The Importance Of Getting Things Wrong

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Think about our planet for a second. Earth has an elliptical — oval-shaped — orbit. That means we're closer to the sun for one part of the year and farther away another part of the year.

Does that fact explain why it's hotter in the summer and colder in the winter?
Lots of kids think it does. Lots of adults think so, too. And they're wrong.*
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Philip Sadler is both a professor of astronomy and the director of the science education department at Harvard University, and he is obsessed with wrong answers like these. "Students are not empty vessels," he says. "Students are full of all kinds of knowledge, and they have explanations for everything." From birth, human beings are working hard to figure out the world around us.

But we go about it more like the early Greek philosophers than modern scientists: reasoning from our limited experience. And like those early philosophers — Ptolemy comes to mind — we're often dead wrong.
Sadler says that cognitive science tells us that if you don't understand the flaws in students' reasoning, you're not going to be able to dislodge their misconceptions and replace them with the correct concepts.

"It's very expensive in terms of mental effort to change the ideas that you come up with yourself," Sadler says. "It's a big investment to say, 'I'm going to abandon this thing that I came up with that makes sense to me and believe what the book or the teacher says instead.' "

In one study, which he recently wrote about in American Educator magazine, Sadler gave 20 multiple-choice science questions to a group of middle school students. For each test item, one of the "distractors" was a very common misconception. In fact, often the misconception was far more popular than the right answer.

For example:
2. Eric is watching a burning candle very carefully. After all of the candle has burned, he wonders what happened to the wax. He has a number of ideas; which one do you agree with most?
a. The candle wax has turned into invisible gases.
d. All of the wax has melted and dripped to the bottom of the candle holder.

The wrong answer, d., was chosen by 59 percent of the students; only 17 percent chose the right answer, a.

The study gave the same test to these students' teachers. They asked them which of the wrong answers was most commonly chosen. They found that teacher knowledge of common student misconceptions was weak: They knew 85 percent of the right answers, but only 41 percent of the "right" wrong answers.

But, among teachers with stronger knowledge of student weaknesses, their students learned significantly more science, based on a retest at the end of the year.
Having discovered the importance of wrongness, how can teachers act on that knowledge? The first step, Sadler says, is to teach Socratically (there's the Greeks again), by asking questions and having students think out loud. This works much better than lecturing. "Teachers who find their kids' ideas fascinating are just better teachers than teachers who find the subject matter fascinating," he says.

The next step is to give students exposure to the information and experience that will enable them to reason their way to the right answer.

For example, Sadler and colleagues created a high school astronomy course. In one of the lessons, students looked at pictures of the sun taken through the same telescope at each month of the year. Most predicted that the sun would appear larger in the hot months. However, once they got out the rulers, they would discover that the sun is biggest (i.e., closest) in January. (The closest point in our orbit, the "perihelion," was Jan. 2 this year.) "That throws a monkey wrench into the logic of the elliptical orbit," says Sadler.
*The true cause of the seasons is our planet's 23.5 degree tilt off its axis.

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