the color of the flower appearing on the die. One side of the die had a smiley face, which allowed a player to pick up a flower, and one side had a frown, which meant that player lost her turn. They found that three-year-old children would use demonstration to teach their friend how to play the game. Interestingly, these children had low performance on ToM assessments, which by itself would suggest that they would not be able to teach because they didn't have a strong understanding of their learner. However, they were clearly able to teach. Some children even explained their steps as they engaged in the demonstration. When peers made an error while playing the game, the children would either ignore the mistake or correct it by performing the task correctly for their peers. All of these behaviors are more cognitively taxing than merely pointing or correcting, the type of teaching happening in the younger age groups.

The teaching strategies of children continued to advance in the older age groups. At the age of five, there was some demonstration taking place, but primarily the children explained the game. They would often repeat the rules when their friend committed an error: "You have to throw the die and if it shows red, you pick the red flower," "Look, the die shows red, so I pick a red flower, not blue, see?" These remarks point to a ToM—the children were teachers monitoring the progress of their learner. It turns out that children at this age also showed stronger performance on ToM assessments, which include activities that are not relegated to the artificial setting of research environments.

One could argue that when a student learns via demonstration only, the resulting responses might be pure imitation rather than the result of teaching. Whatever the case may be in that regard, the key lesson from these experiments is the undeniable difference between the patterns common to the three-year-olds' behaviors and those common to the five-year-olds. And when there was little demonstration happening and more explanation of rules and procedures, it is more likely that the learning is a result of teaching. The five-year-old teachers monitored their learners and adapted their teaching (via explanation) to the learners' progress.

As children reach age seven, they adapt even more to the learner's progress by offering more explanation and less demonstration based on how well the learner was playing the game.<sup>25</sup> This more interactive, response-oriented type of teaching (referred to as contingent teaching) continues through children ages nine through eleven. Their teaching is even more advanced in that they offer the learner alternative ways to learn to play the game.<sup>26</sup>

Let's pause here and consider what this tells us. As we age, our natural ability to teach moves from proto-teaching to demonstration, then explanation, and eventually contingent teaching (see [Appendix C](#)). On a basic level, this means that teaching, like learning, becomes more complex as we develop over time. This is hugely important because typically we don't think about teaching as a skill (or set of skills) that changes over time, but rather something more static. We also tend not to think of teaching as something that children do regularly. Nor, even though common sense signals it to be true for people of all ages, do we often think of teaching as something that exists outside of a classroom.

Despite the importance of ToM, it still does not offer a complete understanding of what it means to teach. What it does offer, however, is one important takeaway: teaching is a human-specific activity because it requires the highly cognitive skill of ToM, which only humans have. This is great progress because humans are not just like animals!

But ToM is not the only thing that distinguishes human teachers. It is only one skill in a very complex pattern of cognitive and affective skills that operate at multiple levels. For example, simply mapping ToM to teaching does not completely capture the context-dependent interaction involved.



teaching, nor the teacher's awareness of that context. A teacher using ToM might create her own image of how a child perceives the concept of slavery, but ToM would not give the teacher insight into how this perception interacts with the child's larger environment, emotions, and memory. It also would completely ignore the teacher's own contexts—her background knowledge and experience, personality, attitudes, beliefs about teaching, and ability to manage stress.

## TEACHING IS A NATURAL HUMAN ACT

This ToM research presents two critical lessons that form the foundation of a new definition of teaching:

1. **Teaching is a process.** It is an interaction that occurs between humans who express a desire to connect with each other and join their knowledge. Both people benefit from the collective knowledge and the interchange, and this kind of interaction can and does happen everywhere: within and outside classrooms, with and without formally trained teachers.
2. **Teaching is a natural human act.** Teaching is a uniquely human endeavor that we employ when we want to join together and become of one mind.

