Students, teachers, and neuroscientists compare notes on classroom lessons that ignite motivation and promote mastery.

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In extensive interviews over the past four years, hundreds of teenagers from around the United States talked to me about the conditions that ignited their curiosity and inspired them to strive for excellence. That research, conducted for What Kids Can Do, revealed a disturbing pattern: The most significant learning these young people described was usually not happening in the classroom.

When adolescent learners reported what they were “getting really good at,” the accomplishments they spoke of—in athletics, in the arts, in community action—nearly always took place outside school. In contrast, what young people said about their daily school experiences often seemed pale, passive, and dull. They rarely spoke of new ideas they had grappled with or exciting work they had done at school. As evidence of academic success, they cited grades given for work they had largely forgotten.

Educators also feel this sharp contrast, I know. Since the 2010 publication of our research with students in Fires in the Mind, many have asked me, “How can I build that kind of student interest and accomplishment in my classroom?” Frustrated both by their workaday constraints and by what they saw as students’ apathy, they craved examples of highly motivating curriculum and instruction. They also wanted to link how they taught to scientific research that illuminates how people learn.

At the same time, the National Science Foundation was increasingly pressing the researchers it funded to connect with classroom teachers in their communities. The confluence of interests was irresistible. Why not bring together these key perspectives—of students, teachers, and learning scientists—in a three-way dialogue to investigate classroom motivation by looking closely at successful lessons? I proposed that idea to a group of two dozen experienced teachers who served on the Distinguished Educator Advisory Panel to the National Science Foundation–funded Temporal Dynamics of Learning Center (TDLC) at the University of California–San Diego. In our four meetings during the year that followed, the insights came tumbling out like kids released by the bell.
Studying Lessons to Understand Student Motivation

Our group’s process was simple. Any teacher could volunteer to describe a lesson, a unit, or an overarching approach that had resulted in high student motivation and high levels of learning. The teachers in the group then discussed the instructional practice, imagining what challenges might face others who emulated it, and the neuroscientists followed up by providing insights into the cognitive processes that explained why these particular learning activities had lit “fires in the mind.” Most of the teachers also brought comments from the students involved in the learning experiences describing what drew them in and

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what kept them trying when things got hard. In some cases, we solicited student comments after the fact.

Every presenting teacher was asked to address the questions, “What helped your students connect this learning challenge with something they valued?” and “How did you support students’ expectation that they could succeed at it?” Research has long linked learners’ motivation with both the value the learners place on the task and their expectation of success (Bandura, 1997; Eccles & Wigfield, 2002; Toshalis & Nakkula, 2013). Building on an idea from the University of California–Los Angeles Center for Mental Health in Schools (2002), I called that relationship the motivation equation:

\[ V \times E = M \]

Value \times Expectation = Motivation

As the multiplication sign indicates, both value and expectancy on the part of the learner are necessary to motivation. If either of these factors is zero, then motivation will also be zero.

We used the motivation equation to analyze the lessons presented in our group. Let’s look at how some of the teachers designed instruction that incorporated value and expectancy to ignite student motivation.

**Value: Kids Believe the Learning Task Matters**

When John McKinney wanted his 8th graders to learn about the science of combustion, one of the first things he did was light some things on fire. After more than 20 years teaching middle school, he had learned that to get the attention of an early adolescent, it helps “if you can do something that’s a little bit dangerous.” In carefully controlled conditions and taking every safety precaution, he set up activities that excited interest and curiosity from the start.

After learning to use a lighter, his students burned a sticky note and then lit a candle, comparing the quality of the two flames. They drew the candle flame in detailed color. They observed a candle burning under an overturned beaker and then alcohol burning in a beaker, and they speculated together on what the differences in how these substances burned meant.

When our neuroscientists discussed Mr. McKinney’s learning unit, they noted that it was likely to stick in students’ memories because it aroused emotions that enhanced both attention and problem solving (Fredrickson & Branigan, 2005; Gasper & Clore, 2002). This teacher had taken advantage of his students’ fascination with flame to engage them directly in an important scientific question: What is actually happening when something catches on fire?

The day their teacher set alight the smoke from a snuffed candle before their eyes, the 8th graders were giddy with amazement. The startling smoking wick trick—which kids got to practice themselves as they figured out what was going on—provided “just the right level of excitement” to put the students’ neural systems into a more attentive state, said Andrea Chiba, the science director of the National Science Foundation Science of Learning Center at University of California–San Diego. “There’s an issue of novelty: not knowing what’s going to happen with the experiment, not knowing what’s going to happen with the flame.”

