

# K–12 science education and “broader impacts”



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Most federal granting agencies, including the National Science Foundation (NSF), require that research proposals satisfy “broader impacts” criteria in addition to having scientific merit. Broader impacts can generally be defined as the benefit the research may have to society. While the NSF website lists examples of broader impacts, a scientist interested in obtaining grant support may feel like a deer caught in the headlights when it comes to “disseminating effective models and pedagogic approaches to science” ([www.nsf.gov/pubs/gpg/broaderimpacts.pdf](http://www.nsf.gov/pubs/gpg/broaderimpacts.pdf)). Here, we share our collective experience of working in kindergarten through 12th grade (K–12) classrooms as NSF Graduate Teaching Fellows, and offer suggestions appropriate for any graduate student or researcher for designing and implementing a broader impacts program focused on K–12 education. We propose a bottom-up approach with three easy-to-follow steps:

**Step 1: Make contact.** Brainstorm what type of K–12 setting would best complement your research goals and select a school with courses in your area of expertise. For instance, HLS located local high schools that wanted to integrate more marine science into their curriculum – a perfect fit with her research on algae and deep-water corals. It is important to seek out good teachers – the quality of your broader impacts will depend on their investment of time and energy. Recognize that finding appropriate teachers in a supportive environment can be challenging. Consult with education specialists at your university or your local science teachers association (see [www.nsta.org/about/collaboration/chapters/#chapterlist](http://www.nsta.org/about/collaboration/chapters/#chapterlist)), or integrate your work with an existing K–12 outreach program. The National Academy of Sciences website has additional advice on securing partnerships, as well as information about your role in the classroom ([www.nas.edu/rise/roles.html](http://www.nas.edu/rise/roles.html)). Once you find suitable “teacher partners”, be gracious and appreciative of their voluntary contributions. Remember also that your teaching partners are professionally trained in effective pedagogy and can help you improve your own teaching skills.

**Step 2: Get it in writing.** Once you have identified a classroom and teacher, be creative and design a program that excites you and relates to your research interests and

expertise. Work with the teacher to develop objectives, lessons, activities, and measurable outcomes that satisfy the teacher’s instructional goals. Pay particular attention to meeting state standards and benchmarks that most public school systems require – helping teachers meet these will make your efforts more relevant over the long term. Determine a realistic timeline for the program and decide how much time you can commit to this project. It’s critical to outline roles and responsibilities for you and your partner teachers.

Calculate the amount of funding required, including supplies, substitute teacher costs, and transportation. Obtain letters of support from teachers or principals; you may need these for grant proposals. Be patient throughout this process, and write thank-you letters to individuals who have helped you. Before the start of your program, decide how you will evaluate its success and, if available, consult with a professional evaluator through your university. Possible evaluation tools include student surveys at the beginning and end of your program, lesson worksheets, or products (lab reports, essays, display boards, dioramas, video presentations, etc) created during the program. These measureable results should be useful in grant reporting, will help you design more effective programs in the future, and (with proper analysis) may be publishable (see Baumgartner and Zabin 2006).

**Step 3: Teaching science to K–12 (and beyond).** At this point, you have designed and been funded for a wonderful broader impacts program for your research, and you are ready to hit the classroom. However, science in K–12 courses needs to be taught differently than in college; a “top-down” lecturing approach will not work effectively with young people. We advocate that you engage both students and teachers in inquiry-based, hands-on projects. Inquiry-based science education involves teaching science as it is practiced, where the process of discovery is as important as the answer (Young 1997). In doing so, students become scientists themselves, rather than simply learning what scientists have done in the past. For example, instead of simply lecturing on land use and water quality, AG engaged students by having them build watershed models and develop and test their own hypotheses. Because the activity was hands-on and inquiries were student-generated, AG found that the children retained and expanded on this information throughout the school year. It is also a good idea to use place-based learning; emphasize local issues that students care about. One of the most effective ways to teach students about ecology is by taking them outdoors to study pressing issues in local habitats (Hamilton-Ekeke 2007). Just as you should be getting out in the field as much as possible (Nuñez *et al.* 2008), so should K–12 students.

