▲ Interview with Dr. Monica Nevins

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Ann Arden is a math teacher in the Ottawa-Carleton District School Board and is currently an instructional coach. She has also taught in the Faculty of Education at the University of Ottawa, and her son's teacher this year was a former student! Ann is very interested in assessment to improve learning, especially through the use of conversational and observational evidence. Ann is on Twitter as @annarden.

Monica Nevins is a Professor (Department of Mathematics and Statistics) and Vice-Dean (Governance and International Relations, Faculty of Science) at the University of Ottawa. She was named a Fellow of the Canadian Mathematical Society in 2019.

For this interview, Ann was joined by two Grade 6 students, Caitlin and Charley, who had never met a mathematician before.

Can you tell me about your experiences with math as a K–12 student? Do you have anything that sticks out for you?

Honestly, everything that I can remember from my K to 12 schooling is probably about math. I remember a time in Grade 6 where there were two bonus questions—one was easy and one was hard. I messed up the easy one, but I got the hard one, and it was this funny mix of chagrin and feeling great. There's lots of that in math for me: when you get something wrong, it hurts, but when you figure out why, it can be as amazing as if you got it right the first time.

Math class was all about the way I like to think—I was always looking for patterns, and everything was nice and interesting in math. I remember asking my teacher in elementary school, "Why do we have math for an hour and then English for an hour—why can't we just have a day of math?"—and they didn't have a satisfactory answer. I have really good days now where I just do math and that's fun.

Do you have any particular memory in your high school experiences that would have encouraged you to apply to be a math major?

In high school, I did very well in all my subjects, but I really like being 100 percent totally right. Math was the only subject where this could happen, and I thought, "That's the best part!" But I wondered, "What can I do with a math degree?" My teachers didn't know either, but the ones I admired had gotten there by following their own interests, so… why not? Maybe I'd be a teacher, too.

When I started university, I thought math, computer science, and physics were all in the right range. In second year, I took a course in group theory and I was so excited: "This is what I've been waiting for!" and let physics go. In third year, the chair of the math department actually called me at home to encourage me to upgrade my course choices for the next year, saying I would do well, and this felt like an amazing vote of confidence that I didn't even realize I needed to hear. That's when I let computer science go. It was the right decision: it set me up to take all the coolest math courses in fourth year. I thought, "I need a little bit more of this before I stop and get myself a serious job," and I applied to graduate school in case I made it into MIT. [Note: Dr Nevins went straight from undergraduate math to complete a PhD at MIT.] I found the hardest courses have the best payoff: when you figure something out, it is so great. That was true for high school too.

What are your research interests?

I do research in two quite distinct areas, and the common theme to my research is about putting algebraic structures to work.

The main one is about p-adic groups: sets of matrices whose entries are not real numbers or complex numbers, but the infinitely more fascinating (from algebraic, topological, and number theoretic perspectives!) p-adic numbers. The big problem that I (and many others!) work on is trying to prove a vast set of conjectures about p-adic groups that would answer deep questions in number theory; we chip away, and it's coming into focus.

My second area of research is in mathematical cryptography, which was in some sense my first love; puzzles fascinate me. Modern mathematical cryptography is the critical, irreplaceable magic to our secure communications on the Internet, for example, but we need to keep ahead of advances in algorithms that can attack this core. Both the core

and the attacks are based on hard mathematical problems arising from various algebraic structures.

Do you think it was your teachers who made you want to be a mathematician, or did you just always know that you wanted to do it eventually? [Charley's Question]

I didn't always know that I wanted to do it, but over time, it became the only thing I really, really wanted. There were some teachers who had a really big impact (like that professor who called me at home); others just conveyed how happy math made them in a way I could really identify with. I think I ended up modelling my career after the teachers I appreciated the most, the ones that were really nice and generous with their time.