Five months later, in a follow-up assessment by Mr. McKinney, every one of his students could accurately recall the details of the science they had mastered in the combustion unit. They also reflected on the fun they had in breaching the barrier to something usually reserved for adults.

**Expectation: Kids Know It’s Safe to Try**

But no matter how much they value the learning task, students easily lose their balance in the classroom without a sense of safety and well-being as learners. Teachers foster that important feeling by supporting students as they risk trying any new learning challenge, thus increasing their students’ expectation of success. Without such support, our neuroscientists pointed out, students sometimes experience fear or feel threatened, which can trigger...
neurochemical changes in the brain that inhibit learning.

Carrie Pierce’s 9th and 10th grade math students largely came from families that emigrated from Somalia and Mexico. Some had been in the United States longer and spoke better English than others. Eighty percent spoke three or more languages. But on the high-stakes California math test, they had to decipher academic language on a fast clock. If they took five minutes to figure out each question, they would not pass—or graduate.

Ms. Pierce recognized that she would have to improve her students’ understanding of test language dramatically if they were to answer problems quickly enough to pass the test. She wanted to desensitize them to the stressful conditions of the test and to eliminate the stigma of trying and failing so that they could accurately demonstrate their math skills. So she made up a high-speed, low-tech game that her class could play as a group. Her kids dubbed it “the student blast.”

Watching the blast on a visit to her classroom, I saw Ms. Pierce pluck a student at random to stand at the whiteboard and work on a practice test problem. The other students leaned forward intensely to watch; they knew that when this student’s time was up, anyone could be next. As the student looked at the question—which number equals $(2)^{-4}$?—and stared at the four possible answers, the teacher fired off questions and encouragement: “Which answers can you eliminate? Good. Now what? Good.” In two minutes, the first student sat down and another one came to the board to continue working on the same problem.

Ms. Pierce said “good” after every choice a student made, even if it was not correct. At first I thought this was strange, but she explained, “As long as they’re taking risks, they’re doing what they’re supposed to be doing.” In this context, “good” meant that a student was sticking with a high-stress task and taking a risk, whereas “right” or “wrong” would put an end to the high-intensity thinking process going on in the room. Only after the student sat down would Ms. Pierce ask the rest of the class, “Why did he say that?” The other students would take up her question, agreeing or disagreeing with their classmate as they went through their own reasoning. Then, without indicating who was right or wrong, Ms. Pierce would pluck out another student to take the hot seat as the public problem solver.

“During the blast, when students are working together, they have the support of everyone around them to reach one solution,” she explained. “This is extremely motivating for students who don’t normally participate and don’t know how to access or finish a problem. I go back then and I describe what I just heard. And together we develop a strategy that would help solve the problem.”

The intensity built markedly in the room during the blast. “We’re kind of shaking every time,” said Faiza. “She just calls random names and says, ‘Go to the board and answer that question.’ It was kind of scary, but at the same time it was interesting. It made us brave and made us believe that we could succeed on it.”

This kind of deliberate practice in

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retrieving information on the spot leads not only to better results but also to deeper results (McDaniel et al., 2013; Rohrer, Taylor, & Sholar, 2010). As students transfer what they are learning to new and novel tasks, they are gradually approaching mastery. A classroom culture begins to evolve in which learners feel safe and believe they can succeed. At the same time, they are strengthening their ability to handle stress. Mistakes are just part of finding their own way through the blast.

By thinking through a difficult task while surrounded by a high level of social support from peers and their teacher, hypothesized Dr. Chiba, students should get better at the task itself. When learning content or making complex decisions, the brain functions best when it does not have to divide its attention, she explained. Students who need not guard against the threat of humiliation are thus more likely to maintain “a long-term, steady state of focus that engages all their neuromodulators.”

**Combining Value and Expectation**

Again and again, as teachers presented their successful lessons, we heard the two factors of the motivation equation working together. We saw countless entry points to the value factor, including social learning with others, links to students’ own interests, cultural connections, physical activity, relevance to the larger world, competition, an element of choice, and sheer curiosity about an intriguing puzzle. We also noticed that, as students came to expect that they could improve their academic skills through effort, their motivation to engage with difficult academic work increased—and so did their capacity.

An example of instruction that combines value and expectation is Tom Fehrenbacher’s yearlong 11th grade humanities course, which he punctuates with six mock trials about controversial situations in U.S. history (such as Miles Standish’s encounters with American Indians and George W. Bush’s decision to go to war with Iraq). The teacher serves as trial coach and judge; students play prosecutor, defendant, witnesses, and jury. As students enact their parts, they conduct a fast-paced battle of wits that depends on high-level research and rhetoric.

