CHAPTER TWO

How We Learn

To understand the power of natural critical learning environments we must, first, explore the research on how people learn and what can go wrong. We often act as if learning is a simple process of remembering ideas and information, but it isn't that easy. Even if we toss understanding into the mix, we still haven't captured the complex undertaking involved in human learning. While the bold research on the brain and its function has offered fresh insights, even that mechanical exploration hasn't fully captured what it means to learn deeply. For more than a century, people have pieced together insight into what takes place. Let's take a quick tour through some of the most important discoveries. In that excursion we will begin to understand the nature and power of the Super Courses that are transforming higher education and are even reshaping some corners of secondary and elementary schools.

Let's start with how our learning begins. When we are born, light, sound, touch, smell, and taste bombard our senses. They are our only contact with the outside world. We take that input and try to understand it, noticing patterns and building mental models of reality in the process. We then use those resulting models to understand any new sensory stimulations that come along later.

Someone walks into a room, for example, and an electromagnetic field called light tickles the retina of that person's eyes. We label that sensation "seeing," but it isn't the electromagnetic field alone that informs. Rather the individual takes the sensory input and wraps it around some already existing models and understands the room in terms of those frameworks constructed years ago. The person already has a concept of tables and chairs, rugs and walls long before the light zings the eyeballs. Students hear a lecture or read a book and interpret the sounds and sights with some existing paradigm, comparing and contrasting the new information with what they already "know." The memories that humans hold shape what they see, hear, and learn.

Thus, we understand the present in terms of some earlier experience, and that ability and habit serves us well. We can go somewhere we've never been and still make sense of the place. Otherwise, we'd live like Drew Barrymore's character in *Fifty First Dates*, always forced to start from scratch with each encounter. But that practice of depending on past experiences also proves to be our greatest challenge as learners and educators. Why? Because we often, especially in deep learning, want our students to build new models of reality, or at least have the capacity to question their existing ones. In the humanities we often say that educated people realize the problems they face in accepting whatever they may believe. Our friends in the sciences will sometimes go further and encourage their students to abandon certain models—say, that the earth is the center of the universe—and form new ones. Either way, we are asking people to do something quite unnatural. Indeed, when Sam Wineburg wrote about the phenomenon in his own field, he called his book *Historical Thinking and Other Unnatural Acts*.[1] While his discipline asks people to use evidence from the past to understand a former time, many will rely only on the mental models they have constructed about their own world.

By the time students arrive in middle school, high school, and college, they have constructed thousands of models that will have more influence than anything a professor tells them. They may know nothing about a subject, but if they make any attempt to understand it, they will use something already constructed in their brains to do so. They will compare and contrast, looking for analogies and differences.

Even if their current ideas are faulty, however, people find it quite hard to abandon an existing concept and build a new one. We can even become emotionally attached to our mental models, afraid to give them up because the unknown is a little scary and any changes suggest that we didn't do such a hot job in the first place. But those difficulties don't always show up in standard assessments. A story we told in 2004, at the beginning of the second chapter of *What the Best College Teachers Do*, illustrates the point.

In the mid-1980s two physicists at Arizona State University asked this important question. Does my introductory course change the way students understand motion. If it doesn't, you have two possibilities. Either they didn't need to study that material because they already understood it, or the course had failed them.

To grasp learning in their classes, Ibrahim Abou Halloun and David Hestenes devised an instrument to measure someone's conception of physical motion. They called their invention a Force Concept Inventory and administered it to approximately six hundred students coming into four different sections of an introductory physics course. On the front end, they discovered that most students began their study with what the Arizona professors called a commonsense theory of motion, "a cross between Aristotelian and 14th-century impetus ideas."[2] Without going into the physics details, let's just say that if this were the primary way we understood motion today, we wouldn't be able to put a satellite in orbit or even build a highway around a curve without sending cars into a ditch.

But that's before students took the course. Once they had done so, Halloun and Hestenes gave them the Force Concept Inventory again to see how much their understanding of motion had changed. Guess what. For the overwhelming majority of students, the shift was small if any. Even people who made high grades in the course often kept their original mental models. When the researchers approached some of the students with additional questions, many of those pupils refused to change their view, argued with the researchers, and engaged in all sorts of mental gymnastics to keep from confronting a challenge to some deeply held paradigms.

Those people had constructed a mental model of motion, using everyday experiences, and they refused to let go. But this attachment to existing paradigms doesn't happen just in physics. It occurs in history and every other field where people study because it is a human habit.

