Reflections on my summer as a PGCERM Fellow

Maxine Elena Calle

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The tl;dr Summer 2022 was my second summer working with the Netter Center as a Penn Graduate Community-Engaged Research Mentorship (PGCERM) fellow. I worked on a project together with another math graduate student, Marielle Ong, and was mentored by math Profs. Mona Merling and Yumeng Ou. Marielle and I spent the summer thinking about how to build infrastructure for math circles in West Philly, and in particular how such a program could utilize and harmonize with pre-existing partnerships and math outreach efforts at Penn.

PGCERM and Me (Take 2)

I first learned about the existence of the Netter Center last summer, in 2021, when my advisor Prof. Mona Merling invited me to be part of her PGCERM project. Our project that summer focused on developing the curriculum for her ABCS class, Math 123, and I spent a lot of time thinking about how we teach mathematics and how to combat the all-too-common perception that math is boring, difficult, and not useful. That summer was the first time I heard about community-based research (CBR), the first time I met people at the Netter Center and at Robeson High School (the partner institution for Math 123), and the first time I had a chance to reflect deeply upon my own mathematical pedagogy.

Fast forward a year later, and Mona invited me to participate in another PGCERM project, this time a joint project with Marielle Ong and Prof. Yumeng Ou focused on math circles. Marielle and I had worked together a lot before: in addition to our (small-ish) overlap in mathematical interests, we also co-organize the graduate/faculty social group for gender minorities in the math department "Penn GeMs in Math" and we co-taught a class together for the Prison Teaching Initiative in Spring 2022. I admire Marielle very much for their passion, dedication, and "get things done" attitude; I'm glad we had the chance to work together on this project. We both care deeply about efforts supporting diversity, equity, and inclusion in mathematics, and I think we both came away from this project thinking "I wish I could do more."

The 5 W's

What is our project? Our project proposed to collect resources and build infrastructure for math circles in West Philly. Initially we thought we would spend the bulk of our time collecting resources from a bunch of different sources and compiling them in some sort of data base, like a Google Drive folder. But we quickly discovered that this wouldn't be necessary, thanks to the website (which Mona pointed us to) https://mathcircles.org. So our focus shifted towards questions like *What would math circles at Penn look like?* and *What do we need to do to make math circles happen?* Most of what we ended up doing over the summer was meeting with different people, affiliated with Penn or a partner organization in West Philly (specifically Robeson High School), and trying to get a sense of what was already happening and how math circles could fit into this picture.

Something we encountered early on in these discussions was that many people didn't know what we meant by "math circles." (And why would they?) Roughly speaking, a math circle is meant to be a collaborative, friendly environment where folks can get together and explore math concepts which might

not be part of standard math curricula, usually guided by mathematicians (who can be professors, students, or even recreational enthusiasts). Typically math circles are meant to be supplemental, and are not meant to prepare its participants for anything in particular (e.g. a standardized test). I think that Marielle, Mona, Yumeng, and I – as people who have dedicated a lot of our time to studying abstract mathematics– envisioned math circles as a vehicle to expose people to the subject that we love, to show them the way we think about math and why we enjoy it so much. We especially wanted to reach people that may not otherwise have a chance to experience math in this way. This brings us to our next W:

Who is our project for? Math circles can look very different, depending on the organizers and the participants, so understanding who your target audience is very important to designing and implementing such a program. For example, is your math circle designed for math teachers, or math students? If math students, are these students who already love math / are bored in class / want to go above and beyond? Or are they students who are struggling, who maybe don't like math that much, and your goal is to show them that math can actually be fun and interesting and that they're better at it than they think they are? What age are the participants, or will you have a variety of age-groups? Do your activities need to be accessible for a variety of skill levels, or will the participants have comparable backgrounds?

For us, specifically, we knew going in that we wanted our project to serve the West Philly community, but beyond that we didn't have concrete answers to these questions. We primarily talked to people in the Robeson High School community because this was a pre-existing partnership, and one that Mona and I specifically had worked with before. Given Penn's good relationship with Robeson, it makes sense to pilot this project with them, although we hope that whatever program we implement could eventually reach students from other schools in West Philly as well.

When is the project happening? Just as there are many potential target audiences for math circles, there are also many different ways that math circles can look, logistically. For instance, will the content of each math circle be self-contained, or will there be a continuous thread over the course of several meetings? Will the meetings happen once a week? Once a month? Every day for one week? How many hours will the meetings last? And on and on. While none of these options are objectively better than any other, this is a place where community input can make a huge difference. That is, deciding when (and how often and for how long) math circles should happen is a great opportunity to find out what will best serve the community you are trying to reach, rather than making these decisions in isolation and then being surprised when no one shows up to the events you spent so much time and effort on.

