AC 2009-545: DESIGNING EFFECTIVE EDUCATIONAL INITIATIVES FOR GRANT PROPOSALS

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Designing Effective Educational Initiatives for Grant Proposals

Abstract

The National Science Foundation requires that grantees make an effort to extend the reach of academic research to communities beyond the laboratory and address the work's possible "Broader Impacts" to society. NSF CAREER awards and many of the NSF Research Center grant solicitations are even more explicit, requiring that grantees craft educational initiatives that are based in best practices, bring the academic research to the broader community, and positively impact the pipeline of students pursuing science, technology, engineering and mathematics (STEM) education and careers. For new faculty, and even veteran faculty, these requirements for creative educational initiatives that significantly affect a community outside the confines of the laboratory can be very daunting. This paper addresses how to design an effective educational plan that incorporates undergraduate and graduate education or K-12 educational outreach and that will have a real impact on the target audience. It also gives advice, from the point of view of a former college president and NSF officer, about issues of the reward system in general, promotion and tenure at different types of higher education institutions in particular, and how these differing standards should be taken into account as one decides how much and what type of educational initiative should prudently be undertaken.

Introduction

In 1990 Earnest Boyer published a seminal work[1] that enlarged the perspective of "research" by calling it "scholarship", and describing it in terms of four overlapping descriptors: the scholarship of discovery (research), the scholarship of teaching, the scholarship of integration (putting ideas together through the use of multiple lenses, viewing specialties in larger contexts, or connecting across ideas and disciplines), and the scholarship of application. The Scholarship of Teaching was later changed to be the Scholarship of Teaching and Learning (SOTL), and the last category was later broadened by Boyer to include the scholarship of engagement and service (originally outreach)[2]. By the mid 1990's, the National Science Foundation had implemented a "broader impacts" criterion to research grant proposals, requiring that scientists and engineers applying for research funds think carefully about, and describe, the ways in which their work might impact society, and that they design education and outreach plans to enhance this impact. Essentially, NSF promoted the ideas of scholarships of teaching and learning, engagement and service by tying research (discovery) grant support directly to these criteria.

Though the broader impacts criterion is still controversial in some arenas[3], the Carnegie Foundation for the Advancement of Teaching, which categorizes higher education institutions, now has an elective category designating "Institutions of Engagement and Service", and has selected 195 colleges and universities for its Community Engagement Classification[4], including such research intensive universities as Duke, Purdue, and the University of Michigan. Educational and outreach initiatives developed through NSF grants also promote the type of engagement by science and engineering professionals called for by the National Academies of Engineering and Science[5] to improve our educational pipeline of students into science,

technology, engineering and mathematics (STEM) and by extension, our national competitiveness. Even very modest education and outreach plans can play an important role by impacting the career aspirations of the next generation. However, it is critical that STEM researchers craft these plans in ways that make efficient use of their time, that don't disrupt their regular research operations, and that have a real impact on the targeted communities. The advice in this paper addresses these concerns and is drawn from the direct experience by research faculty in designing and implementing education and outreach plans.

Broader Impacts Criterion: What is it?

The NSF website provides the following questions to help prospective grantees evaluate their proposal in terms of broader impacts[6]:

What are the broader impacts of the proposed activity?

1. How well does the activity advance discovery and understanding while promoting teaching, training and learning?
2. How well does the proposed activity broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic, etc.)?
3. To what extent will it enhance the infrastructure for research and education, such as facilities, instrumentation, networks and partnerships?
4. Will the results be disseminated broadly to enhance scientific and technological understanding?
5. What may be the benefits of the proposed activity to society?

These questions are intentionally vague to encourage creativity and a wide range of initiatives. An effective educational plan builds upon the strengths and interests of the faculty member, makes use of existing resources and infrastructure at the university, is rooted in real educational need, minimizes the amount of time spent on administrative and other non-STEM tasks, and positively impacts the educator's chance of being promoted and tenured. Centers for Teaching and Learning and K-12 Outreach Centers, both present at many institutions, can often provide assistance with the research design, assessment metrics and background literature, as well as with forging connections to schools and aligning university research with state and national K-12 educational standards. This leads to Recommendation #1:

Recommendation #1—Locate the resources, infrastructure, and programs already in place at your institution, and make use of them.

