Reflections on my summer as a
Graduate Community-Engagement Research Fellow

Summer 2021

(but written a bit later than that)

What is math good for, anyways?

If your high school was anything like mine, most kids *hated* math. Many people found the subject difficult, boring, or (worst of all) just not useful. A common complaint was *Why are we learning this? We'll never use this stuff in real life!* When pressed about it, maybe they would say math is good for things like doing taxes, or balancing a checkbook, or making measurements, etc. While all of these things are important and good to know, I believe there is so much more to math than this alone! Saying that mathematics is just arithmetic is like saying all there is to music is scales and chords.

A lot of people secretly like math, especially when it doesn't "look like math" in the way they might be used to from their high school Algebra II class. Give a child a set of colored blocks to build with, and they will happily construct symmetric or repeating patterns -- a deeply mathematical activity. In the introduction of Ramond Sullyman's logic puzzle book, he describes a letter he received from a little boy who loved this puzzle book. When Sullyman called the father (a friend of his) about it, the father said: "He is reading your book and loves it! But when you speak to him, don't let him know that what he is doing is math, because he *hates* math! If he had any idea that this is really math, he would stop reading the book immediately!"

Humans love to find and make patterns and to solve riddles, but this joy and fascination with mathematical thinking is often juxtaposed with a strong dislike of the dry techniques introduced in mathematics schooling. Even though I was considered "good at math" in elementary school, I much preferred to spend my time reading books and making art than I did playing with numbers or shapes. I did not expect to fall in love with math in college, but now (as a graduate student in math) I have a great appreciation for the beauty and creativity that the field holds. I have spent a lot of time over the past few years trying to reconcile my love of math with the common negative feelings surrounding the subject.

What surprises me most about my field is how far removed a standard mathematics curriculum is from the actual work of the professional. What I do now, as a mathematician, is nothing like what I did in my middle or high school math classes. I can't think of many other subjects where this is the case. For example, in an English class, you learn *how to do English*, i.e. how to read a book, analyze it, and communicate your thoughts with others. The technical skills like sentence structure and verb conjugation are often by-products of the lesson, not necessarily the focus. Both a 10th grader and a graduate student could be asked to read Homer's *The Odyssey* and write a conceptual essay about it (although the essays would undoubtedly be at different levels of sophistication).

Unfortunately, math curriculum does not often enjoy the same sort of art-centric approach, and instead focuses on covering a list of computational techniques and rules. And given the United States education system's emphasis on tests and grading, it's hard for me to see the standard approach changing anytime soon, except for a privileged few. But, as someone who is invested in making these sorts of changes, I try to have an impact wherever I can, whether through individual conversations, organized outreach efforts, or other projects. The project I'd like to talk about here is one I worked on in the summer of 2021, funded by the Netter Center at the University of Pennsylvania.

Academically-Based Community Service and Math 123

The goal of my summer project was to help my advisor, Dr. Mona Merling, develop curriculum for an academically-based community service (ABCS) class she teaches at Penn. This class, Math 123: Community Math Teaching Project, provides Penn undergraduates with the opportunity to design and teach math classes at a local high school. Dr. Merling taught the class for the first time in Fall 2020 (virtually) and partnered with Paul Robeson high school in West Philadelphia. The class met twice per week on Zoom; in one meeting, a team of Penn students presented their peers with a slideshow lesson they had prepared, and then in the next meeting the Penn students taught this lesson to the Robeson high school students. The class utilized Zoom breakout rooms to pair a small group of Robeson students with an even smaller group of Penn students. At the suggestion of the Robeson faculty and administration, the lessons were specifically structured around topics covered in a standardized test (the Keystone exam) that the Robeson students were required to take in the coming year: factoring, exponents/radicals, linear inequalities, graphing and solving linear equations, and quadratic equations. The Penn students broke down these larger topics (e.g. factoring) into smaller important concepts (e.g. primes and composites, greatest common denominator, least common multiple, etc.), and worked with the Robeson students, explaining the ideas and working through problems together. The hope is that these individualized sessions would help the Robeson students improve their Keystone scores, as well as boosting their confidence and engagement with math. Dr. Merling plans to teach future iterations of this course following the same model, although hopefully in-person instead of over Zoom.

