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Life After Calculus: 20 Years Later

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Abstract

In 1996 *Math Horizons* interviewed a group of students at the Joint Mathematics Meetings; now, 20 years later, one of those students, Darren Glass, interviews another group of students.

Keywords

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Disciplines

Mathematics | Science and Mathematics Education

Life after Calculus
20 Years Later

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In 1996, I was a junior in college and attended my first Joint Mathematics Meetings, which was held in Orlando, Florida. While there, I participated in a conversation with a dozen other students and two mathematicians about our experiences with college-level mathematics and the advice we had for other students. An article based on the conversation appeared in *Math Horizons* (Robert Eslinger and Jon Scott, "Life After Calculus," April 1996, 25–29).

Two decades later, I thought it would be interesting to conduct a similar conversation with a group of students. I invited nine of the 200 students speaking at MAA MathFest in Columbus, Ohio, to discuss a wide range of topics. What follows are excerpts from our conversation, some of which were edited for length and clarity.

Darren Glass: How did you find the transition from calculus-type courses to upper-level math courses? How are these courses different, and how are they similar?
Ahmad Nazeri (Randolph-Macon College, '16): For me, the main thing was proofs. In calculus, once you knew how to solve one problem, you could solve other problems. Not so in upper-level courses. I did things out of order—right after calculus I went straight to real analysis, which was the worst decision I could make. *[Lots of laughs and nods of agreement from the other students.]*
Santana Afton (College of William & Mary, '18): One other big difference is that calculus and linear algebra are all about objects, and you are applying them and using them. It's not about what an integral *is* but just about

whether you can *use* it. In upper-level math classes you are given objects, and, while you use them to a certain extent, you are really talking about properties of those objects and how they interact with each other.
Hayley Bertrand (St. Norbert College, '17): For me, calculus was just not exciting at all. It was a lot of memorizing and applying and brainless computations. In upper-level classes, you have to understand the abstract concepts lurking behind those ideas. It is much more interesting to think about things like that instead of just plugging in numbers.

DG: What advice would you give to a first-year student contemplating a math major and facing a course heavy in proofs and abstraction for the first time?
Hayley: Some students try to do homework problems the same way they did in calculus, where you copy down an example from the textbook and change a few numbers. But you can't do that with proof writing.
Erik Wendt (Gettysburg College, '19): Learning to question your own work is one of the biggest things you need when learning mathematics. If you really question every statement in your own proofs, then you take ownership of it. That's a big step that math majors need to take.
Alex Mathers (University of Alabama, '17): Some students, when they don't understand a proof, read it over and over hoping that they will eventually understand it. But the best thing to do is to step away. They should come back to it after they have worked on other problems and have a different view of the material. It's also tempting to read through a proof and say, "OK, sure, I get it,"

From left: Sam Edwards, Santana Afton, Caryn Willis, Jeffrey Yujie Jiang, Darren Glass, Ahmad Nazeri, Kelsey Scott, and Erik Wendt (not pictured: Hayley Bertrand and Alex Mathers). Opposite page: Willis and Afton.

without pausing to figure out the big ideas in the proof. It is important to ask questions like "Are we using all of the assumptions? What happens if we don't have each of them?"

Hayley: Students should think of a proof like a puzzle. The pieces all fall into different spots. My professor would always have us start writing proofs from both the top and the bottom, because sometimes it's easier to see how the pieces fit together if you look from a different angle.

Caryn Willis (Indiana Wesleyan University, '16): One issue I had at first was that I would try a problem and not figure it out, but when I read the answer later, it made perfect sense. Sometimes this was because I didn't understand the background. So it was helpful to go back and review the definitions and basic facts, so that I understood them when they came up in the proofs.

Santana: I think there are two difficult parts of writing proofs. One is understanding the concepts, but the other is the writing. I talk to my friends who are science majors about what we do in math classes, and they have no idea what I am talking about. But then I talk to my friends who are English majors, and they completely get it. There is a structure that is important to learn.

Sam Edwards (Gettysburg College, '17): I tend to get a different response from my friends who are English majors. Most of them say, "You *write* in math classes?!?" *[Lots of laughs.]*

Hayley: I work in my college's writing center, and being a math major is very helpful. The biggest problem students have is building a logical argument and making the different pieces fit together.

Santana: One of the most useful things to me was to just dive into the advanced classes. The semester after I took [our introduction to proofs course], I took an advanced linear algebra class that apparently was a graduate-level course, although I did not know that when I signed up. My proof writing got *a lot* better that semester.

DG: Are there things that your professors did or that you wish they had done to help you make the jump from the more computational courses to the more theoretical courses?

Santana: I was fortunate because I stumbled across a book about proofs before I even entered college. Professors should introduce proofs earlier—the later you start proofs, the harder they are going to be.

Caryn: At my school, discrete math is a first-semester, freshman-year course. So it introduces you to the theory right off the bat. It scares some students away from being a math major, but it helps to get that mind-set right when you start college.

Sam: It might be useful to have calculus courses specifically geared toward math majors. I know that biology and chemistry majors need certain parts of calculus, but if you had specific courses for math majors, they could focus on the parts that are more abstract—rather than computational—and would be useful to math majors down the road.

Ahmad: Randolph-Macon has a sophomore seminar. We met once or twice a week to discuss different things related to being a math major, including proofs of certain material. While everyone is in the calculus course together, this is a chance to separate out a group that is mostly math majors.