It is far easier to design an educational plan by tapping into the knowledge base accumulated by an education professional, and by plugging into existing programs, than by starting something from scratch. If there are people at your institution whose duties include improving teaching and learning on campus, expanding the diversity of the STEM student body, or connecting with K-12 education or the local community, talk to them about participating in one of their programs and ask them to provide you with a letter of collaboration. Educational plans do not necessarily need to be new and "out of the box". It is much more important that they are realistic and effective.

Recommendation #2—**Define your audience.**

Typical audiences are:

- **Higher Education**: Postdoctoral fellows, graduate students, and/or undergraduate students
- **K-12 Outreach**: Students (elementary school, middle school, high school) and/or teachers, and occasionally policy makers (e.g. the state Department of Education)
- **Informal Science**: The general public, through museums, zoos, media broadcasts, websites, etc.

Whichever general audience you choose, it is always best to target your interventions in some ways towards groups underrepresented in STEM—namely minorities, females, low income students, people with disabilities, etc. This does not mean that you should exclude all others, just that the project should have plans about how to promote involvement by people from underrepresented groups.

When creating your plan, it is important that you decide where your passions lie and with which audience you are most comfortable working. If rowdy middle school students make you nervous, don't plan on working with them. If you have elementary school children of your own and you are interested in aligning your educational initiative with your volunteer work at your local school, by all means do so. The project, however, should not be focused (only) on your children or their classroom. Teachers and school administrators are savvy to the difference between someone who is willing to help in the school while their child is enrolled there, and the individual who is in the schools to address the general needs of the school, its students, and the curriculum for the long haul. If, on the other hand, you most enjoy working with undergraduate students and are concerned about the low numbers of women and minorities, then design a plan that targets this group. There are needs at all levels. Don't feel obligated to work with a particular group if you aren't comfortable with it.

Recommendation #3—**Decide how extensive you want your program to be.**

Different types of grants have different types of educational requirements. NSF CAREER awards and large research centers generally require more extensive educational plans than do other types of research grants. Given the type of grant you are writing, decide what type of end result you are looking for, and whether journal articles in this domain are important to you. As much as possible, create an educational plan that allows you to pursue activities that you are genuinely interested and excited about. Otherwise they won't get done.

There are three ways that faculty and STEM researchers can approach their educational initiatives:

As a <u>Program</u>: This is a pragmatic approach of providing an intervention to satisfy an educational need. The basic process for this is to:

1. Identify the audience and need
2. Do some background research on other programs of this type
3. Design the program
4. Advertise the program

5. Run the program
6. Assess the success of the program
7. Repeat with improvements built in.
8. Possibly extend to additional audiences.

You will most likely want to partner with others to do some of these steps (especially the administrative ones--see Recommendation #1.). Programs are usually designed to impact an audience, often in ways that are difficult to quantify but that can be very effective and personally satisfying. There is very little scholarly activity related to this approach, though you might be able to present the results at a conference such as ASEE if you do a good job with the assessment and related data collection and analysis.

As <u>Action Research</u>. This is similar to the program approach except that it includes the following steps:

1. Define specific goals and objectives for the intervention,
2. Create some hypotheses about the likely outcomes,
3. Communicate with your Institutional Review Board (IRB)
4. Collect baseline data at the onset,
5. Collect and analyze data at the conclusion of the program,
6. Draw conclusions about whether the hypotheses were true, and the expectations met.

These types of projects can be written up and published in a variety of Scholarship of Teaching and Learning (SoTL) journals, such as those listed in the appendix. At some teaching intensive colleges and universities, these publications "count" towards the scholarship component of Promotion and Tenure review. It is often not overly difficult to move a Program into the Action Research category. However it does require forethought and planning to create the hypothesis and collect the necessary baseline data, and probably will require that you communicate with your Institutional Review Board (IRB) about human subjects in research and about your data collection protocol. Without IRB approval, no data may be published about the study. IRB approval is quite important and necessary but can be daunting. Talking with someone who has done an IRB request or who is an education researcher is very helpful for this complicated process (see Recommendation #1 again).

As rigorous <u>Educational Research Project</u>. These types of projects require that you:

1. Conduct a true background literature review
2. Set the problem into a theoretical context
3. Communicate with your Institutional Review Board (IRB)
4. Collect rigorous baseline and summative data
5. Study how the results can be extended beyond the local setting.