We will seldom rebuild major concepts unless we face repeated challenges to our current models. Merely telling a class that their existing ideas are wrong will not usually turn the trick. Students must enter a space where their paradigms do not work and care that those models come up short. People can then begin to grapple with those pregnant moments and build new ways of looking at the world. We call those experiences "model failures." In the old days, we just called them "intellectual challenges," but the new term better captures what happens. Our brains anticipate something because of the models they hold, but they get a surprise instead.

It's tough to get humans to pay attention when any paradigm doesn't work because we face too many breakdowns to notice all of them. The model failures must be bold and a little shocking. They should spark concern, but not too much. So the successful learning environments often jolt students just enough to trigger their interest without plunging them into a cycle of worry, despair, anxiety, and depression. That is a delicate matter that makes teaching more like the art of playing the violin than the science of mixing chemicals. The best teachers raise questions that challenge but do not threaten—or, at least, not too much. They intrigue and fascinate, perhaps serving some need to know. Surprise, love, and mystery often fuel the emotions that motivate deep learning and any conceptual shifts.

Many teachers can't raise those good questions, however, because they suffer from what we call the "expert's curse." Think of it this way. As a scholar in your field, you are currently interested in certain questions because you were once intrigued with another inquiry. You took up that previous problem after battling with a still earlier query, and so forth, back up through your own intellectual journey that may have begun when you first asked your parents, "Why?"

While you are currently deep underground digging at what you know to be valuable intellectual or professional ore, your students are standing on the surface wondering why anyone in their right mind would be so far underground. To reach them, experts must retrace their intellectual steps and find questions that will capture learners' interest and ultimately pull them into a more advanced conversation. That's not easy to do. But it is the power of questions and problems that drives deep learning.

Any learner must remain highly motivated to stick with the arduous process of building a new paradigm and thinking about its implications and applications. To maintain such dedication, students must believe that their learning will make a difference to themselves and others. The change should have a purpose that satisfies intellectually and emotionally. People are most likely to attempt deep learning approaches when they are trying to answer questions or solve problems that they regard as important, intriguing, beautiful, or fun. Altruism, a concern for others, can play a powerful role in stimulating the hard work necessary.

To learn deeply we must intend to do so. Humans are born with insatiable curiosities. But here's the rub. Our desire to do something will go down if we have the feeling that someone else controls us. Every effort to force students to pay attention and reexamine their existing paradigms will backfire. Extrinsic motivators (for example, grades) tend to suppress internal desires. Maybe we are just ornery creatures, but we don't like to lose what psychologists call a locus of control. We also don't like to do something when we believe we can't do it. One way of thinking about this process is that the motivation to learn has at least three components: purpose; a belief that we can learn; and the conviction that we control when, where, and what we decide to learn.

In school not all students will even try to understand and to think about implications and applications, to theorize about possibilities. Many of them will focus instead only on passing the course ("surface learners") or making the highest grade ("strategic learners"), and neither of these types has the intention to learn deeply. Students become a particular type of learner because of conditioning, however, not as a result of their personalities or intelligence. Maybe they didn't have parents who invited a snake charmer to a first-grade birthday party or read to them every night. Maybe instead an aunt, uncle, or teacher hammered them about "being smart." Perhaps a whole series of teachers fostered a focus on grades rather than learning. The conditioning occurs throughout our society. A barrage of movies, songs, television programs, economic pressures, and even friends can stimulate those surface or strategic approaches. The path students take isn't written into their DNA or a reflection of their abilities. Some highly capable humans can develop predominantly strategic or surface intentions with the wrong experiences in life.

Schools make big contributions to this phenomenon. Some kinds of assessment can leave the impression that learning consists of recognizing correct answers on multiple-choice exams. Highly competitive emphasis on grades can deny students a sense of control over their own education and reduce their motivation to do the hard work of deep learning. Without deep intentions students resort to memorizing correct answers and procedures that will have little sustained, positive, or substantial influence on the way they will subsequently think, act, or feel.

Even when students build perfectly acceptable mental models, "learning" doesn't always produce good problem solving. When people learn some new information or ideas, they do not necessarily develop the capacity to use it in different kinds of situations. Medical students who memorize reams of information on the body and can even explain physical functions in gory detail cannot always use that knowledge to make a proper differential diagnosis or devise a novel and effective treatment for a complex ailment. This "transfer problem," as learning scholars call it, can bedevil the most dedicated students. Knowing a body of information needed to solve a problem does not necessarily entail the capacity to unlock its puzzle.

