

A conversation with Steven Strogatz (continued)
Patrick Honner

For the rest of the interview with Steven Strogatz see pages 8–11 and 34 of the February 2014 issue of *Math Horizons*.

Patrick Honner: Do you enjoy teaching entry-level calculus?

Steven Strogatz: Teaching calculus can be a little problematic because there's a lot of unlearning that has to happen. Many students have already taken calculus in high school and sometimes haven't done it right, or mislearned it.

On the other hand, with differential equations, it's usually the first time they've seen the material. And the students are sophisticated, but not too sophisticated so as to be jaded. So I find that it's sort of a sweet spot.

PH: What's your impression of today's college students? In what ways are they similar to you and your peers at that age? In what ways are they different?

SS: As in my day, there is still a clear cohort of students who like math and science. They take these advanced math courses because they match their interests and inclinations.

But I think there are also a lot of students who are in these classes who don't want to be there. Maybe it's due to the push for STEM and the talk about how we need so many millions of people with STEM degrees for the workforce.

PH: Maybe those students just think math and science are paths to a good job?

SS: Right. Or their parents think it's a way to make sure they get a good job after college.

PH: It's the new "doctor" or "lawyer" in some sense?

SS: Something like that. Also, other majors are requiring more math than they used to. For example, social sciences now feel that their students should take calculus, and premeds have to take calculus.

PH: Has technology fundamentally changed students?

SS: There are very noticeable changes. For example, the advent of graphing calculators has changed what students know and don't know.

PH: It sounds like you are about to say "for the better and for the worse."

SS: I don't know what I'm about to say: Let's just see what comes out!

Something that is noticeable to me is students' lack of familiarity with curve sketching. If I ask students to draw the graph of a function with a parameter in it, say $1/(x - a)$ for different values of a , many of them are crippled by it. And that's an easy one!

I find that familiarity with the basic shapes of graphs of functions—rational functions, exponentials, sines and cosines, the elementary functions—just isn't there. Students aren't as intimately familiar with them anymore because I think they're used to drawing graphs on their calculators.

There's a feeling that I get when students are trying to step through solving a problem, that each step is laborious, because each step has to be plugged in to a calculator. I think that students are weaker as a result of their reliance on it.

PH: On the other hand, calculators are a pretty fundamental part of mathematics at this point.

SS: In real life, I use calculators and computers all the time, and any applied math student or engineer should know how to do that. But just like you should memorize the multiplication table, I think you need to memorize the shapes of the graphs of simple functions. It's part of our vocabulary. Maybe this is just a question of age, and the next generation won't feel this way.

Like you said, there's better and worse. To me, my students are fantastically good at writing little scripts for handling data. I don't really know how to do that. I'm from a generation where FORTRAN was our computer language. So I can't do anything. And I'm slow at Mathematica. So if they watch me using Mathematica, then I must look pretty...

PH: Every step is laborious.

SS: Yeah. So there is definitely this tradeoff. They have tremendous power because of the technology they have. But it feels like the power is more external to them, and they just know how to tap into it. Whereas I have a lot of power in my head that I know how to tap into, but I'm sort of weak at tapping into the external sources of power.

PH: *The Calculus of Friendship* is a revealing, emotional story [about Strogatz's 30-year correspondence with his high school calculus teacher, Don Joffray]. Did you find it difficult to open yourself up like that?

SS: It was emotional for me. There were times when I was writing it that I cried, and even to this day when I read parts of it, it makes me cry.

It was meant to be raw, yet understated. I didn't want to be blubbing on the page, but there was a lot at stake emotionally. It's a very intimate story. I've never had any particular trouble being direct or open about myself or my feelings, so that was not hard.

In fact my kids always tease me about TMI—too much information. It's in my nature to be frank and open about things; I'm not shy about that.

PH: The book is both emotional and understated. It's not blubbing at all.

SS: I always thought it was just a collection of problems that might be interesting to some calculus teachers. It was my wife, Carole, who said maybe there's something else going on there: "You must know each other so well." It's the story I tell in the book.

PH: Was writing the book cathartic for you?

SS: I think it was a bit. It was an easy book to write, the easiest of all my books. It felt like that story had to come out, like it wanted to come out. I don't normally feel that. I usually feel like I have to squeeze material out of the tube. Whereas with this, each morning I would just sit down and write for a few hours and just surprise myself with what came out.

My friend Alan Alda told me that in writing this kind of a story, to not think about it. Don't outline it too much, or plan it. Just write.

The Calculus of Friendship wasn't like [*The Joy of x*]; there's a lot in there that isn't teaching. That was a new experience for me; it was storytelling. I wanted it to have some poignancy; I wanted to have a story that would keep the reader turning the pages.

PH: But as it turns out, there's a good deal of teaching in there too.

SS: There's a lot of teaching. There's quite a bit of teaching about calculus in there, although I don't teach the basics of calculus. You can't follow it unless you know the basics.

PH: It's not a textbook.

SS: It's certainly not a textbook. And then there are sections where I try to do a little bit of poetry, the poetry of calculus—calculus as a metaphor for the story. Calculus is the mathematics of change, and this story is about a relationship that changes.

I tried to play on those connections, by thinking about evolution and time, which is what differential equations is all about. Can we think about how this relationship evolves in time and how limited calculus is at understanding the kinds of change that occurs between two people over the course of their lives?

So, it's a little about the strength of calculus and the weakness of calculus; the strength of a mathematical outlook on the world, and the naiveté of the mathematical outlook in trying to think about human affairs.

PH: Do you have former students who communicate with you about math problems now?

SS: Nothing like what Mr. Joffray and I did.

PH: I guess the bond between a high school teacher and a student is kind of unique.

SS: And also people don't write handwritten letters to each other in the way that we used to. There's email, of course, and I certainly keep in touch with my former students, but not really about math.