It is strongly advised for this type of project that you partner with researchers from other education or social science-related areas to assist with the actual research. These results can be published in scholarly journals such as the *Journal of Engineering Education* (JEE), and may even count towards promotion and tenure at some research intensive universities.

Recommendation #4—Identify and document a need.

Identify a need in your target audience that matches with your scholarly interests and expertise. This can be related to content, process, or background, and should be documented with a literature review. You would not start out on a technical research project without doing one – don't skip this step here either. Your campus teaching and learning center or library can assist you with this important step. On the K-12 level, most states now have "report cards" available online that provide ample data to document weaknesses in STEM education in all school systems and even individual schools.

Ensure that your identified need matches the strategic plans of the people involved with your target audience. In higher education, this means ensuring that the department or unit that houses the initiative supports the goals of the project. In K-12 and Informal Science, it means communicating from the beginning with the educators at the school, school system, or museum where you plan to work to make sure that your plans align with their perception of needs and goals. It is critical to secure support from the relevant administrators.

In the K-12 arena, it is also important to align your plans with the curriculum and educational standards that the schools are expected to teach. If the content that you want to share is unrelated to what a teacher is expected to teach, then he or she will probably not implement it in their regular class. It might still be appropriate for an after-school club or summer enrichment camp, or for a special topics class in high school or a "discovery" or "connections" class in middle school. A good place to start for assessing what K-12 students are expected to learn is the National Research Council's *National Science Education Standards*[7], the American Association for the Advancement of Science's *Benchmarks for Science Literacy*[8], and the National Council of Teachers of Mathematics standards[9]. Many states also have their own set of standards that you can usually identify online. Having read the state standards for math or science before talking with teachers will increase your credibility and believability significantly.

Recommendation #5—Identify partners to work with, and nurture the partnership.

Educational work is rarely a lone pursuit. In the K-12 arena, you will need to partner with the individuals at the school (or school district or museum, etc.) where you will implement your initiative. It is important that this is a true partnership – most K-12 educators are leery of higher education faculty who appear to want to ride in on their white horse to solve all of the school's problems, or who come across as thinking they know all the solutions to education's ills. It is important that the members of the partnership believe that all who teach, whether university faculty or K-12 teachers, deserve respect for their expertise. It works much better to work up front to understand what the real issues are on the ground and how your background and content can help to address these issues in concert with the teachers. Again, as mentioned in the first recommendation, getting to know your campus' outreach resource people will help – often they already have relationships with the local schools and informal educational organizations. In higher education plans, it is just as important to find partners for your work. Your new course, or module, or lab experience will not be offered in a vacuum. You will have a better chance of success if you build your initiative in partnership with the other faculty who teach in your discipline.

Another important type of partner is the one who has complementary skills. You are an expert in your domain, and you are not expected to be an expert in educational research, course design, outreach, or educational assessment. Find one or two people who have the skills that are needed to ensure success in your project and add them to your team. If you can, locate faculty for whom these areas are their scholarly discipline. They might be interested in partnering with you for their own gain since your project could provide them with an authentic setting for their own research agenda.

Recommendation #6—Explain your educational initiative thoroughly in your proposal.

For many educational initiatives, you should follow the process laid out by Wiggins and McTighe in "Understanding by Design"[10] by specifying:

(a) What are the outcomes you want to achieve?
(b) How will success in these outcomes be measured?
(c) What experiences will facilitate this student success?

In your proposal, you should answer the basic "5W's and an H" of any good news article:

- **Who**: Who is the intended audience of your new initiative? Be as specific as you can be: What level students or teachers? In what disciplines? With what backgrounds (including demographics where possible).
- **What:** What content and/or skills is your initiative going to deliver? Again, be as specific as you can and include how this relates to your research project, and how it fits into existing curriculum and programs at your institution or in the school system.
- **Where**: Where will your work be carried out? Will it be on your campus? In your department? At a school or museum?
- **When**: Give a timeline of design, development, implementation, assessment, and improvements.
- **Why:** Include a literature review that shows the need for this work. What gaps are you filling with this initiative? Show that you know what others have done and whether that applies to your setting. This is often the weakest part of the educational component of grants.
- **How:** How are you going to do your work? Include your partners, where you will be getting assistance and who you will be collaborating with including centers on campus, names of teachers, etc.