During weeks of research and trial preparation, students work together to build their understanding of the historical period and to rehearse their testimonies. Scientists believe this kind of social affiliation can increase kids’ engagement with content. “We often selectively process that which is important to us,” Dr. Chiba explained, noting that many youth value social interactions at school more than their studies. By engaging them with a social learning activity, she went on, a teacher can co-opt such distractions. The brain structures that might otherwise have had to filter out what peers are doing can now instead attend to learning and memory.

Some of Mr. Fehrenbacher’s students put high value on the activity from the start and also began with the expectation of success. “We, as teenagers, generally like to argue a lot,” explained Esteban. His classmate Rachel, in contrast, dreaded playing the attorney’s role. “I grew up with ‘Be nice, don’t argue,’” she said. “But it actually turned out to be—I hate to say this—fun.” As with Ms. Pierce’s student blast, the excitement of the contest trumped Rachel’s initial unsteady expectation of success; at the same time, her active engagement in defending her assigned perspective increased her ability and confidence.

David Weber, who teaches trigonometry to a heterogeneous class of 11th graders, also knows the importance of value and expectations. He ignores math formulas at the start of the year. Instead, he just asks a simple question, like, How high is Mount Everest? How do you know? How far apart are the stars? How do you know? How do you measure that? Driven by their own curiosity, his students derive the formulas from scratch by analyzing the world around them. However long it may take, he says, he will “inch them along” through the inquiry process until they attain success.

Above all, Mr. Weber tries to instill perseverance in his students. With enough patience and practice, he believes, they will transfer their growing confidence to other situations in the exam room or in the larger world. He pictures them saying, “I’m not really sure what to do. But hey, I’ve had the experience of working through things that were unknown before, and I came up with a result that seemed to work.”
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**Eight Conditions for Learning**

As our working group used the motivation equation to analyze successful classroom lessons, an infrastructure of vital learning conditions began to emerge from the conversations like invisible ink under an ultraviolet light. From the combined perspectives of teachers, students, and scientists, we eventually developed eight central conditions that support powerful learning for young people:

- I feel OK.
- It matters.
- It’s active.
- It stretches me.
- I have a coach.
- I have to use it.
- I think back on it.
- I plan my next steps.²

These eight learning conditions often overlap and intersect, of course. For example, students have told me that as their teachers make them use what they’ve learned, the teachers coach them and create an atmosphere in which they feel OK about making mistakes.

Each of the conditions contributes to the motivation equation, as well. Some of the eight conditions (such as “It matters”) have more to do with the value students place on a learning task; others (such as “I have a coach”) have more to do with students’ expectation of success.

**When Learning Ignites**

Why should we bother analyzing our instructional practice with motivation in mind? The most important reason is that it reminds us that kids can feel it when they’re really learning. They may be working alone or with someone at their side; they may be on their 10th try or their 100th. But whether the light dawns slowly or strikes them in a flash, they sense that something is happening. They experience a rush of feeling when they start to understand some hard, new thing—and they want more of it.

Teachers can feel it, too. Kids sit up straight; something shifts in their attention, in their voices. Maybe our teaching has taken them by surprise. Maybe we’re noticing and building on their stories and their strengths. Students differ in countless ways, so there’s no single way to draw them into a given challenge. But when something we try lights the fires in their minds, we can harness that energy to inspire excellent work.

Scientists have their own ways of seeing those fires in the mind. New imaging instruments light up neural pathways so researchers can watch the brain change and develop in real time as people think and learn. Hundreds of recent studies on the development of expertise—along with giant leaps in brain change and develop in real time as people think and learn. Hundreds of recent studies on the development of expertise—along with giant leaps in the field of genetics—shed new light on old questions of nature, nurture, intelligence, and ability. Whatever our age or other differences, the research brings good news: Given the right conditions, we all can learn.³

³What Kids Can Do (www.WhatKidsCanDo.org) is a national nonprofit organization founded in 2001 to share a dual message: the power of what young people can accomplish when given the opportunities and supports they need and what they can contribute when we take their voices and ideas seriously. The youth who concern What Kids Can Do most are those marginalized by poverty, race, and language, ages 12 to 22.

³For an expanded discussion of these eight conditions and the importance of value and expectation, see the What Kids Can Do site www.HowYouthLearn.org. Its educator resources include a whiteboard animation and the multimedia e-book The Motivation Equation, featuring the voices of students, teachers, and neuroscientists who participated in the research.

**References**


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