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Reflections on Running an REU (With an Eye towards Equity)

Siddhi Krishna and Marissa Kawehi Loving

In summer 2021, we designed and ran our first REU. From the start, our goal was to create a positive first math research experience for students from groups historically excluded from academic mathematics. Overall, we had a wonderful time, as did our students! In this reflective piece, we pose the key questions we asked ourselves throughout the process. We hope that readers will not consider our guiding questions as prescriptive or exhaustive—they were simply what worked for us. This article, structured both chronologically and according to some major themes, is aimed at other junior faculty who are organizing REUs with marginalized students in mind.

Every REU should be welcoming to *every* student. Whether you succeed at this or not will have a significant impact on your students' perceptions of themselves as mathematicians. Because most mathematical research communities are, by default, constructed for white, cis, straight, and able-bodied men, it is essential to consciously design a space where marginalized students feel equally represented, supported, and valued. You have the power to create a program where your students have their mathematical talent and identities affirmed.

Why Are You Organizing an REU?

Before doing any organizing or planning, stop to ask yourself: *Why?* You should not be running an REU just to get a line on your CV—this is a serious long-term commitment to your students. Take the time to ask yourself: *What are you hoping to accomplish by running a summer REU? What do you hope to contribute to your REU students and their mathematical journeys?*

Thus, the first step in designing an REU is to set a goal. *Who are you trying to serve and why?* Outlining a guiding principle for your REU will pay off in the short and long term by focusing your efforts throughout the program. Our guiding intention (of providing a positive first mathematical research experience for minoritized students) shaped how we advertised, recruited, and structured our program; we discuss these aspects later in this piece.

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Your goals for the program should influence who you ask to co-organize with you. For example, to help serve students of color in a holistic way, ask and answer the following:

- Do you have the expertise and skills to effectively mentor students of color?
- Can you effectively facilitate conversations about navigating racism in mathematical spaces?
- If the answer to any of the previous questions is "no" or "I'm not sure," can you partner with someone who can supplement the gaps in your knowledge and/or skill set?

The bottom line: anyone can organize an REU that meets the needs of all of their students, *but not everyone is equipped to do so on their own* (or with the first few people that might come to mind as potential co-organizers). Be intentional about collaborating with people whose strengths complement your own. If your collaborator is bringing expertise that you do not have, defer to them and their knowledge in these areas; your time can be spent bringing value to the REU in other ways (perhaps by taking on more of the logistical aspects of organizing).

Mathematical Planning

The next step is to pick a research project for your students. The first questions to answer are: *What and how much background knowledge is expected for a student to be able to contribute to this project? Is the mathematical background required for this project consistent with the students you are aiming to recruit?* For example, if your project requires having taken advanced undergraduate courses (or even graduate courses), you are almost certainly limiting your pool of potential participants to more highly resourced students.

Here is one strategy for selecting a project: each organizer individually brainstorms potential projects, and then pitches them to their partner. By explaining the motivation, techniques needed, and possible proof strategies to each other, you can better determine the accessibility of your project and identify different entry points for students. *Are there accessible warm-up problems and exercises to establish fundamentals and intuition in the area? Are there computer programs that students can use to experiment with examples or do computations?*

Another question to ask yourself is: *How much background do the students have to learn before you can introduce them to the research problem?* The sooner you are able to introduce a problem to your students, the better. First and foremost, an REU is a research experience, not a topics course! Moreover, if your students will need to spend several weeks learning background material, then your problem may not be as accessible as you intended. This is especially important to consider with respect to the length of your program.

Indeed, these were the factors that we used to pick our REU project. Since our primary goal was to provide a first research experience in mathematics, we knew our students would have a range of exposure to college-level math (and that their undergraduate trajectories could have been disrupted by the COVID-19 pandemic). Accordingly, we made the conscious decision to expect a proofs class (or equivalent), but nothing more. Our goal was to introduce our students to their research project by the third day of the REU, and we did it!