Recommendation #7—Seek out and listen to advice from colleagues who have received grant support, participated in NSF study sections or panels, etc.

Below is advice about proposals from three sources: campus collaborators, successful NSF CAREER grant recipients, and NSF reviewers.

<u>Re: Higher Education Departmental support</u>

"There are two central questions the reviewers will be asking when reading the educational plan – (1) Is this needed? and (2) Will it succeed? Therefore, it is vital that the proposer has made it clear that there is a gap between what is currently offered and what is the current

state of the art in the field, or that there are skills (cognitive or research process related) that the students are lacking, etc. Further, filling this gap must be in the strategic best interest of the department. Every department can not teach everything in the related fields. Prioritization decisions are made regularly and the identified gap might be there intentionally. Therefore, it is imperative that the Principal Investigator has had the necessary discussions with the department head and/or dean about the proposed educational initiative and confirmed that it is indeed strategically aligned with the direction that the department is headed. This must then be communicated clearly to the reviewers."

Re: Literature review

"Reviewers were impressed that my educational plan had references/citation to justify what I wanted to do. My literature search largely involved searching the abstract databases of a few publications (JEE abstract database on ASEE site, IEEE Xplore for IEEE Trans. on Education, Advances in Physiological Education) to answer a simple question researchers ask when writing the research part of their proposal: What do we know? What has been done? Where are there unresolved issues?

I've served on several CAREER review panels, and most of the researchers have no familiarity with the educational literature; there are also few educational plans that are full of citations justifying rationale and methods. So I've seen this from the panelist side too - it sounds absurd, but attempting to create a well referenced educational plan conveys a positive impression. A lot of educational plans will cite facts and statistics from educational reports to make an argument, but adding a peer-reviewed aspect is more compelling. So the take home lesson is for the grant writer to treat it like a research project, not a side project."

Re: Project Focus

"I think that my plan being fairly specific may have helped me get the career grant. It is important not to promise the world or to spread yourself too thin – only propose a focused and doable project that the reviewers will have confidence that you can succeed at."

Re: Flexibility

"My educational plan sounded good on paper, but was actually not as well executed as I would have liked. This is due in part to the fact that it was tied to certain kind of courses, but I wound up not teaching those courses due to changes in circumstances [he received an administrative post that changed his time priorities]. *The good news is that, like any good research project, I was flexible and applied the goal of the plan to the development of a new graduate course. So in the end, while I did not execute the education plan as intended, the approach I outlined was ultimately useful in creating a new course that required some of the discussion concepts I had tested in earlier courses."*

Re: Campus resources

"The education-related comment from my reviews was (paraphrased) that I did a very good job of building on current initiatives at my institution for my education component, so I would recommend doing this for anyone who is writing such a proposal. I had letters from programs and centers who I would be partnering with, and individual professors whose classes I was going to use to test my educational materials, so I think it was obvious that I

had thought out how my materials would further improve programs/classes already going on here. In this vein, although not a part of my original proposal, I have actually taken advantage of our department's teaching fellows program to pair with a graduate student for this academic year to design the curricular materials I proposed in my CAREER award and she and I will be classroom testing them in my undergraduate course this semester. This way, the undergrads benefit from the discussion surrounding these case studies, the graduate student has had an opportunity to improve her teaching portfolio, and I have had to devote less time than I had originally planned in developing the written documents. I would highly encourage young faculty to take advantage of things like this so that they can still produce creative education plans/materials without sacrificing large amounts of time from their research endeavors, which are, in many cases, crucial to promotion and tenure."

Recommendation #8—Read examples of successful proposals.

Ask your colleagues if they will share examples of successful grants. In the appendix is included an example of a successful K-12 outreach NSF CAREER educational plan, with identifiers removed, plus reviewer comments.

Recommendation #9—Be cognizant of the reward system at your university.

There is sometimes an uncomfortable relationship, both at a macro and micro level, between the standard university reward system and the requirement for faculty to engage in educational initiatives. These differing expectations beg the question: What are the possible consequences of pursuing educational initiatives in addition to your research agenda? Are there ways to address these issues and concerns? The answers to these questions depend very much on what type of scholarship is valued at your particular university. Even that is often difficult to assess, as it involves formal stated policies, the vagaries of committee decision making, and general faculty attitudes. However, typically, faculty at research intensive universities face more questions regarding the wisdom of investing time in educational initiatives than do faculty at a regional university or liberal arts college. The latter are generally far more receptive to educational initiatives than are research intensive universities.