When you were growing up in elementary and high school, were you one of the people who always "got it" or one of the people who had to "work through it" each time? [Charley's Question]

"Getting it" is something about when the teacher has a concept in mind and is trying to convey it to you, and once it's clear, it just "clicks" into place. I remember in Grade 10, my teacher said something was true "in general," and I argued intensely back and forth with him ("Is it true all the time or not?"), and then there was a big click when I learned that the mathematical meaning of "in general" is "in all cases." I think I had felt furious because it sounded wishy-washy!

Sometimes I "got it" quickly and was eager to do a problem to test it out, but there were certainly times when it took more work. Integrals in university had me in tears one weekend, but I wanted to understand so badly, I thought, "I better try harder because I really want to get there." That "click" felt AMAZING, because I'd worked so hard for it.

In school, I hated the phrase, "You're really good at math," because I worried it was like something you could lose. What might happen if the next time I got a math problem, I don't know how to solve it? Is it over? Eventually I stopped worrying I would "lose it" and about what other people think—I'm doing the math (and persisting and thus succeeding) because it's fun. To get back to your earlier question, my teachers had a huge influence on how I felt about things. If they gave me a good problem and set me up properly, it became about the math and not about what everyone else was thinking.

I'm still learning more math all the time. My real life is all about learning math. I go to plenty of places where I don't understand something and then I am making a choice: "Okay, do I care enough about this that I'm going to try and figure this out?" If yes, I listen really hard, take some notes, and then get my questions ready. Or maybe I need to go look something up. I know from experience, now, that when I care enough about something, I know I will be able to figure it out. Just give me enough time, and if I really want it, I can have it!

I can see that you really love math! Were there any times that you were really frustrated and maybe didn't want to do this anymore? [Caitlin's Question]

Yes. You get these times of highs and lows, and maybe want to do something easier. But "easier" just isn't as rewarding—those "highs" are what it's all about.

It was a big shock for me to start at MIT. I was a pretty good student, and then I showed up at MIT and it was like, "Whoa, these people are geniuses!" I felt so intimidated. I think that was probably one of my lower points. I thought to myself, "What am I going to do? Okay, I guess I'll do my homework and then I'll go to the seminar because they are all going to the seminar. And it looks like they understand everything, but I don't understand anything!" Actually, the others didn't understand anything either. They were just trying—we were all just trying.

I was afraid that everyone knew more than I did. Sometimes people can sound very convincing, or you can have kids in the class who are super fast and really loud. That wasn't my personality: I always waited until I was sure before I said anything, if at all. It took me a while to realize that that's all it is, personality—it's not good or bad; it's not about how much math they know compared to me.

The most eye-opening thing for me was working with a colleague who was very confident. I was in awe of this person. Then, after spending meeting after meeting with him, I realized he was wrong half the time! He was just willing to say things as if they were true, thinking out loud. It's just like when I do my calculations quietly by myself and I make all these mistakes and have to correct them until I get it right, and the fact that I made the mistakes was a huge part of learning, they're the things that advanced the project, but I'd hate to do it in front of people. My colleague was just more willing to do that out loud and be happy about what we figured out in the end. Realizing this, I felt like I had finally seen behind the curtain, and could stop worrying about whether I was as smart as the confident person next to me.

We made a great team: we're doing the same stuff, but he is "out there" with his math, and someone like me, I'm kind of "in my head" and the math is "in here."

As a teacher, I feel the perceptual part of math in particular is so important. People feel that they're either "in the club" or they're "not in the club." They feel like they can do the math, or they feel that they can't do the math. I find a lot of students doubt themselves. How did you overcome that and what's your advice for teachers to encourage their students?