Another approach to consider is involving students directly in ongoing research investigations. This forms a two-way street, with both the student and researcher benefiting from the experience (Handler and Duncan 2006). Depending on the complexity of the research, data quality issues may be a concern. However, Osborn *et al.* (2005) and Cox and Philippoff (2008) found, for example, that when ecological monitoring was performed both by high-school students and professional researchers, the student data were highly reliable for conspicuous and relatively “easy-to-identify” organisms.

To better ensure the sustainability of your program, develop projects and lessons that teachers can implement in your absence. Post PDFs of your lessons and highlights of your broader impacts program on your department’s and partner school’s websites (if available). When writing your next grant proposal, you can direct reviewers to these websites as an example of your work. Our final advice is to have fun! Our own experiences with this type of activity have taught us innovative ways of thinking about our research, helped us further develop effective communication skills, and provided opportunities for local educators and students to improve their scientific literacy and unleash their scientific curiosity. Attempting to teach your research topic to a class of second-graders can be challenging, but criteria requiring broader impacts were developed to provide the public with more information about what scientists are doing and to force scientists to think more carefully about the ways in which their work affects society (APS News 2007). Designing and implementing a K–12 broader impacts program will require time, but the payoff is worth it. As a result, you will become more positively engaged in science education (Gibson and Chase 2002) and your teacher partners will better understand the real-world applications of the subject matter they teach. Ultimately, with a strong broader impacts program, you will likely be a stronger grant writer, researcher, and educator.

## Faculty response



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Ecological literacy represents a central element of the intellectual capital of any country. Ecology provides fundamental knowledge to understand the living world and, given the implications of anthropogenically driven environmental change, an understanding of ecology among sectors of society beyond scientists is essential, so policy and societal opin-

ion are ideally based on the best available knowledge. Ecological science’s findings, perspectives, and relevance to the human enterprise need to be better appreciated by K–12 teachers and students, as suggested by Spalding *et al.* Their article strongly resonates with our estimation of the need to engage research universities in partnerships with K–12 students and teachers, working collaboratively with science faculty and students.

Spalding *et al.* present recommendations for graduate students to engage in K–12 education, and we suggest that such engagement can be applicable for *undergraduates* as well. They recommend, as a first step, identifying schools with courses in the graduate student’s area of expertise. We propose that graduate students can also identify and encourage potentially interested faculty to develop suitable programs with them.

We agree that science in K–12 settings needs to be taught differently and advocate, in particular, the value of hands-on learning by doing and that the “doing” be actual research – prioritizing student discovery of general principles over lecture-based classes and the memorizing of large numbers of facts that may prevent them from *enjoying* science. Spalding *et al.*’s recommendation of involving K–12 students directly in graduate student or faculty ongoing research is appropriate in some circumstances, but may be problematic in others. We encourage the approach of designing research projects specifically tailored to the educational program. In our program (“Ecology: Learning by Doing” – <http://news-service.stanford.edu/news/2009/february25/redwood-022509.html>), we use the small creek on the premises of Redwood High School in Redwood City, CA, to engage students in a stream restoration project, making research the guiding principle of the restoration plan. We complement this with visits to research sites (eg Stanford’s Jasper Ridge Biological Preserve), where students and teachers are exposed to ongoing research.

As suggested by Spalding *et al.*, nature is the best ecology laboratory. Prioritizing hands-on, outdoor learning also helps address the “nature-deficiency” syndrome we increasingly see among K–12 students and teachers. The use of place-based learning can be supplemented with discussions of local environmental issues and, certainly, with discussions of local–global environmental interconnections.

We welcome Spalding *et al.*’s enthusiasm for promoting the multiple benefits that graduate students may achieve through K–12 education, but insist that this can be equally rewarding for undergraduates and faculty. University students and researchers would thus fittingly justify the broader impacts statement typically required in research proposals and would help address the need to improve K–12 science education and ecological literacy.

## References

For a list of citations, please see WebPanel 1.