The mission statement of your institution is a natural first place to look for the official, stated way in which your institution values educational initiatives and academic outreach. However, even these statements can be ambiguous and subject to interpretation, as in one that states "[Our mission] *is achieved through educational excellence, innovative research, and outreach* ***in selected areas of endeavor***." [Bold added.] Though there may be formal university policies that promote engagement and service, the real evidence of the dedication of the institution to education and outreach is revealed by the many faculty judgments that occur concerning promotion, tenure, and other rewards. Regrettably, at many institutions the formal policy and the decisions that are made by committees are often out of synch.

The Carnegie Foundation for the Advancement of Teaching defines Outreach and Partnerships as "*two different but related approaches to community engagement. The first focuses on the application and provision of institutional resources for community use with benefits to both*

campus and community." In terms of the reward structure, however, Carnegie Consulting Scholar Amy Driscoll, who directs the Community Engagement Classification process for the Foundation, states:

> "*With regard to faculty rewards for roles in community engagement and community-based achievements, there seems to have been little change from last year's applications. We continued to see that few institutions described promotion and tenure policies that recognize and reward the scholarship associated with community engagement. It's often considered in a broad category of either campus-based or discipline-based service. So, despite excellent and extensive examples of faculty scholarship related to both curricular engagement and outreach and partnerships, there is still work to be done.*"[11]

There are clearly a number of institutions that want to be labeled an "institution of engagement" in the Carnegie sense. Our concern is whether the label actually includes a reformation of the reward system for faculty who participate in extensive educational initiatives and outreach.

If the promotion and tenure structure doesn't reward educational initiatives, why would an engineering faculty member get involved in such endeavors? What are the consequences of pursuing such a course? Perhaps simplistically, there are three common motivators. One is that some grant competitions demand educational initiatives (i.e. the "broader impacts criterion" of NSF), and since procuring grants is something that is rewarded in promotion and tenure, the engineer does what is required to get the grant. A second reason is that some people have a passion for spreading the excitement of one's discipline to others---especially to K-12 students who know little about engineering. For those people, outreach can be one of the things that makes the job worthwhile.

A third motivation is to professionally broaden ourselves and our students. The NSF GK-12 program introduces graduate students to the issues of the K-12 classroom and requires that they communicate STEM content material to school-age children. This experience pushes them to understand more deeply their own discipline and also makes them grapple with how to explain science, math and engineering—that is, how to improve their pedagogical skills. Not only will those activities be helpful to those who are future faculty, but it has been found that they increase the appeal of the graduate students in the job market. Many former GK-12 fellows report that interviewers, both in academia and industry, are very interested to hear about the GK-12 experience, and ask questions about whether the candidate is willing to participate in outreach should they receive a job offer.

What are the consequences or benefits of pursuing educational initiatives to fulfill the first motivation listed above--the Broader Impact Criterion? Probably not much, from the point of view of most of your colleagues. The criterion of the grant demands outreach, and so it is put in. The evaluators of your work will usually pay little attention, should the grant get funded, to the K-12 or broader educational aspects of the project. At some institutions, educational publications can be a plus, provided that the published educational work still looks like scholarship. That is, as long as it is a part of the scholarship of integration or engagement in Boyer's terms, and the work is published in a good scholarly journal such as the Journal of Engineering Education. However, one must be aware that some colleagues may still criticize the

work as being too "fuzzy". In educational research, qualitative methods using case studies can give quite interesting insights, but those who have never seen such methods have a tendency to believe that they aren't worthwhile because they are not quantitative (or in their minds, "scientific"). Careful documentation of research methods and publication in peer-reviewed, high quality journals will help refute such opinions.