Children provide the greatest example of our inherent ability to teach, and they also give us insight into our fundamental drive to do so. My nephew Jordan is four years old. One summer day, after being dragged to his older brother's football game, he decided to play a game of naming the clouds. "Titi," he said to me, "look at the really big cloud over there. What do you think it looks like?" I made the mistake of thinking this was an open-ended question, but Jordan already had a lesson in mind. After informing me it was *not* a dinosaur, he explained, "You see it's floating. Fish float. It's a big fish that takes up the whole sky, and those are the fins. Do you see them?" Jordan continued to teach me the rules of the game: he got to choose the cloud animal in the sky, and my job was to say what the animal was doing up in the sky. (An aside for curious readers: the big fish was looking for a camp where he could fit in the door, because Jordan noted that the doors in regular camp couldn't possibly fit big fish. Our newly designed sky camp had no walls, just a roof to keep out the rain. A brilliant idea, until I learned that a giraffe might want to join the big fish camp!) Jordan was teaching me because he wanted to play a cloud-naming game and I didn't know how to play. It was not a selfless act on his part.<sup>27</sup>

I was able to catch on rather quickly to how Jordan was teaching me to play. However, on at least one occasion, Thomas, his older brother, announced that he thought this game was "stupid." He had many questions and comments: "Why is it a fish? Fish aren't in the sky, they're in the water. Are you saying that the sky is the water? I think it's a baseball. Why can't it be a baseball?" In order to ensure that Thomas would know how to play the game, Jordan would have had to adapt his instruction. And while at age four Jordan could demonstrate, at age seven Thomas required more explanation, guidance, and reciprocity.\*

Jordan was not yet developmentally able to adjust his teaching based on Thomas's needs. The result? Both children grew highly frustrated—Thomas felt Jordan was being inflexible, and, sounding wholly exasperated, he complained, "Jordan isn't letting me choose! Why can't I help choose?"—and decided to play with other children.

Unlike learning, teaching cannot happen independently. It must involve a teacher and a learner. A

teachers, we go as far as we are able in order to close the gap between ourselves and our learner. But we've exhausted those options and still have not reached the optimal learning dynamic, both sides tend to get frustrated and move on, mentally, physically, or both. I knew that I would receive demonstration and some explanation of the game from Jordan, but he surely wasn't going to adapt to my learning preferences—I could take it or leave it.

But then I hijacked Jordan's teaching moment and made it my own. I thought it would be interesting to challenge Jordan to figure out how all of his cloud animals could go to the same camp that he had created in the sky. In the end we had a camp with three new design elements. One accounted for the big fish that needed doorway-free camps, the second for giraffes who needed roof-free camps, and the third for Mrs. Hippopotamus, who couldn't understand why there were no girls at this huge open camp. Parents do things like this all the time. They find small opportunities to turn an otherwise ordinary moment into a teachable moment, even if that means hijacking a lesson that began with the child as the teacher.

I first began to pick up on this early in my teaching career. In New York City many of the middle schools are located directly above elementary schools, in the same building. Space is rather tight, so you'll often find a four-story building with the first two floors for elementary school children and the top two for the middle schoolers. The younger kids get there first and usually arrive around the same time as the middle school teachers are coming in to prep. One day I watched as a father wrestled with the seat belt of the booster seat as his daughter, Eva (who years later would become a student in my class), whined, "I can't close my coat." In his rush he replied the way most of us would, assuring Eva that she could indeed close her coat. But Eva replied, "No, I can't—this is not my coat. Look, this one has holes in it!" She proceeded to explain that *her* coat closed when she pushed the side with a "nose" into the side with the hole, and that when it was done right, it "sneezed." "It's just a little sneeze, Dad. Try it—you'll see that it doesn't work." Here was a little girl teaching her dad how to close a snap on a coat. Eva described both sides of the snaps, the side with a "nose" and the side with a hole, and tried to demonstrate how they work. But her coat that day had buttons, not snaps, and she hadn't yet learned how to fasten buttons.

