Anthony Várilly-Alvarado Interview

Conducted by Alexander Diaz-Lopez

Anthony (Tony) Várilly-Alvarado is associate professor of mathematics at Rice University. He investigates the arithmetic of surfaces and was awarded an NSF CAREER grant in 2014. He has received several teaching awards and is founder and director of Patterns, Math & You, a STEM program for middle school students. He is currently a member at large of the AMS Council, and a member of the Human Resources Advisory Committee at MSRI.

Diaz-Lopez: *When did you know you wanted to be a mathematician?*

Várilly-Alvarado: When I was in high school, I was introduced to the idea of mathematical proof through Math Olympiads, mostly by accident. On the day of the first round of the Costa Rican Math Olympiad in 1995, one of my high school's team members failed to show up to school. My math teacher, Paul Murray, pulled me out of class early that morning and put me on a bus to go take the first-round test; I think he saw in me a talent I didn't know I had. The questions on the test were like nothing I'd ever seen before, and I was fascinated by this new world.

I loved proof-based problem solving, but I wasn't particularly fast at it. Even as I was finishing high school, I thought I might try my hand at civil engineering, but the only bits of Stewart's calculus book that seemed interesting to me were the explanations of why things worked. Around the same time, I had the chance to write an extended essay for the international baccalaureate in mathematics and proved a small result in triangle geometry. It was thrilling, and by the time I got to college I was seriously interested in a mathematics major.

My father, Joseph Várilly, is a mathematician. Having him as a role model and supporting mentor throughout my teenage years (and beyond!) contributed unquantifiably towards my love for mathematics. Not once did he push me to become a mathematician. He always encouraged me to find my own path. We work in different areas of mathematics, but last year we finally converged at a conference, the Mathematical Congress of the Americas, in Montreal. It was wonderful to be able to share with him in a professional setting a passion that brings us together.

Diaz-Lopez: *Who else encouraged or inspired you?*

Várilly-Alvarado: There are too many people I could name here; I'll try to keep it brief at peril of leaving out some key figures. My PhD advisor, Bjorn Poonen, is another role model I imperfectly strive to emulate. His passion, intuition, patience, work ethic, and generosity shaped who I am today. Brendan Hassett, my post-doctoral mentor, taught me a lot about taste, and how to keep a big picture in mind while working on small parts of a research program. During the six years we overlapped at Rice, Brendan was always generous with his ideas and time (despite being chair for five of the six years!). I learned how to be a professional mathematician through our interactions.

Mathematics is a social activity. I have been deeply inspired by my collaborators. I tend to learn by talking to other people, by trying to understand how they think about mathematical ideas.

In the "otherwise" category, I was fascinated by Jorge Luis Borges' short stories as a teenager. His obsession with infinity and time, and the way he could effortlessly bend language to convey it, encouraged in me a passion for abstraction (and literature!).

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Diaz-Lopez: *How would you describe your research to a graduate student?*

Várilly-Alvarado: I work in the part of arithmetic algebraic geometry that studies the structure of the set of rational points on algebraically defined spaces over number fields. Geometric properties of these spaces, like curvature, bear heavily on the qualitative and quantitative nature of the set of its rational points.

Recently, I have been thinking about K3 surfaces, which are 2-dimensional analogues of elliptic curves, but they have no group law. I've also been studying related objects, such as cubic fourfolds and abelian varieties, which often shed light on the cohomology of K3 surfaces. The geometry of K3 surfaces was extensively studied and understood towards the end of the 20th century. Despite much progress in the last 15 years, K3 surfaces are still relatively mysterious from a number-theoretic perspective. It's an exciting time to investigate them!

Diaz-Lopez: *What theorem are you most proud of?*

Várilly-Alvarado: It's probably early in my career to have a favorite theorem, but one paper I am particularly proud of is "Arithmetic of del Pezzo Surfaces of Degree 4 and Vertical Brauer Groups," which is joint work with Bianca Viray. Bianca and I were both post-docs when we began the project, and we were each trying to find a new direction for our research. I visited Bianca in Boston, where she showed me some work she had done on a surface studied in 1975 by Birch and Swinnerton-Dyer. The surface had a cohomological obstruction to the existence of points with $\mathbb{Q}$-coordinates, and Bianca had reinterpreted this obstruction in a beautifully geometrical way. She showed the surface could be fibered into curves, each of which failed to have $\mathbb{Z}/N\mathbb{Z}$-points for some N; it was a stunningly visual interpretation of a Brauer-Manin obstruction. Bianca was convinced this phenomenon is widespread, and I must confess I was skeptical. Bianca was right: we showed that every del Pezzo surface of degree 4 behaved similarly, that in some sense Birch and Swinnerton-Dyer's surface was not special (even though it is a fantastically well-chosen example because it's amenable to explicit computations).

I like that paper a lot. We shed light on the arithmetic of a class of surfaces that had been thoroughly studied for decades. It taught us to not underestimate ourselves. Each one of us has proved fancier-sounding theorems since that paper, but I think that result was a personal watershed moment in each of our careers.

Diaz-Lopez: *What advice do you have for current graduate students?*

Várilly-Alvarado: A few things come to mind:

(1) Choose an advisor, not a subject. You can always move away from your thesis topic after you graduate (slowly, by analytic continuation). Having an advisor who can help you harness your strengths, and push you to improve on weaknesses, is key.

(2) You will feel discouraged periodically throughout your career: this is completely natural, and it does not mean you are not cut out for mathematics. For most of us, the self-doubt never goes away, but over time you learn to co-exist with it in peace.