From left: Jeffrey Yujie Jiang, Darren Glass, and Sam Edwards.

Erik: The main place we used them was in multivariable calc, where we spent a lot of time looking at three-dimensional graphs and contour plots and things like that. Also, in some later classes, being able to do a little bit of computer programming helped bridge the gap between intuition and a full proof.

Caryn: My math modeling course was project based, and we used Maple and Excel all the time. We had three projects on topics like population models, and for each of them we had to write up a report and give a presentation to the class. That's when I learned different kinds of writing and presentation skills.

Sam: I took a wavelets course, in which we used Mathematica extensively. At the end of the semester, we had group projects where we learned about a topic and then implemented it on the computer. It was *very hard*—I did one on facial recognition, and it took forever to code.

DG: Was there a course that made you decide you wanted to go on and study more math?

Erik: There were two courses: our abstract mathematics course, in which I thought, "Whoa! There's a reason why this stuff works!" and then abstract algebra, which let me understand the uses of these proofs and let me see some beautiful mathematics.

Jeffrey Yujie Jiang (Wake Forest University, '18): I started thinking about studying math when I was in high school, and I did lots of math competitions. They were very interesting, and I enjoyed the problem solving. If I had to name a single course that made me decide to major in math, it would be organic chemistry, because that is what made me realize that biology was not for me!

Kelsey Scott (Grand Valley State University, '18): For me it built slowly, rather than coming from a specific course. As I kept taking more math classes and kept enjoying them, my interest kept growing.

DG: I am largely basing these questions on what I was asked 20 years ago, and at that time they asked us how many of our professors used computers in the classroom, and very few of us said yes. How many of you had a math professor use a computer in the classroom? *[Lots of laughs. Almost every hand raises.]* **Maybe a better question is: How do your professors use technology in your math courses?**

Kelsey: My calculus class had a Maple component. In linear algebra we used Mathematica a lot to demonstrate linear transformations, and that was very helpful.

DG: One big difference between 1996 and 2016 is the emphasis on undergraduate research. In 1996, there were 32 posters by students at the Joint Mathematics Meetings, while now there are more than 10 times that number. Can you talk about the opportunities you have had either inside or outside the classroom to do research?

Sam: A lot of my courses had final projects where we had to write up a report on an independent topic with a partner at the end of the semester. We also have a math research course where students work with a professor on unsolved problems in additive number theory and write up their results.

Santana: At William & Mary, undergraduate research is a top priority. A lot of faculty have open problems listed on their websites. If you want to do research, it is easy to approach a faculty member and ask them about those problems. I did that twice, and both professors were eager to hang out and talk about our ideas in a casual way.

Jeffrey: We have a summer research program where hundreds of students across campus work with their

Where Are They Now?

Twenty years later, I was curious what happened to my fellow panelists. Here is what I was able to turn up about what some of them are doing now.

Teena (Conklin) Carroll—Mathematics professor at Emory-Henry College

Karen Downey—Chemistry professor at SUNY Cortland

Darren Glass—Mathematics professor at Gettysburg College

Dan Isaksen—Mathematics professor at Wayne State University

Izzy Kyle—Johns Hopkins Applied Physics Lab

Ayana Moore—Biophysicist at FHI 360, a nonprofit human development organization

Pamela Moses-Snipes—Mathematics education professor at Winston-Salem State University

Ruth Britto Pacumio—Physics professor at Trinity College Dublin

The discussion was led by two of the MAA's mathematicians in residence. Since that time, **Robert Eslinger** retired from Hendrix College where he was the Elbert L. Fausett Distinguished Professor of Mathematics. **Jon Scott** retired from Montgomery College and remains active in the MAA. ∎

Ahmad Nazeri.

professors on individual research projects. There are also a lot of classes for juniors and seniors that help you to do that.

Caryn: At Indiana Wesleyan, math majors are required to do two semesters of research, each of which includes a 15- to 20-page paper and a 30-minute presentation. I was tempted to switch my major because it sounded like a lot of work, but I am glad it was a requirement because I learned a lot and enjoyed it.

DG: What other thoughts do you have about your experiences as a math major, and what other advice might you give to students or to faculty?

Ahmad: Faculty could sometimes do a better job connecting their courses to other math courses or courses in other departments. To that end, my advice for students is to get involved with the math community and take advantage of extracurricular math activities, because that is often how you can see those connections.

Caryn: When I was taking the more abstract math courses, I would get frustrated and wonder when I would ever use it. But once I started my job, people started telling me that I knew how to approach projects well, and I would think, "There are those pure math classes at work." So, my advice to students is to not worry so much about why they are taking courses or when they will use that material.

Sam: I just did an REU [research experience for undergraduates], and it was a great experience. At our school, all math majors basically take the same courses, so it was nice to be with students from across the country with lots of different experiences and who know different stuff. It broadened my horizons.

DG: I don't want to keep you much longer, especially since it's noon and the lines at Jeni's Ice Cream are getting longer as we speak, but thank you for your time. ∎

Darren Glass is a professor of mathematics at Gettysburg College. His talk at the 1996 Joint Mathematics Meetings was about group theory and Rubik's puzzles, but now his mathematical interests tend toward algebraic geometry and graph theory.