The Application

Most REU programs in the US run applications through `MathPrograms.Org`, a service of the AMS similar in form and function to `MathJobs.Org`. This platform streamlines the REU application/selection process in many ways, but there are components which you can customize. The information you ask for, and how you ask for it, signals who you consider your default student to be (whether you like it or not!). Here are some questions to ask yourself as you decide what information to solicit in your REU's application:

- *Are you able to see the information that you care about?* For example, although `MathPrograms.Org` asks for information regarding gender, race, and ethnicity as part of their cover sheet, this information is not accessible to program directors in a disaggregated way. To view demographic information while selecting students, you can add additional demographic questions to the customizable portion of the application. These questions can be made optional, in case students prefer not to share this information as disaggregated data.
- *Do you provide inclusive options for gender, race, and ethnicity?* The framing of these questions matter! For example, providing the options "male/female/other" is a red flag as these choices conflate sex and gender. Similarly, the sole options of "woman/man" reinforces a binary view of gender, and excludes nonbinary and genderfluid students. Our application provided the following options for gender: "woman/man/non-binary/other/prefer not to say."
- *Do you include questions about whether students are first-generation college students or veterans?* To serve these groups, you first have to identify them in your applicant pool!

Make these edits to your application *before* students start submitting theirs!

Finally, be sure to have your application up-and-running well in advance (i.e., at least five weeks) of your deadline. If a student is not already preparing to apply for summer programs, a condensed timeline can make it hard to write a personal statement, prepare a resume/CV, and solicit faculty letters of recommendation.

Advertising and Recruiting

Advertising is a crucial component of running an inclusive program: you want to ensure the students who would

benefit most from your REU actually know that it exists. We had two main approaches to advertise our REU:

- Social media—We advertised in Facebook groups designed to support and share resources between folks who are marginalized in mathematics, such as the *E-mentoring Network* and the *Network for Minorities in the Mathematical Sciences*, as well as on our own personal social media accounts (Facebook, Twitter, and Instagram).
- Personal emails—We directly reached out to trusted faculty at a range of institutions who we know regularly work with students from various marginalized backgrounds, and asked them to encourage their students to apply.

In every post and email, we included a general audience description of our project, as well as the structure of the program (i.e., tentative dates, program length, stipend, and planned professional development opportunities).

Evaluating Candidates

Before reviewing applications, ask yourself: *What criteria will I use to evaluate candidates, and how do these relate back to my goal?* One important caveat: do not conflate background knowledge with potential and capacity to excel! It is a common pitfall to ask yourself, *how do I get the "best" students to participate in my REU?*, without asking yourself what "best" means! Just because a student has significant research training and/or background knowledge does *not* mean they are better suited for your REU—it only means you will need to do less teaching and training throughout your program. In other words, who gets deemed the "best" student is not a reflection of an individual student's ability, but simply a result of their previous experiences.

Interviewing students is an invaluable way to evaluate applications before sending out acceptances. You will spend a lot of time with your students, and they will spend a lot of time with each other. In particular, you are not just choosing students to advise and mentor, but also choosing a group of students who will be each other's collaborators (and hopefully friends!). Investing this time during recruiting can potentially help avoid unnecessary tension or conflicts during the program.

We received nearly 450 applications and interviewed 20 students individually, each via a 30-minute Zoom call. We provided the following interview prompts ahead of time. Not only did this relieve some stress for the students, but it also gave us the opportunity to evaluate clearly articulated responses and a more robust sense of the student's experiences and goals.

1. Please share a joyful math experience you have had.
2. Please share a story about a collaborative project you have worked on (it does not have to be math related).
3. What is the number one thing you hope to gain from this summer research experience?
4. What questions do you have for us?

After selecting the students you want to accept, ask yourself: *Have we picked a group of students in line with our original program goals?*

For our program, we holistically evaluated applications based on first-generation college student status, non-traditional academic backgrounds, and non-traditional entry to the math major, amongst other factors. We also kept in mind our goals for the demographics of our final group (for example, we did not want women to be minoritized within our group). We also looked for students who could benefit from mentorship and community external to their university, and whose career trajectory would be most impacted by joining our group.