It is, of course, easier to solve problems someone else has already mastered. We can go to school on their work, learning to apply standard answers to known types of difficulties. But we live in a world of rapid change with new kinds of trouble no one has ever seen. Back in the 1980s some Japanese theorists saw two kinds of experts: routine ones who know many if not all the standard answers, and adaptive wizards who also know those common routines but have additional powers. They have both the ability and the attitude to recognize and relish the opportunity and necessity for invention. The adaptives like taking on those unique difficulties, and they are good at it.[3]

How then do people learn to become that kind of expert? Practice and feedback. Lots of opportunity to speculate with problems *they* have never encountered before.

Imagine, for example, two math classes. In one, the instructor performs algebra in front of the students (that's what often happens in many math classes). The pupils take notes and then try to apply the procedures to equations they encounter on their homework and tests. In the second type, the teacher gives students conceptually rich and fascinating problems that are slightly more advanced than anything they've tried before and invites them to invent their own solutions, perhaps working in groups. They haven't encountered the problem, and no one is there to solve it for them. They are invited to become adaptive experts. The teacher becomes a guide by the side rather than a sage on the stage, ready to ask a question to help students think past some conceptual difficulty rather than performing the problem for them.

Manu Kapur, at the National Institute of Education in Singapore, discovered the secrets of what he calls "productive failure."[4] Students "who engaged in problem solving before being taught," he concluded from an elaborate comparison study, "demonstrated significantly greater conceptual understanding" than did people who received "direct instruction" on how to do problems. Furthermore, the ninth graders who struggled to invent solutions, made mistakes and corrected them, could more easily solve "novel problems" than could "those who were taught first."

All the learning we have discussed involves memory. But people are most likely to remember what they have used and maybe invented, not what they have had drilled into their heads. Marshall and Albert began learning French in the sixth grade, but six weeks into the fall semester, Albert's parents moved to Paris, taking the young boy and his sister with them. By the time he graduated from high school, Marshall had taken six years of French, memorizing vocabulary and usually acing the exams. His parents drilled him, using all the sophisticated procedures of spaced repetition. It doesn't take much imagination or insight, however, to guess which one of the two boys read, spoke, and wrote French with almost perfect fluency when they met for a reunion right before going off to college, and which one struggled to keep up with the chatter.[5] People learn deeply by doing in authentic situations.[6]

Students are more likely to remember what they understand. When we comprehend we make rich associations between ideas and information, and the network of connections we lay down in our brains enhances our memories. If through speculation, someone has invented a solution, that person can more easily recall its steps and why you should take those steps than if the person had picked up the solution from watching someone else perform the process.

To engage in the difficult business of learning deeply people often need help. This is a tricky matter because it doesn't mean simply providing them with "correct answers." That's largely what traditional lectures do. Rather students require assistance in constructing insights and inventing ways to solve problems. Maybe the help comes as a question that sparks thought and understanding, rather than as an explanation. Students need an opportunity to try, fail, and receive feedback. Novice learners who have recently struggled with the same problems can often provide the best assistance to the absolute beginner. Those novice learners remember the tough parts while experts have forgotten the potholes along the route. The scholar often uses shortcuts in thinking while the neophyte may need to think through every step. But students also need far more than intellectual assistance. Emotional help is often crucial, not simply because humans harbor anxiety and misgivings, but also because struggling with deeply held paradigms can prove traumatic.

If learners must meet new standards, they may require assistance in understanding them and practice in applying the criteria to their own work. To remain motivated, people need to believe that their work will matter and that it will have lasting consequences for themselves and perhaps for others, and that the standards will be applied honestly and fairly. That process begins with clearly defined standards and lots of practice in comprehending the criteria.

Going Bad

What can go wrong beyond those pitfalls we've already mentioned? Let's explore threats that emerge from a couple of strong social forces. You may have noticed that we've made no mention of "intelligence" as a factor in learning, even though many traditional educators have relied almost exclusively on that concept to explain who succeeds and who comes up short. “It doesn’t matter what I do in class,” a math professor in the Courant Institute of Mathematical Sciences at New York University once told us. “The gifted students will get it, and the weak ones won’t.” This genius theory of education pervades schools on all levels, but it doesn’t set well with everyone, or with some important research on human development.

