Why Math Is the Best Way to Make Sense of the World

To tell truth from fiction, start with quantitative thinking, argues the mathematician Rebecca Goldin.

By Ariel Bleicher

Max Hirshfeld for Quanta Magazine

When Rebecca Goldin spoke to a recent class of incoming freshmen at George Mason University, she relayed a disheartening statistic: According to a recent study, 36 percent of college students don't significantly improve in critical thinking during their four-year tenure. "These students had trouble distinguishing fact from opinion, and cause from correlation," Goldin explained.

She went on to offer some advice: “Take more math and science than is required. And take it seriously.” Why? Because “I can think of no better tool than quantitative thinking to process the information that is thrown at me.” Take, for example, the study she had cited. A first glance, it might seem to suggest that a third of college graduates are lazy or ignorant, or that higher education is a waste. But if you look closer, Goldin told her bright-eyed audience, you’ll find a different message: “Turns out, this third of students isn’t taking any science.”

Goldin, a professor of mathematical sciences at George Mason, has made it her life’s work to improve quantitative literacy. In addition to her research and teaching duties, she volunteers as a coach at math clubs for elementary- and middle-school students. In 2004, she became the research director of George Mason’s Statistical Assessment Service, which aimed “to correct scientific misunderstanding in the media resulting from bad science, politics or a simple lack of information or knowledge.” The project has since morphed into STATS (run by the nonprofit Sense About Science USA and the American Statistical Association), with Goldin as its director. Its mission has evolved too: It is now less of a media watchdog and focuses more on education. Goldin and her team run statistics workshops for journalists and have advised reporters at publications including FiveThirtyEight, ProPublica and *The Wall Street Journal*.

When *Quanta* first reached out to Goldin, she worried that her dual “hats” — those of a mathematician and a public servant — were too “radically different” to reconcile in one interview. In conversation, however, it quickly became apparent that the bridge between these two selves is Goldin’s conviction that mathematical reasoning and study is not only widely useful, but also pleasurable. Her enthusiasm for logic — whether she’s discussing the manipulation of manifolds in high-dimensional spaces or the meaning of statistical significance — is infectious. “I love, love, love what I do,” she said. It’s easy to believe her — and to want some of that delight for oneself.

Quanta Magazine spoke with Goldin about finding beauty in abstract thought, how STATS is arming journalists with statistical savvy, and why mathematical literacy is empowering. An edited and condensed version of the conversation follows.

Where does your passion for mathematics and quantitative thought come from?

As a young person I never thought I liked math. I absolutely loved number sequences and other curious things that, in retrospect, were very mathematical. At the dinner table, my dad, who is a physicist, would pull out some weird puzzle or riddle that sometimes only took a minute to solve, and other times I’d be like, “Huh, I have no idea how that one works!” But there was an overall framework of joy around solving it.

When did you recognize you could apply that excitement about puzzles to pursuing math professionally?

Actually very late in the game. I was always very strong in math, and I did a lot of math in high school. This gave me the false sense that I knew what math was about: I felt like every next step was a little bit more of the same, just more advanced. It was very clear in my mind that I didn’t want to be a mathematician.

But when I went to college at Harvard, I took a course in topology, which is the study of spaces. It wasn’t like anything I’d seen before. It wasn’t calculus; it wasn’t complex calculations. The questions were really complicated and different and interesting in a way I had never expected. And it was just kind of like I fell in love.

You study primarily symplectic and algebraic geometry. How do you describe what you do to people who aren't mathematicians?

One way I might describe it is to say that I study symmetries of mathematical objects. This comes about when you're interested in things like our universe, where the Earth is rotating, and it's also rotating around the sun, and the sun is in a larger system that is rotating. All those rotations are symmetries. There are a lot of other ways symmetries come up, and they can get really, really complicated. So we use neat mathematical objects to think about them, called groups. This is useful because if you're trying to solve equations, and you know you have symmetries, you can essentially find a way mathematically to get rid of those symmetries and make your equations simpler.

What motivates you to study these complex symmetries?

I just think they're really beautiful. A lot of mathematics ultimately is artistic rather than useful. Sometimes you see a picture that's got a lot of symmetry in it, like an M.C. Escher sketch, and it's like, "Wow, that's just so amazing!" But when you study mathematics, you start to "see" things in higher dimensions. You're not necessarily visualizing them in the same way that you could with a sculpture or piece of art. But you start to feel like this whole system of objects that you're looking at, and the symmetries it has, are really just beautiful. There's no other good word.

How did you get involved with STATS?

When I arrived as a professor at George Mason, I knew I wanted to do more than research and mathematics. I love teaching, but I felt like I wanted to do something for the world that was not part of the ivory tower of just solving problems that I thought were really curious and interesting.