Initially, we thought that it would be great to integrate math circles into pre-existing programs like Math 123 or the academic support services offered by the Moelis Access Science (MAS) fellows. However, it quickly became clear to us that this was not the way to go. The assistance provided by MAS and Math 123 is meeting a specific need: extra help in the classroom *with the pre-existing math curriculum*. Since the intention of math circles is to provide exposure to *extra*curricular math topics, we felt that it would be better to plan math circles to take place outside of school hours, so as not to take up valuable time and resources necessary for the students to succeed.

But this raises another issue: how do we incentivize students to engage with these extracurricular math circles? Some students may be interested of their own accord, but even these students may face

circumstances which make it difficult for them to participate. For example, a student might have an after-school job due to financial necessity, or they might need to provide help with childcare for their family. How can we ask these students to prioritize (or justify to their families) something as seemingly esoteric as math circles?

Taking all of this into account, Marielle and I landed on the idea of piloting math circles in the style of a summer camp, and providing students financial compensation for participating. There is precedent for this, for instance, the environmental science program which ran out of Cobbs Creek Community Environmental Center this past summer and Bard's CAMP math circles. Piloting math circles in this way would also help gauge interest in such a program without a long-term commitment (i.e. a whole semester). We could recruit math students (grad and undergrad) from Penn to help run the math circles without worrying about further overloading their already-busy schedules. In summary, summer camp seems like a great option for everyone involved.

Where is the project happening? In terms of physical location, I think this is a question which should be answered at a later time. Math has the wonderful feature that you don't often need a lot of supplies: pen and paper, a whiteboard or chalkboard, and you're good to go.

Why does the project matter? I like math. I've spent a lot of time and energy learning about math. But I recognize that this experience is not the one that many Americans have. I wrote in my reflection last year about this tension between the way that math is often taught (repetitive, dry, emphasis on memorization) and the way that I think of math (creative, conceptual, emphasis on exploration). Unfortunately, many people walk away from their educational experiences thinking that they are "just not a math person." Those students who *do* get to experience math as a creative subject often do so through specialized programs, and access to such programs typically requires some socioeconomic privilege or parental/teacher involvement. All this to say, I think this project is important because it aims to show these students a different side of math that they may not otherwise have access to. If there's a "Maslow hierarchy of needs" for (math) education, this project takes aim at the upper part of the pyramid, beyond just the foundations: we hope that having access to math circles will help students build connections, self-confidence, and the desire to become the best they can be.

Process Research

A term that I found simultaneously helpful and frustrating throughout this project was "process research." The idea of process research is that the work you're doing is not just about the end result, but also about the road you use to get there. You're carving out a path through the jungle and documenting your journey to make it easier for those that come after you. I think keeping this in mind is particularly important for community-engaged researchers since oftentimes the focus of your work is on building and sustaining partnerships, not producing papers.

However, process research is frustrating exactly for this reason: there is a notable absence of deliverables. You can spend hours (or a whole summer) working on something and come away feeling like you have nothing to show for it. I struggled with this feeling, like I wasn't "doing enough" and that I was a "waste of time and resources" that could be better spent on someone who would actually Do Something Concrete. It helped to re-frame our project as primarily one of process research, one where we were

laying the groundwork for future plans and also putting ourselves in a better position to be successful when we did start taking steps to put our plans into action.

Marielle pointed this out in their reflection, but the philosophy of process research harmonizes surprisingly well with math research. In fact, most of what you do in math *is* process research — reading papers, bettering your understanding of what's been done before and how the pieces fit together, talking to other people to try and figure things out. In the words of Fields medalist Maryam Mirzakhani, doing math research is like "being lost in a jungle and trying to use all the knowledge that you can gather to come up with some new tricks, and with some luck you might find a way out." In my opinion, this is part of what makes math so difficult, frustrating, and incredibly rewarding, and I'm sure the same can be said of community-engaged research.

A Concrete Idea

As a parting thought, I'd like to propose something that Marielle and I discussed which I think could go a long way into turning our summer research into something more tangible: creating a community-engaged graduate fellow position. The position we envisioned would be different from the current PGAEF fellowship and more like the CTL fellows whose responsibilities include running small workshops about various aspects of teaching and pedagogy. It would be great to have a similar position which focused on community-engagement efforts, such as (e.g. for the math department) math circles and Math 123, as well as other pre-existing projects like the directed reading program and the partnership with Princeton's Prison Teaching Initiative.

I think part of what makes it so difficult to get community efforts like math circles off the ground is that everyone is busy. Understandably and unfortunately busy. It's difficult to prioritize these projects that are perceived to be "extra" when you have deadlines to meet, meetings to prepare for, graduation/tenure requirements to stress about…Official (and funded!) positions would give people permission to dedicate time to these efforts and an obligation to follow through. Regardless, I hope that Penn continues to encourage its faculty and students to make use of our academic skills to have a real impact on the wider community.