My strategies for mentoring undergraduate researchers

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By Meghan Duffy August 28, 2018

At this year's ESA meeting, I was part of an Inspire session organized by Nate Emery on "Students As Ecologists: Collaborating with Undergraduates from Scientific Question to Publication". It occurred to me that my talk would be good fodder for a blog post. So, here are (some of) my thoughts on some specific strategies for working with undergraduates in the lab. This post includes information both on types of projects that we've had undergraduates work on, as well as things that I think are important related to working with undergraduates in the lab.

Having undergraduate researchers in the lab is great for both undergraduates and their mentors. Undergraduates develop research skills, learn more about ecology, and develop close connections that make them more likely to continue on in STEM. Those close connections also mean that they know someone who can provide a strong reference in the future – that's useful no matter what they choose to do after graduating! The mentors, meanwhile, develop mentoring skills, get assistance with projects, and generally find the experience highly rewarding. I certainly love working with undergraduates in my lab, and I know my grad students, postdocs, and technicians do, too.

Originally, I thought that my ESA talk would focus on the different types of projects we have students work on. I ended up not focusing on this in the interest of time, but, since I'm not time-constrained in a blog post, here's a quick sampler:

1. **A student works side-by-side with their mentor on an existing project:** This is probably the default approach and is one that probably can be implemented the most easily. It has the benefits of having very close interactions between the mentor and mentee, and also potentially allowing the mentor to collect more data than they could otherwise. But some potential downsides are that it might not be possible for a student to reliably collect a particular kind of data without extensive training, and, in the case of a new student in the lab, there's a certain amount of risk in relying on someone you don't know well (e.g., if you need two people to collect the data, what do you do if they don't show up?)
2. **A student works on a spin off of a project that already existed, adding a new dimension:** I love this approach, since the student often feels more ownership of the project, and it can be lower risk – if something goes wrong with the student's project, the rest of the project still exists. Sometimes, this is something that is added while the main project is underway (e.g., a student might track phytoplankton dynamics in a project where someone else is already quantifying *Daphnia*-parasite dynamics) or sometimes it uses previously collected samples (e.g., using plankton samples that we collected to measure *Daphnia* density and population dynamics to quantify invertebrate predator

densities). The main downside of this approach is that not all projects lend themselves to this particular structure.

3. **A team of students work together to create a cohesive larger project**. This is also a really fun one, and is one that we used earlier in my career. We were developing a new system, and five different undergraduate researchers worked on it, each developing a different portion of it – some worked on collecting and counting field samples, some worked on figuring out how to culture it in the lab, and others did infection assays and life tables. This was a lot of fun, but is also a lot to manage and, again, not all projects will lend themselves to this sort of project.
4. **The student drives the project.** This is the honors thesis approach – maybe the student didn't come up with the project in the first place (but maybe they did!), but they are very much driving the project. This is the most rare, but also really neat. I just had a student propose a hypothesis that he came up with on his own for a phenomenon he observed, and he's now off to the races working on that as his project – it's such a cool thing to watch!

As I prepared my ESA talk, though, I realized that the sampler I just gave above wasn't really the most important part of what we do in the lab. Instead, a lot of the nuts-and-bolts things about how we work with students in the lab seemed more important. So, my talk focused on those.

Here are 9 things I think are really important related to working with undergraduate researchers in the lab:

1. **Undergraduates working in the lab are paired with a day-to-day mentor.** When I first started my lab at Georgia Tech, this was me. Now, it's almost never me, because my schedule is too fragmented to generally allow me time to work in the lab. Instead, undergraduates in the lab are paired with one or more of my graduate students, postdocs, or technicians (though I was the day-to-day mentor for one student's honors thesis this past year.) The students work very closely with their day-to-day mentor, including working out a schedule. Oftentimes they have a general weekly schedule, but then we make adjustments based on experiment needs and based on the student's schedule (e.g., if they have a big physics exam, they might work less that week and then more the following week). At first the student generally works side-by-side with their mentor, learning new skills and learning more about the project. Over time, the students work more and more independently, and, eventually, some of the students work quite independently.
2. **Students working in the lab all get research credit or paid for their work in the lab.** I do not have undergrad volunteers in the lab, because that would be creating an opportunity that some students couldn't afford, and I want to make sure that opportunities in my lab are accessible to all students.
3. **Students in the lab are almost always working on projects that already existed.** They might take it in a new direction, and often make really interesting and important observations along the way, but it's not a project they came up with from scratch. I think

that’s reasonable – it takes a long time to get into the literature enough to identify a gap that needs to be filled!