It's the low-level doubt that keeps me fired up. If you always

felt, "I can do this!," why would you ever bother? It's only because you wonder if you can do it that you actually dive into it. People will say, "You're good at math, you're gifted," implying math is a "thing" you have that can be taken away, that other people don't have. That's a horrible thought—and that's not what this math stuff is like. It is not about a "thing" that I own that could wash off. If a student in Grade 10 feels like they can't do math anymore, I wonder, "What do they think they have been doing all this time?" We are just progressing, and you are building your knowledge. If there's something in Grade 10 that does not make sense, you just have to back up and figure out which piece got lost along the way. It is not like our brains are capable of linear functions, but then reject quadratics.

I see students in first-year university who are incredibly bright. If someone is stuck, it is about, "Let's back up and see where the problem is, and let's build out a plan of what you need to work on to get up to speed and figure this thing out." Students need to be willing to "fess up" that they didn't understand something, and that's very hard (especially if they believe that "you're either good at math or not" spiel).

I think it can become dangerous for students if they have been told they are very good at math because they do not want to ask questions. If they get stuck, they just wait until the usual thing happens, which is that it "clicks." But sometimes they need to be more active, to ask questions and get some help to get it to "click." Students start to realize that sometimes the explanation was not in the language needed to make it "click" for them. They realize they need to keep developing more resources for how to learn math.

As a math professor, what would you like high school teachers to be thinking about in Grades 10 to 12 about communicating to students, encouraging them to go into math or math for business or math for engineering?

This is a very big question. Our big encouraging message, at any stage, is that students should find out what they like and let it lead them. For the ones who love math, I want to communicate that they have a chance to really invest in themselves. By challenging themselves to keep the math in their studies, they're rising to the top, standing out in the playing field, and opening doors they don't even know about yet. AI, quantum computers, big data… we're entering a very math-rich era and they can own it.

I think it helps to be sensitive about the perception that math requires brilliance, which is so reinforced in society and can really turn people off who don't see themselves that way. We can help by instead reinforcing how everything in math builds on everything learned previously; as a math student, you walk into the class, and everything else you learned in math classes beforehand is with you right now. We have vocabulary that is unleashing a whole torrent of information. When you hear the word "probability," just think about how many things you have attached to that word: like coin flipping, fractions, pie charts, statistics, balls pulled out of bags, poker odds, and more! That is what you are bringing with you to class. When a student comes into my first-year class and I say "logarithm," I want that to unleash dozens of thoughts—the graph, the function, base, exponential, equations—I want everything! Those interconnections and that reinforcement take a lot of time, but without them, they forget everything after the exam.

And honestly, the real math (and the real joy) is all the understanding and learning new ways of thinking —it is the process that we went through, not just the result. We have so much emphasis on producing the right answer, but we forget that this is just a proxy for "I have learned this material." I want us to give students a chance to explore and to have those "ups and downs," and to realize that the process is the fun part, the real part of math. I wish we had more time to do that. How do we invent time for high school students (any students!) to be in that headspace and devoted to really thinking things through?

(Then there's a whole tangent to be had about, "How can people these days, with devices, focus for the length of time it takes to figure something worthwhile out?")

Have you seen Dan Meyer's 2010 TED talk "Math class needs a makeover?" I think he calls it an "impatience with irresolution." We as a society want everything to be like a sitcom: 30 minutes with a laugh track and a beginning, middle, and an end.

Right. Another analogy I have that's related to that is that some students do math with the tips of their fingers instead of with their minds. They do this symbol manipulation: "There's the example and I just substitute the symbols."

Tips of the fingers. Wow, I just saw that visual!

Absolutely. It's when there is an example in the book and it's practically the same—maybe the numbers are different. You copy what is there, just moving numbers and symbols around, and get to the end and say, "Well there, I did some math!" And I say, "No math whatsoever happened." Math is when it went in your head, and the stuff that came out of your fingertips onto the page is what came from your mind, processed and thought about. I definitely see students doing symbol manipulation (that is meaningless to them), copying examples, and thinking that this mimicry is what math is, no deeper than a sitcom.

In high school, maybe we don't get to play with the real math as much as we need to. And playing is good!

Thank you very much! ▲