When Carol Dweck finished her doctorate in psychology at Yale in 1972, she had one burning question on her mind. Why do some people melt in the face of failure while others zip right through adversity, even using it to improve their work? “I grew up in an . . . era that worshipped IQ,” she told her campus newspaper recently, “and thought that” it largely determined your future. “My sixth grade teacher even seated us around the room in IQ order.”[7] After more than forty years of research, the Lewis and Virginia Eaton Professor of Psychology at Stanford University has found that people’s *conception of intelligence* has more influence than does anything you might measure as an IQ. “If you believe your intelligence is just a fixed trait,” Dweck explained, you’re likely to develop a sense of helplessness. If you think you don’t know and can’t learn, you’re not apt to try something. But that feeling of helplessness can also emerge among people who think they are smart and also believe human brains can’t grow.

Imagine a kid who has heard all his life, “You’re really brilliant.” He may then build his whole self-image around being a genius. Soon he may grow afraid to try anything new for fear he will fail and prove he’s not so sharp after all. In contrast, “if you think . . . your talents, abilities and intelligence . . . can grow“ then “you want to jump in and develop them,” Dweck summarized. That can make a huge difference in someone’s learning.

Thus, people who believe their intelligence is fixed for life often have difficulty embracing failure. They tend to recoil from their mistakes rather than learning from them. If a teacher tries to put them in a situation where their mental models do not work (creating a “model failure”), they resist and learn little because they cannot stand to fail. Meanwhile, students flourish with challenges to their thinking if they believe intelligence can grow.

Fortunately, Dweck and her colleagues have found that fixed and growth mindsets, as she calls them, come from conditioning, not from any innate qualities of someone's brain or personality. They can change. In a series of powerful experiments, she and her colleagues discovered certain experiences that cause children to develop one mindset or another. People who hear a steady stream of *person praise* ("how smart you are"), for example, often grow a fixed view of intelligence and a feeling of helplessness, while those who encounter task-oriented feedback ("you must have worked hard on this") build a strong growth mindset. In her research, Dweck found that students with the fixed view gave up easily, sometimes complaining that they were "not a math person" (or "writing person"), and growing easily bored with school, especially if they failed. Furthermore, and this is probably the most disturbing result, their abilities actually decline in the face of failure. Meanwhile, students with growth perspectives sail right through adversity and often deliberately seek hard challenges.[8]

None of this means we've discovered a magic cure. We continue to face enormous problems in changing anyone's mindset, especially as people grow older. Yet some of the Super Courses we will explore have devised some innovative approaches with promising results. They deserve additional trials and careful research to find out what works and what doesn't.

Stereotype Threat

Joshua Aronson and Claude Steele found different social forces shaping learning outcomes.[9] If you are a member of a group about which there is a popular negative stereotype, that common belief can influence your performance in school and elsewhere even if you personally reject it. Obviously, if you accept the negative idea that "people like you" can't do something, you will give up easily. Failure will become a self-fulfilling prophecy. But you don't have to accept the negative stereotype for it to affect you. On a subconscious level it may simply bother you that others think of you in terms of that popular image, even if you never internalize a sense of inferiority. In a silent and unspoken dash to exonerate yourself and others, tensions grow. Nervousness increases, and your academic performance tanks.

Margaret Shih knew that research but asked a brand new question. We have lots of stereotypes in our culture, she noticed. Some positive. Others more negative. Many people believe, she pointed out, that women can't do higher mathematics as well as men can. At the same time, many Americans also think that people of Asian descent possess some kind of "math superiority" gene. But what about Asian American women? Which stereotype, negative or positive, will influence their performance?[10]

To find out, she created three comparable groups of Harvard undergraduates. They were all females and Asian Americans, were majors in mathematically oriented fields, and wanted to attend graduate school in their discipline. In other words, she had fairly reliable evidence that if she gave the advanced portion of the Graduate Record Examination in math to everyone in her sample, the group performances would be statistically indistinguishable. But that's not what happened. Shih's intervention changed the outcome. It was her experiment.

She asked each woman in her three groups to fill out a questionnaire before taking the test. It looked fairly innocent: name, telephone number, and so forth, about a dozen items of seemingly innocuous questions. But the first group had an inquiry designed to trigger a subconscious reminder of their gender. The second group didn't have that question but had another one meant to prompt a reminder of ethnicity. Psychologists call this process making something salient. The third group had neither of the subconscious triggers. You now have the data you need to predict how the three groups did. The group that had the reminder about ethnicity performed better than the other two; the one with the prompt about gender came in last. Little things a teacher does can have a huge influence on students' learning, lives, and academic performance. So much for the genius theory so popular at places like the Courant Institute![11]