For the faculty member who likes to share his or her passion for engineering with a broader audience, or wants to write an education-based grant proposal as a way of participating in the general welfare of the discipline and community, it is important to first establish a robust and respected research career. While promotion to full professor might well be awarded at a regional institution or liberal arts college on the basis of outreach, it is unlikely that, in the absence of traditional discovery research, such a faculty member would have been tenured in the first place. In fact, there is a feeling among some faculty that, even if a junior faculty member's basic research is going well, that too much pre-tenure educational outreach might indicate a person who might not continue to give her/his all to "real research" once tenure is granted. In a positive sign of progress, there are some research institutions that now formally recognize outreach activities in the promotion to full professor. In one example, a physics professor at a Midwestern research institution spent 75% of his effort on traditional research and 25% on the scholarship of engagement, and both factors were included in the promotion decision. On the other hand, even when there are very clear written guidelines for merit raises, candidates have been known to receive a negative recommendation because "*it is easier to write an education paper than a research paper*" or "*education papers are longer because they are easier to write*" or "*it is just the money that comes into the institution from the grant that matters*" and so educational initiatives are irrelevant. Sandmann[12] has labeled it "*The Dilemma: Viewing scholarship broadly but evaluating it narrowly*." Another similar conclusion regarding the reward structure and outreach is set forth by Bartel et. al. [13]. Sandmann, in an upcoming book, gives an overview of service learning and concludes that we have a long way to go as it is clear "*…just how deeply rooted traditional categories of evaluations are even among institutions achieving Carnegie community engagement status*." [14]

Prudent advice for junior faculty, in all STEM disciplines, is to concentrate on the STEM discovery research and traditional scholarly indicators of quality during the pre-tenure period. Educational funding from NSF, NIH, DoD, etc. certainly indicates the high merit of the proposed work. However, your colleagues may still say that it is "easy money" or "not really challenging work". Remarks overheard at departmental promotion and tenure committee meetings include "*That's just money.*" and "*How long does it take <u>you</u> to write a research article? Now compare that to X's article which has almost no equations and uses non-scientific methods for conclusions.*" (In this case, "non-scientific" was used to mean "non-statistical" or, even worse in the minds of some STEM faculty, that fuzzy "qualitative analysis".)

There have been some documented instances in which STEM assistant professors have been hired with the understanding that educational research and outreach would be the focus of their tenure-track positions. This process may have worked out in some places, but even with explicit criteria for success in writing, the candidate can have a quite difficult time should the Dean or Chair of the department change. For example, one southeastern research university hired two assistant professors to do K-12 outreach and each had left for other institutions by their fourth

year. Of course, this is an n = 2 example (see the "fuzzy methods" comments above) but not an unusual one. In this case, the institution, with a different Dean and department chair, filled those positions with more traditional researchers.

Perhaps in summary, the issues can be thought of as a tension between what is being valued throughout the hierarchy of the institution. It is not unusual for conversations between promotion and tenure committee members to consider money (the amount) vs. scholarship (its meaning in theory and its actual meaning in practice at that institution) vs. the mission of the institution. Since you are much more valuable to the broader educational community if you earn tenure than if you don't, do not allow your interest in education and outreach distract you from doing what is required by your colleagues on the tenure committee. After that, you are free to pursue a variety of passions. Without people who have the passion for educational initiatives, the science and engineering disciplines would be diminished, and our nation would be less prosperous. We are thankful to those who reach out for the effect that they will have on the future of engineering education and the K-12 students who learn from these professors.

The third author would like to dedicate his portion of this article to his late Father. Jacob Millman was a leader in engineering education as the Batchelor Professor of Electrical Engineering at Columbia University and recipient of the IEEE James H.Mulligan, Jr. Education Medal in 1970 "for his impact in the areas of electronic devices and circuits through his outstanding textbooks and his stimulating teaching."

Appendix

RESOURCES

General SoTL Journals and Resources:

- International Journal for the Scholarship of Teaching and Learning
  http://academics.georgiasouthern.edu/ijsotl/
- International Journal of Teaching and Learning in Higher Education
  http://www.isetl.org/ijtlhe/
- Journal of the Scholarship of Teaching and Learning
  http://www.iupui.edu/~josotl/index.htm
- MountainRise
  http://mountainrise.wcu.edu/

Engineering Education Specific Journals:

- Advances in Engineering Education
  http://advances.asee.org/
- Chemical Engineering Education
  http://cee.che.ufl.edu/
- IEEE Transactions on Education
  http://www.ieeexplore.ieee.org/xpl/RecentIssue.jsp?puNumber=13
- INFORMS Transactions on Education
  http://www.informs.org/site/ITE/
- Journal of Engineering Education
  http://www.asee.org/publications/jee/

List of SoTL conferences:

http://www.kennesaw.edu/cetl/resources/na_conf_list.html#sotl

Online list of SoTL resources:

http://www.libraries.iub.edu/index.php?pageId=3208

Course Design Resources

Creating Significant Learning Experiences: An Integrated Approach to Designing College Courses, L. Dee Fink, San Francisco, Jossey-Bass, 2003.

