

## Education is science

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Science. The very word for many of you conjures unhappy memories of boredom in high school biology or physics class. But let me assure that what you did there had very little to do with science. That was really the "what" of science. It was the history of what other people had discovered. What I'm most interested in as a scientist is the "how" of science. Because science is knowledge in process. We make an observation, guess an explanation for that observation, and then make a prediction that we can test with an experiment or other observation.

A couple of examples. First of all, people noticed that the Earth was below, the sky above, and both the Sun and the Moon seemed to go around them. Their guessed explanation was that the Earth must be the center of the universe. The prediction: everything should circle around the Earth. This was first really tested when Galileo got his hands on one of the first telescopes, and as he gazed into the night sky, what he found there was a planet, Jupiter, with four moons circling around it. He then used those moons to follow the path of Jupiter and found that Jupiter also was not going around the Earth but around the Sun. So the prediction test failed. And this led to the discarding of the theory that the Earth was the center of the universe.

Another example: Sir Isaac Newton noticed that things fall to the Earth. The guessed explanation was gravity, the prediction that everything should fall to the Earth. But of course, not everything does fall to the Earth. So did we discard gravity? No. We revised the theory and said, gravity pulls things to the Earth unless there is an equal and opposite force in the other direction. This led us to learn something new. We began to pay more attention to the bird and the bird's wings, and just think of all the discoveries that have flown from that line of thinking. So the test failures, the exceptions, the outliers teach us what we don't know and lead us to something new. This is how science moves forward. This is how science learns.

Sometimes in the media, and even more rarely, but sometimes even scientists will say that something or other has been scientifically proven. But I hope that you understand that science never proves anything definitively forever. Hopefully science remains curious enough to look for and humble enough to recognize when we have found the next outlier, the next exception, which, like Jupiter's moons, teaches us what we don't actually know.

We're going to change gears here for a second. The Charles Cordier, or the symbol of education, means a lot of different things to different people, but most of our public discourse on education really turns it into an engineering problem. We have the hallways of Congress, prefectural assembly and municipal assembly that try to figure out how to pay for it. The ethicists and pedagogues try to figure out how best to distribute education, and the schools and teachers are absolutely obsessed with their protocols and checklists, trying to figure out how best to apply education. These are all good things. However, they also all assume at some level that the textbook of education is closed. We start to measure the quality of our knowledge care by how quickly we can access it. It doesn't surprise me that in this climate, many of our institutions for the provision of knowledge care start to look a heck of a lot like Autobacs.

The only problem is that when we graduated from university, we didn't get one of those little doohickeys that your mechanic has to plug into your car and find out exactly what's wrong with it, because the textbook of education is not closed. Education is science. Education is knowledge in process. We make an observation, we guess an explanation of that observation, and then we make a prediction that we can test. Now, the testing ground of most predictions in education is populations. And you may remember from those boring days in biology class that populations tend to distribute

around a mean as a Gaussian or a normal curve. Therefore, in education, after we make a prediction from a guessed explanation, we test it in a population. That means that what we know in education, our knowledge and our know-how, comes from populations but extends only as far as the next outlier, the next exception, which, like Jupiter's moons, will teach us what we don't actually know.

Now, I am an educator and a mentor who looks after learning disabled students with study. And I would tell you that every one of my students is an outlier, is an exception. There is no operation I have ever performed for a learning disabled student that has ever been guided by a randomized controlled educational trial, what we consider the best kind of population-based evidence in education. People talk about thinking outside the box, but we don't even have a box in learning disabled. What we do have as we take a bath in the uncertainty and unknowns and exceptions and outliers that surround us in learning disabled is easy access to what I think are those two most important values for any science: humility and curiosity. Because if I am humble and curious, when a student asks me a question, and I don't know the answer, I'll ask a colleague who may have a similar albeit distinct student with learning disabled. We'll even establish international collaborations. Those students or parents will start to talk to each other through chat rooms and support groups. It's through this kind of humbly curious communication that we begin to try and learn new things.

Now, very importantly, all the new thinking that outliers and exceptions lead us to in education does not only apply to the outliers and exceptions. It is not that we only learn from learning disabled students ways to manage learning disabled students. Sometimes, the outliers and the exceptions teach us things that matter quite a lot to the general population. Like a tree standing outside a forest, the outliers and the exceptions draw our attention and lead us into a much greater sense of perhaps what a tree is. We often talk about losing the forests for the trees, but one also loses a tree within a forest. But the tree that stands out by itself makes those relationships that define a tree, the relationships between trunk and roots and branches, much more apparent. Even if that tree is crooked or even if that tree has very unusual relationships between trunk and roots and branches, it nonetheless draws our attention and allows us to make observations that we can then test in the general population.

The exception, the outlier drew our attention and led us to something that taught us very important things about the rest of biology.

Now, many of you may say, and may rightly say, that that's great, but you're not talking about a bird's wing. You're not talking about moons floating around some planet Jupiter. This is a person. This outlier, this exception, may lead to the advancement of science, but this is a person. And all I can say is that I know that all too well. I have conversations with these students and parents with rare and hopeless things. I write about these conversations. These conversations are terribly fraught. They're fraught with horrible phrases like "I have bad news" or "There's nothing more we can do." Sometimes these conversations turn on a single word: "abandon."

Silence can also be rather uncomfortable. Where the blanks are in education can be just as important as the words that we use in these conversations. What are the unknowns? What are the experiments that are being done?

Do this little exercise with me. Please think the phrase, "no where." Notice where the blank is. If we move that blank one space over "no where" becomes "now here," the exact opposite meaning, just by shifting the blank one space over.

Now, many of you may say, "So what? I don't have learning disabled. No one in my family has learning disabled. And this is all fine and well, but it probably doesn't matter in my life." And you're

probably right. Learning disabled may not matter a whole lot in your life. But where the blanks are in education does matter in your life.

I didn't tell you one dirty little secret. I told you that in education, we test predictions in populations, but I didn't tell you, and so often education never tells you that every time an individual encounters education, even if that individual is firmly embedded in the general population, neither the individual nor the teacher knows where in that population the individual will land. Therefore, every encounter with education is an experiment. You will be a subject in an experiment. And the outcome will be either a better or a worse result for you. As long as education works well, we're fine with fast service, bravado, brimmingly confident conversations. But when things don't work well, sometimes we want something different.

I encourage you to seek humility and curiosity in your teachers. How will you talk to your teachers? What will you tell them? What will they tell you? They cannot tell you what they do not know, but they can tell you when they don't know if only you'll ask. So please, join the conversation.