Dr. Merling's course was modeled after a similar neuroscience ABCS course at Penn, called "Everyday Neuroscience," which has been taught by Dr. Lori Flanagan-Cato in partnership with Robeson for many years. In the summer of 2021, Dr. Flanagan-Cato was awarded the Penn Graduate Community-Engaged Research Mentorship (PGCERM) fellowship by the Netter Center, which is the University of Pennsylvania's main organization for community partnerships and civic engagement. This fellowship funds faculty members and their graduate student mentees to work on a community-engaged research project for 10 weeks of the summer. As part of the award, Dr. Flanagan-Cato was able to select another faculty member (that's Dr. Merling) to develop their own project, and both faculty members selected graduate students to work with. That's where I come in!

My job essentially was to help Dr. Merling enrich the already-existing curriculum. I mostly spent my time reading books, tracking down potentially helpful resources, and designing various course materials. The main book that I found which Dr. Merling and I worked with was *Mathematical Mindsets* by Jo Boaler, a professor at Stanford who is well-known for her work on innovative mathematics K-12 curriculum. In this book, Boaler advocates for a vision of mathematics education which gives students a "mathematical mindset," where they view math as a "subject of growth, and their role is to learn and think about new ideas"' (pg. 66). Her book covers topics like the importance of growth mindset, the beauty and creativity of mathematics, and how to design more equitable assessment methods and in-class activities. I was able to incorporate some of Boaler's ideas into Math 123 through various reflective assignments I designed for the Penn students. In these assignments, they would be asked to think about things like the importance of making mistakes in math or the role of technology in mathematics education. By asking students to reflect on these readings, I hope that they will be able to re-contextualize some of their own math education experiences, whether positive or negative, and see math as a beautiful and creative subject. I want them to know that math is good for more than just memorization and arithmetic, and that there is more than one way to be good at math. These reflection exercises are important to the course because they ask students to center identity (their own and their Robeson mentees') in the context of mathematics — a rare opportunity in most STEM courses.

Math 123 is a unique mathematics course because it is a math course which asks Penn students to engage with their heads, their hands, and their hearts. Additionally, it directly impacts our local community members and the next generation of students. For these reasons, and many more, Math 123 should continue to be supported by the University of Pennsylvania and the Mathematics Department. I feel very lucky to have been a part of this project and I hope that my contributions from this summer will be helpful in future iterations of the course. I believe that efforts like Math 123 are crucial to shift the perception of mathematics away from something that is difficult, useless, and "just not for me," and towards something that is fascinating, accessible, and maybe even fun.

Community-Engaged Research

This project was supported by the PGCERM, which pairs professors with graduate students and supports them in summer-long projects that are focused on local communities in West Philly. In addition to working with Dr. Merling and Dr. Flanagan-Cato, I also worked closely with Sarah Hatch, the graduate student mentored by Dr. Flanagan-Cato. Sarah's project was focused on assessing the impact of the Everyday Neuroscience course and developing tools for data analysis in future iterations of the course. It was really great to work with her because she brought a fresh perspective and many helpful tools from her background in studying education. We had a lot of great conversations about the importance of courses like Math 123 and Everyday Neuroscience, how we hoped this project might impact the role of the University of Pennsylvania in West Philly, and our own educational experiences.

One tool Sarah brought to the project which I found helpful was the theory of change. The idea of the theory of change is to start big-picture and work your way backwards to specific, actionable goals. Tougher with Dr. Merling, I developed a theory of change for each community we hoped to impact with our project (the Penn students, the Robeson students, and the broader Robeson community). For example, for the Robeson students, our long-term goals included higher Keystone exam scores, more positive outlook on mathematics, and more positive outlook on their abilities as STEM students. These long term goals determined our intermediate goals; for instance the goal of higher Keystone scores might be targeted by intermediate goals like increased comfort with Keystone topics, math self-efficacy, and math readiness. These intermediate goals are in turn met by immediate goals, for example, things like increased comfort with asking for help, increased ability to understand and communicate complex ideas, and increased problem-solving skills in the 5 main Keystone topics. I then designed specific curricula which would address the immediate goals, and thus bring us closer to our intermediate and long-term goals. By breaking down our goals using the theory of change, I was able to intentionally develop concrete plans without getting lost in abstract ideas, but at the same time there was no danger of losing the forest for the trees.