Designing & Assessing Courses & Curricula, Robert M. Diamond, San Francisco, Jossey-Bass, 1998.

Educational Outreach Example

(Excerpted from a funded CAREER proposal. Original is 3-4 pages long.)

Educational Plan

Objective 3: Use the diversity of cichlid jaws as a vehicle to disseminate educational modules in math, biomechanics and evolution. Partnerships with the *** School System and the *** Aquarium will facilitate learning activities for students and community members.

Task 1, *(Years 1&2): Design high-school instructional materials to facilitate learning in science and mathematics using the cichlid fish model.*

- The research group will host a biology and a mathematics teacher from *** High School in the *** School system, for 7 weeks each summer as part of a *Research Experience for Teachers* (RET) program.
    - *** is an urban school system of more than ***students, **% of whom are African American, **% of whom are eligible for free/reduced lunch.
- The teachers and lab group will discuss basic biology of the cichlid system and the opportunities for teaching specific modules in math and biology using cichlid jaws and biomechanical models as the raw material.
- Educational modules will focus on new Performance Standards in math and science mandated by the *** Department of Education and aligned to both the National Research Council's *National Science Education Standard* (NRC 1996) and the American Association for the Advancement of Science's *Benchmarks for Science Literacy* (AAAS 1993).
    - The teaching modules will emphasize 'science process skills' of measurement, prediction, and hypothesis testing, and will align with standards addressing 'natural selection' and 'geometry.'
- Dr. ***'s group will provide the teacher team and school with large working models of cichlid jaws, high speed videos of cichlids feeding in the laboratory, and ….
- Modules designed in consultation with Dr. *** will be employed by the RET teachers in classrooms at *** High School during the school year.

Be specific about your partnerships, and include letters of collaboration.

Have a specific task and goal in mind.

RET-funded teachers can help you design materials based on your research.

Describe the target population of K-12 students.

Be as specific as possible about what the educational objectives are.

Connect your K-12 work with state and national education standards. Being specific shows you are familiar with what teachers need to teach.

Be specific about what the schools will gain.

- Modules will be evaluated for effectiveness by ……, and redesigned during Year 2.

Task 2 (Year 3): *Design workshops at the *** Aquarium to disseminate successful lesson plans to high school teachers.*

- Dr. *** will meet with the RET teachers and the educational staff at the *** Aquarium to plan teacher workshops. (See letter of support from Aquarium.)
- Two teacher workshops will be held at the *** Aquarium to facilitate learning in math and science using cichlid jaws as a model. The workshops will be overseen by *** Aquarium educational staff, with input from the RET teachers and Dr. ***.

Task 3: <u>Implement a Summer Biomechanics Fellowship program to place high school students in Dr. ***'s laboratory</u>.

- We will support two high school students per summer from *** School System schools (as Biomechanics Fellows) to join Dr. ***'s lab and the RET teachers and carry out directed research on cichlid jaws and biomechanics.
- Students will work on ….

Task 4 (Years 4-5): <u>Partner with the *** Aquarium to develop a community education component, via integration of learning about science and math into aquarium exhibits.</u>

- Using what has been learned from students and workshop participants, we will integrate aspects of math and biomechanics into aquarium exhibits. RET teachers working directly with Dr. *** and the aquarium education staff will coordinate this effort.

<u>Significance of the Education Plan</u>

Science and math are difficult, often because it is not easy to find teaching materials that bring these subjects to life. **The significance of this educational plan lies in the creative use of ecological biomechanics to generate learning activities in math and biology**. We can show students in mathematical terms why the jaw of *Dimidiochromis compressiceps* is well designed to bite eyes, and that …. Our educational plan targets specific learning goals set forth in the *** State Performance Standards, and as such will influence the way that science and math are taught in *** Schools. Finally, the truly unique partnership with the *** Aquarium increases the reach of the learning modules we develop, aimed not only at high school students but also towards members of the community at large.