These instances, often referred to by teachers as "teachable moments," are the times when learning is most achievable, when the time is right for knowledge to be shared and built.<sup>28</sup> These are the moments where a learner provides intentional feedback on her learning (including a lack thereof or misunderstandings), presenting the opportunity for intentional teaching to follow. While all of us can act on instinct, seize those naturally occurring moments and give student-centered responses, adults often have the skill to actually *create* intentional teaching situations. This is the level of teaching that Jordan was missing when he was teaching me and his brother the cloud game.

In Eva's case, the father processed the feedback he was getting from Eva and responded in a way that took into account her individual needs. In essence, he formed a theory of her learning brain and then considered how he should respond in order to intentionally teach her something that she needed to learn. Rather than just buttoning Eva's coat for her, her dad leaned over and responded, "That's because this is a button. It doesn't have a 'nose' to snap in, so it can't sneeze. It must be frustrating not to know how to use those holes on the other side. Would you like to learn how to button your coat?" Eva's dad began his teaching moment by doing three important things:

1. **Respecting existing knowledge.** Eva's father acknowledges that Eva does know how to close her coat with snaps.

2. **Responding to a need for new knowledge.** Eva is frustrated that she does not know how to close a coat with buttons.

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3. **Offering agency.** Eva's dad provides her with the autonomy to choose whether she would like to learn this new skill.

Eva's father did not take on the role of a transmitter of knowledge (as in the empty vessel approach). Rather, he saw that Eva already had knowledge, needed new knowledge that built on the knowledge she already possessed, and had the ability to decide whether she wanted to receive new knowledge.

If Eva was too frustrated at the moment to engage in this teaching-learning interaction, her dad might have motivated her by asking, "Why might it be a really good idea to close our coats before we go outside?" in an attempt to interest Eva in learning how to button her coat. To continue promoting Eva's cognitive development, he might have begun to brainstorm with her about other things that require buttoning, or he could have asked Eva how buttons are different from snaps. The capacity to find these prompts and motivators comes from an understanding of Eva's interests, her personality, and what methods are most successful for getting her to learn something she finds frustrating. However, it's crucial to keep in mind that motivating someone to perform a task you want him or her to do is not the same as motivating someone to learn.

PET scans and fMRI scans have the ability to reveal that learning is occurring by showing blood flow and oxygenation patterns that indicate activation of certain parts of the brain. But we don't yet fully understand the actual processes of learning that take place in the brain. At this point we can only see phenomena that we believe correlate with learning taking place in the brain.

Fortunately, this was a good day for Eva, and she showed interest in learning how to button her coat. Her dad then responded, "I wonder how we could get this round button to fit into that slit on the other side of your coat. Why don't you tell me what you tried and why it didn't work?" Her father's method of contingent teaching addressed Eva's need to feel like she was being heard. Like many first graders, Eva wanted to feel empowered to display her knowledge, so this method was just right for her.

These types of interactions happen all the time, quite naturally. Each teachable moment looks different from every other, but children being taught by their parents, or other similarly situated adults, is one of the most common teaching relationships. Looking at why parents teach is yet another path that leads to explaining why anyone teaches. On a very basic level, we teach so we can belong and so we can advance together as a group. A parent helps teach a child how to walk not because we must walk upright to survive but because it is a social norm, something society values. We teach reading and writing not because humans are unable to communicate without them but because they allow us to become part of each other's context.

Past research has leveraged our rich understanding of learning to frame our exploration of teaching and a basic understanding of its cognitive processes.<sup>29</sup> However, in order to truly understand the interaction between a student and a teacher, we must focus just as much effort on understanding the teaching brain, which in part is responding to the learning brain. We've come a long way indeed, but the need for more research that explores the ontogenetic and phylogenetic origins of teaching—from its early development in toddlers to its refinement in the expert, veteran classroom teacher—is still great.\* By acknowledging teaching as a natural human cognitive skill that demands interactive research and policy efforts have the opportunity to shift their focus toward truly understanding



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