Part of the thing that is so important about the theory of change was that it is rooted in community needs; you begin by thinking about "Who is this project for, and what do I want them to get out of it?" rather than thinking about what *you* want out of the project. This harmonizes beautifully with the goals of the PGCERM fellowship. The summer projects supported by PGCERM are required to involve *community-engaged research*, which I had never heard of before this summer. The idea is that the questions that a community-engaged researcher studies, and the projects they undertake, should come from the community they are working with. Rather than an academic who sits up in their ivory tower and creates their studies in isolation (or only in consultation with other academics in other ivory towers), the community-engaged researcher is on the ground, participating in the community in a non-invasive and respectful manner. The community-engaged researcher is offering their services as an academic to the community, as opposed to the other way around.

Sarah and I were not the only graduate students working on these sorts of projects this summer. There were two other graduate students, Antoine and David, who were participating in the same fellowship but working on completely different projects. As part of the program, we met about once a month to discuss our progress on our projects and the more abstract concepts surrounding community based research. We also had the opportunity to meet with other students supported by the Provost's Graduate Academic Engagement Fellowship (PGAEF), which is like a 2-year-long version of PGCERM. In these meetings, I was impressed by how confident and competent my peers were in discussing delicate and complicated subjects. I felt very out of my depth – I've spent the last few years of my life learning about things like homotopy classes and complex integration, how am I supposed to know what I'm talking about with regards to "place-based research" and "mutually transformative projects"? Nonetheless, I learned a lot from listening to my peers and I gained a deep appreciation for the work they were doing, as well as a more well-developed understanding of my own work and my academic values.

In one of our meetings, Sarah brought up an interesting point about a tension in community-based research between the pressure to extract meaningful (i.e. publishable) data and the goal of actually doing work which services the community. This is a very real challenge for academics who want to engage in community-based research yet find themselves stuck in an academic job-market which values more traditional research methods. For this reason, many people feel they must "wait to get tenure" in order to have the security to pursue less traditional research programs. I hope that higher education moves towards a place of valuing things like community-based research in their hiring processes, so that we can pursue opportunities which have direct, positive impact on people, without worrying about jeopardizing our careers.

In the context of mathematics (or at least pure mathematics), there is the additional barrier that the overlap between community-based research and "traditional" mathematics research is pretty small. What I mean by this is that if you ask a mathematician what sort of research project they are working on, they will likely launch into some discussion about trying to study the such-and-such structure of this-or-that space, or trying to understand the moduli space of solutions to some abstract nonsense. The questions that (pure) mathematicians are trying to answer are most often not directly related to any community of human beings, besides other mathematicians. I should say that modern mathematics research *is* a social activity and there *is* some emphasis placed on service and outreach. But as with many other disciplines, these efforts are usually seen as extra and separate from "real" mathematics research. The NSF grants (or at least the GRFP) even ask for separate sections addressing "intellectual merit" and "broader impacts," illustrating how these facets of academia are often separated and compartmentalized.

I believe that service projects and other things which fall under the "broader impacts" category are essential to building a more diverse, inclusive, and equitable mathematics community. These community-engaged efforts should be just as important to a successful career as a research program. Admittedly, this is already true to some degree: to be a successful math professor (e.g. to get a tenured position) you *need* to be able to engage with your community. In most cases, people aren't going to go read your papers randomly, so it's up to you to get people excited about your research by participating in conferences, workshops, or colloquia. Collaborations are also an essential part of modern mathematics research. But these types of engagements fall within the umbrella of "traditional research" rather than the community-engaged research I learned about over the summer. Mathematicians could certainly turn their backs on community-based research since it doesn't really "fit in" with the current picture of math research. But I hope that we take this opportunity to embrace community-based research and find a way to integrate it into traditional research. I'm not saying this will be easy, and I don't even have a clear picture of what such a thing would look like. But I hope for a future of math where we value community over pure intellect, and where we center and celebrate projects which lift up communities around us, rather than relegating those projects to a separate section of our CVs.