AN ELEGANT SOLUTION

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Editor's note: Jennie spoke with Scott Samuelson on 10 July 2008

Scott: Does mathematics exist primarily to solve problems?

Jennie: Yes. That is its main purpose. Many think of math as crunching numbers, but really it's about modeling the world. The word "mathematics" comes from a Greek word which means "inclined to learn." The name of my discipline does not mean anything about numbers; it means curiosity, trying to figure things out, trying to learn and describe our world.

Scott: So is the "text" of mathematics the world? That is awfully big. Might the text of math be the problems that are to be solved?

Jennie: The text of mathematics goes beyond the problems we solve because a problem might lead us to explore a topic in a very abstract way, a topic that initially does not present itself as a problem. We might explore it in a concrete way, first trying to apply it to a problem, but it might also lead us to abstract exploration that leads us to theorems that may have no application to a specific problem. So one way to limit the idea that the world is the "text" of mathematics is to say that the text of mathematics is this body of theorems and rules that we have discovered and postulated through trying to solve problems.

Scott: How do these theorems and rules enable you to look at the world and the problems of the world in ways differently than, say, language looks at them?

Jennie: Well, mathematics is a language if you define language as a symbolic system of notation and expression. A mathematical model helps us gain insight into a problem that would otherwise be unmanageable if we didn't have a way of reducing it into this symbolic language where we can look at it piece by piece and understand it better.

Scott: Do you find it ironic that in order to understand the world better, we move to a complex symbolic system that then enables us to make the complexity of the world simpler? How has practicing mathematics helped you engage the world?

Jennie: I think it has helped me wrap my mind around things better. When I was younger I thought, as I suppose most people do, that there was no way to understand some complex things. How does our money grow with interest, for example? Until you study that subject, it seems a big mystery, but with what turns out to be a simple mathematical model, you can see clearly what's happening.

Scott: And math worked better for you as a way of wrapping your mind around things than other disciplines. You came to math because…?

Jennie: I'm not one of those people who always loved math. Math did not just sing out to me from a young age or anything. I didn't really enjoy it until I was in college.

Scott: Why did it work for you then?

Jennie: I think it's because in high school mathematics is usually taught in such a way that hides what it really is—it is generally taught as a body of equations to learn and apply. Students don't really understand where the principles come from; they are taught to just manipulate numbers and formulas. Thinking that mathematics is just number crunching might be like thinking that literature is just typing. Mathematics really is a problem-solving process. In college I had some classes where teachers focused on that process of looking at the world. I saw how powerful and therefore beautiful mathematics can be. I saw how to take something complex and unexplainable and capture it. The power and the beauty in the discipline appealed to me.

Scott: So some solutions to problems are more "beautiful" than others?

Jennie: Yes. A certain mathematical theorem could have dozens or more proofs. And some of them are what we in the mathematics community call "elegant" because of their simplicity or because of the brilliant way they are reached. In contrast are the "clunky" proofs. In math that elegance appeals to me. I suppose I really am more of a pure mathematician than an applied mathematician. I like math just for the sake of itself and because of the beauty of the process.

Scott: Do you sometimes say to your students in a middle of a proof, "Look how elegant this solution is"?

Jennie: I often say things like that. I may say, for example, "Isn't it amazing that we can describe this complex situation so powerfully? Isn't that cool that we can figure this out?" I rarely just give them a formula. We'll discover a formula together, and they'll see how exciting it is that they came up with it. I try to convey in every possible way the beauty, excitement, and power of mathematics. I guess those qualities drew me to the field, and I want to pass that on. I don't like just solving equations—that's kind of boring. It was not crunching numbers and solving equations that drew me to mathematics.

Scott: You said a moment ago that you are more of a pure mathematician than an applied mathematician. Talk more about that distinction.

Jennie: An applied mathematician explains phenomena in the world with mathematical models. A problem may not be interesting to him unless it has practical application. Such an orientation solves a lot of real-world problems. But there are many theorems or topics in mathematics that currently have no functional application. Of course, often an application or connection is made later. Examples of such theorems are abundant in number theory, in studying prime numbers for instance. Most theorems in number theory are not going to make a faster computer or build a stronger bridge. But mathematicians build on these theorems even though there is no application. And there are theorems that are unproven that people are still trying to prove just for the sake of proving them. Take, for example, the twin prime conjecture: it has been conjectured that there are infinitely many twin primes, pairs of primes that differ by two, like 5 and 7. It has never been proven that there are an infinite number of these, though number theorists have tried for I don't know how long. And I don't know when the conjecture was first made. Well, if we get a proof of that, is that going to change the world? Not directly, not now anyway. So, there's an example of math for the sake of math, just for the sake of saying, "Wow, we can discover this; we can prove that; we can build on other symbolic and numeric relationships we have already observed."

Scott: I remember reading an article in the *New Yorker* about two brothers making a huge computer in their Manhattan apartment just to calculate *pi* further than it had ever been calculated before.