(3) Don't go at it alone: your dissertation research is your own, but it's important to form a support network with other graduate students. Read and constructively criticize one another's work and application materials. Give practice talks in front of your peers and let them tell you frankly what they understood.

(4) Write up carefully TeXed notes of your research as you go along. You will thank yourself later when putting together a dissertation.

(5) The initial stages of graduate school (coursework, qualifying exams) provide an external workframe that shapes your day-to-day life. Once you have completed these requirements, the onus is on you to keep going (but don't forget item #3 above!).

(6) By and large, advisors want to support your goals and aspirations. Have periodic, frank talks with your advisor about what you want to do after a PhD, whether it's an academic position of one flavor or another, or a job in industry or government. The conversation will change over time, but a clear line of communication between the two of you is paramount if you want a positive outcome.

Diaz-Lopez: *All mathematicians feel discouraged occasionally. How do you deal with discouragement?*

Várilly-Alvarado: First, I think this is something we should be thinking about and discussing much more, at all levels. I often tell students in my undergraduate courses that I spend about 95% of my thinking time in a state of confusion, struggling to put pieces of a puzzle together. They often react with surprise, because our carefully choreographed lectures and problem sets tend to make us look like oracles that always have clever answers or ideas at hand. Students should be aware that it's normal to feel confused and lost when you're learning a new subject.

At the graduate level, discouragement can take several forms. I personally had projects collapse at late developmental stages, strong anxiety about the future, fear of running out of ideas, the feeling of standing in front of insurmountable mathematical walls, etc. I have been very fortunate to have had a strong community of friends and mentors throughout my career that I could talk to openly about these issues. At first, I was amazed to hear their stories and feelings of discouragement. You can derive much comfort and the strength to keep going from a mathematical family. Even as a tenure-track professor, the impostor syndrome did not go away. For me personally, things started getting better when I began advising students and mentoring post-docs. Their talent and drive seems obvious to me, but I can see the self-doubt and discouragement they feel, so similar to my own. Providing a forum for discussion for them has in turn helped me deal with my own discouragement.

Diaz-Lopez: *You are involved in several projects involving students at all levels. For example, you are founder and director of "Patterns, Math & You," a 2-week summer program for middle school students. What are your goals in such activities?*

Várilly-Alvarado: Patterns, Math & You (PMAY) grew out of my personal experience (which is also well-documented in studies) that persistence rates in STEM majors are lower among students from underrepresented groups, in great part because of insufficient high school mathematical preparation. I've met many talented undergraduates who gave up on their dream of being an engineer or a scientist because of their performance in first-year STEM courses. In PMAY, we take in a diverse group of students from the Houston independent school district and get them to discover beautiful patterns in elementary number theory through experimentation. The program is directed at middle school students because we want to encourage their STEM aspirations and help them navigate choices in high school that will prepare them for the rigors of a STEM major.

More broadly, inclusion has become an important priority for me. I want to support activities and initiatives that foster an appreciation and love for mathematics across a wide spectrum of people, at many different levels of experience. I think too often as mathematicians we neglect individuals whose background, available opportunities, and life experiences have placed them at a disadvantage relative to privileged upbringings. To paraphrase one of my mentors, we should be much more interested in the derivative of someone's talent than on its value at any given time marker. In this regard, Federico Ardila has been an inspiring figure for me, and I am a strong believer in the axioms on mathematical talent that he laid out here on the pages of the *Notices.*[1]

***Diaz-Lopez:** If you could recommend one book to graduate students, what would it be?*

Várilly-Alvarado: I can't do just one. Several life-changing books and articles come to mind. People wishing to learn a bit of algebraic geometry with a computational flavor should read Cox, Little, and O'Shea's landmark book, I*deals, Varieties, and Algorithms.* At a more abstract level, I am particularly fond of Ravi Vakil's *Foundations of Algebraic Geometry*, a tough read, well worth every minute spent on it. I am also a strong believer in original sources. Several articles of Serre's, e.g., "Faisceaux Algebriques Coherents" and "Géometrie Algébrique et Géométrie Analytique" (GAGA), are masterpieces that everyone with algebro-geometric interests should spend time reading, if only for personal self-edification. Then of course, anything by Grothendieck. One has to be careful, though: the pull of Grothedieck's writing has the strength of a black hole, and it is possible to spend years reveling in it. To some extent one should, but it's important to balance this impulse with one's own research production.

***Diaz-Lopez:** Any final comments or advice?*

Várilly-Alvarado: We, as mathematicians, could be doing a better job of explaining to the public and to our governments what it is that we do, and why it is worth doing. We give up too easily, thinking that it's too hard (and I am sympathetic; explaining the importance of the arithmetic of Shimura varieties to a congressional aide in 15 minutes is no walk in the park). In my experience, people are happy to listen if you try hard to make things understandable. It empowers them to see glimpses of higher-level mathematics. The thirst from the public is there, and I see it as our moral responsibility to quench it.

[1] *"Todos Cuentan: Cultivating Diversity in Combinatorics," Nov. 2016* Notices, *https://www.ams.org/publications/journals/notices/201610/rnoti-p1164.pdf*

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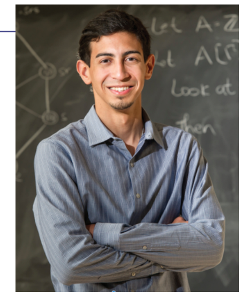
ABOUT THE INTERVIEWER



Alexander Diaz-Lopez

Alexander Diaz-Lopez, having earned his PhD at the University of Notre Dame, is now assistant professor at Villanova University. Diaz-Lopez was the first graduate student member of the *Notices* Editorial Board.