4. **We give accessible readings to introduce the system and question.** To make sure the students understand what they are doing and why they are doing it, we initially have them do some readings that explain the study system we use and that also set up the general area. We choose accessible readings, and then go through those readings carefully with the students, since reading a paper is definitely a skill!

My attempt to draw a figure related to accessible readings

5. **Students are involved in discussions about study design.** When I was an undergrad, I worked with a grad student, Cami Holtmeier, who laid out the general question and system, then asked me to design an experiment that I would want to do if time and money weren’t constraints.

Source: https://giphy.com/gifs/BillionBackRecords-get-your-billion-back-records-hr-block-5fBH6z8aMV1RbA4FaSc

We then met and discussed things and, over time, modified what I had proposed down to a feasible project. With the benefit of hindsight, I'm sure that the experiment we ended up with was one she had in mind all along. But that approach gave me the feeling of designing it myself, and helped me understand why I was doing what I was doing.

So, we aim to use an approach like that in my lab. This approach takes time – it would be a lot faster just to say "do X", but then the student wouldn't develop nearly as much as a scientist, plus I think the data collection would suffer.

6. **Students are also involved in data analysis**. Exactly how much they do depends on the student, including on their interests and how much time they have to devote to the project. Some students sit alongside their mentor while the mentor does the analyses, explaining what is going on. Others do the coding themselves in R. We lay out tasks that need to be done, then the student is allowed a set amount of time (e.g., half an hour) to try a particular task and has to email their mentor whatever they have at the end of that time. This lets them develop skills – often getting a lot further than they thought they would be able to – without getting totally stuck in a quagmire. It also leads to some amusingly named figures in my inbox (my favorites: fail.png and fail2.png).
7. **At the end of each semester, students write up what they did**. We usually use a standard IMRaD format, but sometimes we modify it if that makes more sense for a particular project. This is also a lot of work for both the mentor and mentee – we go through multiple rounds of edits with each student – but it really develops their skills and often that write up is the most detailed account I have of something that happened in the lab. Often, if I am trying to remember a specific detail about something we did a while back, the easiest way to find it is to go to the writeup by the undergraduate who worked on the project.
8. **Make sure expectations of students working in the lab are clear.** We have a website that includes important information for lab undergrads. I share this with all students when they first start in the lab. One thing that probably would be good to add would be

something related to authorship.

9. **Developing research skills and beginning to self-identify as a scientist takes a long time.** This may be obvious, but it really stands out to me based on my experience working with undergraduates over the years. Undergraduates are capable of doing really cool, really exciting research. But developing those skills and beginning to self-identify as a scientist takes a long time. A 10-week REU program is a great start, but it's not enough, particularly for students who are less likely to view themselves as scientists in the first place. A new study found "white men were most likely to report a sense of belonging whereas women of color were the least likely." They also found that a sense of belonging was influenced by interpersonal relationships, perceived competence, personal interest, and science identity and "that students from underrepresented groups are less likely to feel they belong." That's a problem because students who don't feel like they belong are more likely to leave the field. Given that, I think it's really important to think about ways to foster more sustained interactions. This is relatively easy when the student is from Michigan – ideally, they would work in my lab for several semesters. It's harder, though, if it's a student who comes from another university just for the summer. Harder, but not impossible. I have a new grant that will host students from Cal State Dominguez Hills, and where they will continue to work on the project (especially analysis of field data) during the academic year, supported by regular Skype meetings and occasional in person meetings with a postdoc in my lab. (Major thanks to Terry McGlynn for collaborating on this effort!)

Summary

Having undergraduate researchers in the lab is a lot of fun, and has lots of benefits for both the student and the mentor. With the right mentoring, undergraduate researchers are definitely capable of doing excellent, publication-quality work. Having good structures in place makes things better for everyone!