Letter to the Editor

Six Steps for Cultivating Successful Undergraduate Research

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Tell me and I forget. Teach me and I remember. Involve me and I learn.

—Benjamin Franklin

Regardless of the profession, we have all been privy to the stifled groans and witnessed the collective cringing that can occur when a well-meaning colleague or enterprising student asks: "Do you need an intern/summer research assistant/student worker?"

It can be true that mentoring undergraduate projects can be quite the undertaking, but with the proper groundwork, appropriate goals, and clear communication, taking on a mentorship role does not need to be more work than its worth. Instead, it could be argued that successful undergraduate research can benefit an entire academic department, from undergrads to post-docs to faculty, and even the field and community at large.

Researchers at Standard Research Institute International surveyed nearly 15,000 respondents (undergraduates and faculty) between 2003 and 2005 regarding their experiences with undergraduate research opportunities (UROs) in both the sciences and humanities, and found a direct correlation between a student's URO experience and the likelihood that they would pursue an advanced degree. Among the STEM undergraduates surveyed, it was found that undergrads who had participated in an URO demonstrated an increased "understanding, confidence, and awareness," were more interested in pursuing a STEM-related career, and were more likely to express a previously unrecognized interest in obtaining a PhD (Russell et al. 2007).

Furthermore, gone are the days when undergraduate research projects are the sole purview small schools in need of research assistants to help bolster the manpower of a faculty stretched thin in pursuit of publishing credits. Many students are actively seeking out these experiences to develop hands-on,

Reed, D.. 2018. Six Steps for Cultivating Successful Undergraduate Research. Bull Ecol Soc Am 00(0):e01453. https://doi.org/10.1002/bes2.1453

concrete research and data-collection skills, and increase their competitive edge in the post-collegiate job market or as graduate-school applicants (Hansen et al. 2018). Also, countless institutions are now requiring a field component or some demonstration of a practical application of skills such as an internship or research assistantship as a perquisite to a bachelor's degree. And of course, all of this fits under National Science Foundation's Broader Impacts section (NSF 2007).

Knowledge that a student's primary motivation for seeking out a research project in your laboratory might be fulfillment of a distribution requirement should not deter you from taking their interest seriously, however; nor should a major that does not fit neatly in your exact sub-field. Remember, despite what your C.V. might currently state to the contrary, once upon a time you had nothing but a list of relevant coursework and a few scattered examples of leadership. Do not be afraid to take a risk on an undergrad with more excitement than skills. Keep this in mind during the interview and hiring phases: Hard skills can be taught; enthusiasm and genuine curiosity cannot. It helps, of course, if an undergraduate comes to you with strong communication skills, but the finer points of professional etiquette are something that can be cultivated quickly with involved and attentive mentorship.

Moreover, prioritizing a departmental commitment to supporting and mentoring undergraduate research not only deepens the bench, so to speak, but can also further efforts to diversify STEM departments by increasing opportunities for students from historically underrepresented demographics. SRI's research found that all students—regardless of race, gender, or other identifying demographics—benefited from having a variety of mentors from a variety of demographics (Russell et al. 2007). Additional far-reaching benefits are an increase in general scientific literacy for those who decline to pursue further scientific education (Reed and Lyford 2014).

Whether you are newly considering working with undergrads or want to reinforce an existing program of undergraduate scientific research, here are several key points to keep in mind to ensure the success of your (and your undergraduate's) endeavors:

1) Start strong: jointly design clear, established goals and metrics for feedback (that advance *their* careers)

Working together to establish project goals prior to conducting work sets your undergraduate researcher up for success and lays the groundwork for an expectation of clear communication and tangible results. Set up times for regular check-ins and measurements, and include them in departmental communications and discussions.

Goals can be a mix of skills, end products (like posters or a manuscript for peer review), experiences, and a very strong letter of recommendation for their next career step.

A word of caution: For-credit projects are valuable, and, as we previously mentioned, sometimes required, but be careful of volunteer positions that have raised concern in ecology/wildlife fields (Fournier and Bond 2015).

And keep in mind that not everyone is excited about your work as you are, being able to do real science as a real scientist can be just as exciting as the specifics of your sub-field. Focus on broad,

demonstrable, and transferable skills—and make sure your student knows how to communicate the value of those skills to future employers.

2) Put yourself in their shoes (acknowledge limitations)

Undergraduates will very likely have different time constraints than other laboratory members.

Sometimes this will be a great benefit—they will be able to run time-sensitive samples in the laboratory without having to run to the next meeting, or during a summer research experience, they could even be in the office more than you. That is great, but a project will have to contend with classes and extracurriculars once the semester commences; many students have familial responsibilities or need to maintain non-academic employment in order to support themselves.

Remember this is just as much an experience for the undergraduate as it is their job. After they run those time-sensitive samples, kick them out of the laboratory from time to time and have them explore the local area. Ask around in colleagues' laboratories to see if they need help with any short-term, labor-intensive laboratory or field work to give your undergraduate researchers a change of pace, as well as experience-rounding exposure to other types of science and research methodology.

3) Treat all students like colleagues

> *Treat people as if they were what they ought to be and you help them become what they are capable of becoming.*
>
> *—Goethe*

Start with the idea that they will produce meaningful science, and convey that belief to them in the strongest possible terms. Find a small project that you have been meaning to work on that will lead somewhere, and stress to the student its significance and importance to the larger picture, while emphasizing that you expect them to take full ownership of the project.

An undergraduate researcher is not a field or laboratory technician. While data cannot enter itself, avoid having busy work comprise the bulk of the student's experience. Undergraduates should be working on a research project of their own, not cleaning the laboratory.

4) Actively mentor students

In a study conducted by researchers at the University of California-Davis, the results of which were published in the Journal of College Science Teaching, undergraduates reported that the quality of their mentor was the number one determination in their satisfaction with an undergraduate research experiences (Shellito et al. 2001).

Small issues (for you) can quickly slow or block progress for a new learner. Something as simple as how to find equipment in the laboratory or a few lines of code (that you have written dozens of times) can be worked out in a meeting that lasts just a few minutes. Schedule multiple meetings a week and work on issues together; ask them what they specifically want to get done before the next meeting.

According to Russell et al. (2007), "Respondent comments, as well as other research, suggest that mentors who are able to combine enthusiasm with interpersonal, organizational, and research skills play a large role in facilitating positive outcomes."

Be an active role model and mentor, to all genders, races, ages, and socioeconomic backgrounds (Lockwood et al. 2013). The future makeup of ecologists is up to us (Armstrong et al. 2007, Martin 2012).

5) Be willing to put in a little extra

While ownership of their project should fall squarely on the shoulders of the undergraduate, time is a finite resource, and at some point your student will go back to their regularly scheduled lives (and class schedule). Be willing to keep the project going with most of the momentum coming from you, and follow-up with the student with updates regarding the research in a true collegial fashion, treating them as you would a departed colleague.

6) Give undergraduates the opportunity to be first author

This scientist's first authored paper will be much more meaningful than your *n*th line on your C.V. For mentors on the job market, being able to promote your work with undergraduates in a cover letter—especially manuscripts written by undergraduates who were working under your guidance—might be a lot more valuable then you realize (Burks and Chumchal 2009).

Acknowledgments

I would like to thank the multiple advisors that have encouraged me to work with undergraduate students during my career and have allowed me to grow my own mentoring style, including Brent Ewers, Ankur Desai, and Jiquan Chen. I would also like to thank Lynn Vollbrecht for editing this paper and Yost R. for assisting with the plethora of undergraduate researchers.

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