When I first joined what became STATS, it was a little bit more "gotcha" work: looking at how the media talks about science and mathematics and pointing out when someone has gotten it wrong. As we've evolved, I've become more and more interested in how journalists think about quantitative issues and how they process them. We found pretty early in our work that there was this huge gap of knowledge and education: Journalists were writing about things that had quantitative content, but they often didn't absorb what they were writing about, and didn't understand it, and didn't have any way to do better because they were often on really tight timelines with limited resources.

So how has your work at STATS changed?

Our mission at STATS has changed to focus on offering journalists two things. One is to be available to answer quantitative questions. They could be as simple as "I don't know how to calculate this percentage," or they could be pretty sophisticated things, like "I've got this data, and I want to apply this model to it, and I just want to make sure that I'm handling the outliers correctly." The other really cool thing that we do is, we go to individual news agencies and offer workshops on things like confidence intervals, statistical significance, *p* values, and all this highly technical language.

Someone once described to me the advice he gives to journalists. He says, "You should always have a statistician in your back pocket." That's what we hope to be.

What are the most common pitfalls of reporting on statistics?

A favorite one is distinguishing between causation and correlation. People say, "Oh, that's obvious. Of course there's a difference between those two things." But when you get into examples that target our belief system, it's really hard to disassociate them. Part of the problem, I think, is that scientists themselves always want to know more than they can with the tools they have. And they

don’t always make clear that the questions they’re answering aren’t necessarily the ones you might think they’re answering.

What do you mean?

Like, you might be interested in knowing whether taking hormones is helpful or harmful to women who are postmenopausal. So you start out with a question that’s really well-defined: Does it help or hurt? But you can’t necessarily answer that question. What you can answer is the question of whether women who take hormones whom you enroll in your study — those specific women — have an increase or decrease in, say, heart disease rates or breast cancer rates or stroke rates compared to a control group or to the general population. But that may not answer your initial question, which is: “Is that going to be the case for me? Or people like me? Or the population as a whole?”

What do you hope STATS will achieve?

Partly our goal is to help change the culture of journalism so that people recognize the importance of using quantitative arguments and thinking about quantitative issues before they come to conclusions. That way, they’re coming to conclusions that are supported by science rather than using a study to further their own agenda — which is something scientists do too; they may push a certain interpretation of something. We want to arm journalists with a certain amount of rigor in their thinking so they can challenge a scientist who might say, “Well, you just don’t understand my sophisticated statistic.” There’s a lot of value in giving reporters the tools to develop their sense of quantitative skepticism so that they’re not just bullied.

You argue that statistical literacy gives citizens a kind of power. What do you mean?

What I mean is that if we don’t have the ability to process quantitative information, we can often make decisions that are more based on our beliefs and our fears than based on reality. On an individual level, if we have the ability to think quantitatively, we can make better decisions about our own health, about our own choices with regard to risk, about our own lifestyles. It’s very empowering to not be scared or bullied into doing things one way or another.

On a collective level, the impact of being educated in general is huge. Think about what democracy would be if most of us couldn’t read. We aspire to a literate society because it allows for public engagement, and I think this is also true for quantitative literacy. The more we can get people to understand how to view the world in a quantitative way, the more successful we can be at getting past biases and beliefs and prejudices.

You’ve also said that getting people to understand statistics requires more than reciting numbers. Why do you think storytelling is important for conveying statistical concepts?

As human beings, we live in stories. It doesn’t matter how quantitative you are, we’re all influenced by stories. They become like statistics in our mind. So if you report the statistics without the story, you don’t get nearly the level of interest or emotion or willingness to engage with the ideas.

How has the media’s use of data changed in the 13 years you’ve been with STATS?

With the internet, we see a tremendous growth in data produced by search engines. Journalists are

becoming much more adept at collecting these kinds of data and using them in media articles. I think that the current president is also causing a lot of reflection on what we mean by facts, and in that sense journalists maybe think of it as more important in general to get the facts right.

That's interesting. So you think the public's awareness of "fake" news and "alternative" facts is motivating journalists to be more rigorous about fact checking?

I do think it's very motivating. Of course sometimes information gets spun. But ultimately a very small percentage of journalists do that. I think 95 percent of both journalists and scientists are really working hard to get it right.

I'm surprised you're not more jaded about the media.

Ha! This is maybe more a life view. I think there are people who are pessimistic about humankind and people who are optimistic.

You also volunteer with math clubs for kids. What ideas about math and math culture do you try to get across?

I try to bring in problems that are really different and fun and curious and weird. For example, I've done an activity with kids where I've brought in a bunch of ribbons, and I had them learn a little bit about a field called knot theory. There are two things I'm trying to get across to them. One is that math in school is not the whole story — there's this whole other world that is logical but also beautiful and creative. The second message is a certain emotional framework that I have to offer: that math is a joyous experience.

This article was reprinted on Wired.com.