Jennie: Yes, that's a great story. Calculating *pi* to millions of digits does interest some people, but does that change our world? No. Usually a few digits of *pi* is enough when solving an applied problem. If you use 3.14159, that is probably good enough for most applications. Being able to calculate *pi* to the millionth digit—that is a pure math problem. However, interestingly, working on that calculation did actually advance computer technology. So, often in seeking to engage in pure mathematics, you inadvertently advance a field parallel to mathematics.

Scott: What mathematical subjects do the math teachers talk about in the hallways?

Jennie: We may share cool problems that we run into. Of course, we may talk about challenges in teaching math. Or we might discuss what's happening in the mathematical world—like news of a theorem that was proved recently. So there is a kind of buzz when somebody solves an age-old problem or a major theorem that nobody has been able to prove. I would say the most often we talk about a cool problem or a cool way of looking at a concept. Maybe a teacher just saw an old concept or problem from a new angle. She might share that with a colleague. There are countless fun problems out there.

Scott: What did you think of the film *A Beautiful Mind*? (*A Beautiful Mind* is "inspired by" the life of John Nash, a brilliant mathematician who won a Nobel Prize for a theory he developed with important applications in economics. Nash tragically falls into paranoia and schizophrenia.)

Jennie: The film appealed to me for a number of reasons. Cryptology, I think, is one of the coolest mathematics applications. If I were to work outside of academia, I would probably work for the NSA as a cryptologist. That is one of the reasons I initially wanted to see the movie, and when I watched it, I realized that it really wasn't about cryptology or even the mathematics behind it. But what I thought was intriguing about the movie was that John Nash examined his own mental illness and treated it like a mathematical problem. I told you mathematics means "inclined to learn." You wouldn't expect an application of mathematics to be treating your own bad mental health.

Scott: Do you think that math could be used in every field profitably to help solve problems?

Jennie: I would wager to say yes. It is already used in most of the sciences heavily. It's essentially the language of the physical sciences. And we are seeing more and more mathematical models for biological problems. These are obvious examples. The last chapter in our mathematics foundations course text talks about less obvious connections between math and many other fields. For example, politics: the authors talk about voting schemes and the question of whether the majority always rules. It's an interesting question when you look at it mathematically. It can't hurt to look at everything from as many viewpoints as possible and see which ones shed light. Mathematics often sheds light because it is all about finding patterns and method in apparent chaos. I think mathematical principles could profitably apply to almost any field.

Scott: So, for me as a mathematical layman, what is the pattern of calculus?

Jennie: I like to think of calculus as the study of the infinite. We take everything that we've looked at before calculus, and we take those principles to infinity. I refer you to Brother Kent Bessey's book *To Infinity and Beyond;* it talks about the connections of math and the infinite, including gospel topics. In pre-calculus, for instance, we can add up many numbers and come up with a finite sum. In calculus we can actually add up infinitely many numbers and come up with a sum sometimes. Here's one of the classic problems that motivated calculus: suppose you have a curve, if you take two points on that curve and draw a line through those two points, you can find the slope of that line and an equation for that line. But if you take just one point on a curve and want to find the slope of the tangent line, pre-calculus won't help you. How do you find a slope without two points? So what we do is we let these points get infinitesimally close. We look at adding up many things or letting things get infinitesimally close. It's essentially the study of infinity. That is vastly over simplified, of course.

Scott: Are calculus or mathematics spiritual?

Jennie: I think they can be. Historically there has been a huge connection. Galileo has been quoted as saying that mathematics is the language in which God wrote the universe. Newton and Leibniz discovered calculus, and Newton was a learned theologian. A lot of people that appreciate religion and God and are trying to come closer to God also appreciate math. For me, I think there are some pretty cool connections with concepts of the infinite, as we discussed a moment ago concerning calculus. For me mathematics is spiritual in much the same way nature is. You can't go into the mountains without appreciating the beauty of God's creations, and that appreciation confirms to you the existence of God and tells you something about His nature. It's the same with mathematics. You can't delve into these irrevocable laws without gaining insight into God and learning to appreciate Him more.

I have a great calculus class this semester with engineering and science students; they are all very much into their fields. They get excited about calculus and their enthusiasm makes the class really fun. They were talking about the excitement of their fields and they fell into knocking English majors, and I stopped them and said, "What are you talking about? English is just as beautiful as mathematics." They looked at me and said, "Do you really think that?" And of course I do. But I think there's beauty in every field, and English is something I love. I love reading. I love literature. I love poetry. I think the more you learn about anything, the more you start to appreciate, the more you advance in your own field. If you allow yourself, you'll start to appreciate and see connections and beauty in all academic fields.

Scott: I agree. A university is supposed to be a place where we encourage this well-rounded thinking. We gather all the disciplines and work to see the connections. I think a university was originally intended to be a place not just of narrow specialization but a place where all were interested in varieties of points of view and sharing those views—amicably and, let's hope, elegantly.