How will materials be piloted and evaluated?

Have a plan for how your materials might be disseminated more broadly. Spread the plan out—it doesn't need to be completed in the first two years.

Use your partners to help. You don't need to do it all yourself.

Identify additional ways that your lab might interact with K-12 students and teachers. Link it into a coherent whole.

Identify possible informal education avenues for dissemination, and links to the broader community

Don't expect reviewers to understand the significance of your plan. Spell it out.

Reviewer Comments
Broader Impacts of the Proposed Research: Analysis of Reviews and Discussions

Broader Impact Summary Statement:

*"The PI has designed an innovative and effective program for involving teachers and students in learning about interrelationships between biology, math and physics. The plan involves designing educational kits that include actual cleared-and-stained biological specimens, large hands-on models that can be manipulated by students, and high-speed videos showing natural feeding behaviors. The plan includes hosting of high school teachers in biology and math in his lab during the summer, which is also notable. The PI has worked out a compelling plan of staged implementation and subsequent evaluation and improvement. The PI has made initial contacts and has obtained enthusiastic letters of support from the *** School System and the ***Aquarium. The educational component will ultimately have a positive impact on a large population of students from underrepresented groups."*

Individual Reviewer comments about broader impacts:

*"The broader impact of the proposal is outstanding in several respects. As intended by the CAREER mechanism, the proposed plan would clearly promote an exciting and rewarding career trajectory for the PI through a meaningful integration of research and education. Given the strength of the educational outreach plan, the positive impact on area students and teachers is likely to be quite significant. Partnering with the *** School System, with a population that is **% African American, will ensure that the plan is effective in engaging underrepresented groups in learning activities in math, physics and biology."*

"*The broader impacts of this study are extensive and include training of postdocs, graduate students and several undergraduates, facilitating interaction between individuals at different educational levels. Information stemming from this research will be used for educational purposes in the ***School System and the ***Aquarium. Links have already been established with individuals from these organizations. High School students will also be directly involved in this research. The PI is to be commended for providing a convincing argument that this work will have significant and extensive broader impacts not only to the scientific community but to the general public."*

References Cited

[1] Boyer, E. L. [1990] Scholarship reconsidered: Priorities of the professoriate. Princeton, NJ, Princeton University Press

[2] Boyer, E.L. [1996] *The scholarship of engagement*. Journal of Public Service & Outreach (1), 11-20.

[3] APS News. *"NSF's "Broader Impacts" Criterion Gets Mixed Reviews*. June 2007 (Volume 16, #6). http://www.aps.org/publications/apsnews/200706/nsf.cfm

[4] http://www.carnegiefoundation.org/news/sub.asp?key=51&subkey=2821. Taken from the Carnegie Foundation webpage on 1/28/09.

[5] National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, The National Academies Committee on Science, Engineering, and Public Policy. (2007). Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future. Washington, D.C.: The National Academies Press.

[6] National Science Foundation website, 1/28/09 http://www.nsf.gov/pubs/2005/nsf0540/nsf0540.jsp

[7] National Committee on Science Education Standards and Assessment, National Research Council. National Science Education Standards (1996). The National Academies Press. Available online at http://www.nap.edu/openbook.php?record_id=4962

[8] AAAS Benchmarks website http://www.project2061.org/publications/bsl/online/index.php

[9] National Council of Teachers of Mathematics (2000). *Principles and standards for school mathematics*. NCTM, Reston, VA.

[10] *Understanding By Design*, G. Wiggins. and McTighe, J., Alexandria, VA, ASCD, 1998.

[11] Carnegie *http://www.carnegiefoundation.org/news/sub.asp?key=51&subkey=2821.* Taken from the Carnegie Foundation webpage on 1/28/09.

[12] Sandmann, Lorilee [2008], *The Scholarship of Engagement: Making the Case for Promotion*, A power point presentation at Purdue University.

[13] Bartel, Krasny, and Harrison [2003] *Beyond the binary: Approaches to integrating university outreach with research and teaching*. Journal of Higher Education Outreach and Engagement. p. 89

[14] Sandmann, L. R. (in press). *Second generation: Community engagement promotion and tenure issues and challenges*. In J. Strait & M. Lima (Eds.), Service learning between the lines: A discussion of contemporary issues. Sterling, VA: Stylus Publishing.