It may take significant time and energy to build a group that satisfies your criteria and feels right—but that does not mean you should not undertake the task! For us, the process of selecting students (from reviewing applications, to hosting interviews, to sending out acceptances) took close to five weeks, and was well worth the effort. In fact, partway through the process, we reminded our colleagues that we were still actively reviewing applications. This helped ensure our pool of applicants was broad enough to help us reach our overarching goals.

Community Building

To be intentional about how you build community, ask yourself: *Who am I building a community for? How will I make sure the community is comfortable and welcoming for them?*

Building a supportive, people-centered community was a priority for us from the start, and extra attention was necessary because our REU was virtual. Before the program started, we sent out virtual welcome packets, which included a tentative schedule for the REU, a selection of popular math YouTube videos in geometric topology, some introductory (optional!) reading about our research area, and a draft of a community agreement. We hoped this would help alleviate any preprogram jitters for our students.

The community agreement was a key part of the welcome packet; it outlined our expectations for the summer, our responsibilities to each other, and our intentions to hold each other accountable for our behavior. Since this was an agreement we were entering into together, our students had the agency to add to or modify it as needed, before signing it at the end of our first day together.

It is tempting to have a community agreement to signal that your program is inclusive, welcoming, and safe. However, if you are not willing to uphold the standards of conduct you have set, then it is not fair to your students to imply that your space is safe for them when it may not be. Do not have a community agreement just because it is fashionable!

Logistics

One big logistical decision during the planning phase is the time frame. *How much time, energy, and focus can you dedicate to your summer REU?* We could commit to meeting with our students daily for six weeks, but not longer. This decision also guided our project choice—namely, we picked a project that fit within our time frame, and met our primary goal of having an accessible, hands-on project requiring minimal background. Had we instead run an eight-week program, we would have adjusted the scope of research we were hoping to accomplish. Spending less than six weeks together during the summer would have been insufficient, given our desire to build a strong community within our REU group, as well as provide adequate professional development opportunities (see more below).

How much time will you spend with your students on a daily basis? The answer likely takes into account many factors, including the modality of the REU (in-person vs. online), the time zones of your students, and the frequency of the other REU-related activities.

Not only was our REU virtual, but we were split between three time zones (from Eastern to Pacific). We set clear expectations that each student should be doing REU-related work for eight hours per weekday. However, in an attempt to combat Zoom fatigue, only five of those daily hours were blocked off as group coworking time. During this block, we would meet with the students as a group (to get updates, give short lectures, etc.), they would meet with each other (and we would check in periodically), or we would have guest visitors (see more below). Additionally, since we had two lead organizers for our group, we alternated our "on-call" days with the students. This system worked well for us: the students always had at least one mentor available to them, and our "off days" gave us the time to focus on our other responsibilities.

We used Overleaf to keep a daily log where our students, as a group, wrote entries summarizing their day and accomplishments, as well as their goals for the next day. This was one of the best practices we implemented, for a few reasons:

- Continuity: since we were alternating our "on-call" days, the daily log helped us prepare for our next time "on call."
- Organization: keeping track of where you are and where you are going is an important skill while doing research! Since our students were new to math research, the Daily Log provided great practice.
- LaTeX practice: some of our students had never used LaTeX before, so this gave them a little bit of practice every day. This was especially important because we wanted our students to write up their final results in LaTeX at the end of the summer.

After six weeks together, we had a 20-page document summarizing what happened each day, providing our students a tangible record of their accomplishments within a short timeframe.

In addition to the group interactions, each individual student had a set weekly meeting with one or both of us. This allowed us to know our students on a more personal level, while also hearing about what aspects of the REU were going well for them (or not), as well as their perspectives on their overall mathematical trajectory. These one-on-one meetings were especially crucial for a virtual REU, as serendipitous, informal chats are less frequent in the virtual setting.

From the start of the REU, we maintained files for each student of things that struck us, whether it was an elegant solution or insight into a problem, or a comment on things they value in a mathematical environment. These notes (available only to us!) have paid off: we have already written recommendation letters for each of our students.

Professional Development

While REUs are "about the math," the professional development aspects cannot be overlooked, especially when your students are from marginalized groups. It is crucial to dedicate time to the aspects of academia which are often part of the "hidden curriculum," e.g., how to build a professional network, write a personal statement, craft a title/abstract for a presentation, or communicate mathematics.

Weekly visitors were integral to our professional development. Rather than giving research talks, our visitors participated in informal discussions guided by some initial prompts, thereby minimizing their commitment of time and energy. Our visitors, who represented a range of career stages, were selected to:

1. reflect our students' identities,
2. speak honestly about their experiences in mathematics,
3. share advice for navigating academic spaces as people of color, and
4. discuss mathematics from a human perspective.

Remember: if your students belong to marginalized groups, they are likely very observant about things related to their own identity! It is not lost on them when they are the only students of color in a group, nor when they are in a group of *only* students of color (in fact, a few of our students noted how refreshing this was)! Who you choose to invite also indicates what and who you value—*who are you elevating as an expert or potential mentor to your students?* Just because you feel comfortable in a particular academic or mathematical space, does not mean your students will! Design the professional development activities with your community in mind.

In addition to questions of representation, there are also questions of expertise and experience. Most (if not all) marginalized students have faced structural barriers (such as racism, sexism, ableism, transphobia, amongst others) in academic spaces, and often do not have the opportunity to talk about these experiences within academic settings.

If they bring these experiences up, are you prepared to have that conversation? Are you prepared to acknowledge their experiences are real and damaging?

Finally, explicitly provide opportunities for unofficial professional development: a student under-supported at their home institution may not know what they are missing, what they should be asking for, or what support they should expect. For example, we explicitly offered to write our students recommendation letters for future opportunities, and provided guidance on graduate school applications and fellowship opportunities. In general, be proactive about sharing information!

Final Questions

Taking on the responsibility of running an REU can feel overwhelming—as first-time REU organizers, we certainly felt this way many times throughout the process! While our guiding questions forced us to be intentional about every decision, we know there are many questions that we likely failed to consider. Nevertheless, our care and attention to detail was affirmed after our program ended—several of our students thanked us for "creating a space where [they] did not feel like an outsider." We hope these parting questions provide some grounding for your work, regardless of where you are in the planning process: *Are you excluding the students who could use REUs the most? Are you using your power to create a space where any student can feel uplifted and affirmed?*

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The Road Less Traveled?

Lloyd Douglas

I can't say that I was always good at math. I remember as a child, my father, who had a sixth-grade education, trying to explain decimal-to-fraction conversions to my sister and me. He may as well have been speaking a foreign language. I couldn't understand what decimals had to do with fractions, much less be able to convert one to another. My father eventually got frustrated and gave up trying to explain it to us as we had no clue. However, afterwards, I didn't stop trying to figure out what he was talking about. Finally, a light went off in my head. I tried one case, and it worked. Then I tried several more and they all seemed to work, too. I learned two things from the experience. First, although I can be inspired by others, I learn better by thinking about things myself. Second, if you work hard enough, you can figure out some things—though perhaps not all.

After clearing that hurdle, I excelled in math, at least for a while. I went to an engineering high school in Brooklyn, NY, because I thought I wanted to be an engineer. To be honest, I didn't really know what that meant. My high school was very competitive. Only the top junior high school students in the city were even allowed to take the entrance exam, and only about the top 10% of those were admitted. It was here that I faced my next big math roadblock when studying plane geometry. There were these "non-math" things called theorems and proofs. "Why did I have to learn how to prove something that has already been proven," I asked myself. I struggled big time. It was a feeling similar to when my father was trying to teach us decimal-fraction conversions and just seemed completely alien to me. I made it through the semester, though, and then things returned to "normal" when the second half of plane geometry was applications of the theorems. I told myself that I was glad that I'd never have to prove a theorem again. That couldn't have been further from the truth!

In college, I wasn't sure what my major would be. I've always had broad interests and was dismayed that I had to choose one thing. I delayed the decision for as long as I could and took courses that majors would take in chemistry, German, mathematics, and physics before somehow deciding to major in math. I struggled through advanced calculus because, as the professor said, this was the course where you had to prove the theorems that you used in calculus. So, my nemesis had reared its ugly head again, but it seemed worse this time and I didn't know if I'd get through it. But something caused me to stick it out. After an exam

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