Building Capacity to Achieve Broader Impact through the Center for the Integration of Research, Teaching, and Learning

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Introduction

Among United States federal agencies, the National Science Foundation (NSF) has led the way in the integration of research, teaching, and learning. In 1997, the NSF revised its merit review process to create two major criteria: Intellectual Merit and Broader Impacts. **The intellectual merit criterion** requires that grant writers address how their work advances knowledge and understanding within their own field or across different fields and their capacity to complete the proposed work. **The broader impacts criterion** necessitates that proposers describe ways in which they will: advance discovery and understanding while promoting teaching, training, and learning; broaden the participation of underrepresented groups (e.g., gender, ethnicity, disability, geographic); enhance the infrastructure for research and education; and contribute to society. These goals can be achieved through a wide range of activities including sharing data, mentoring graduate students, working with undergraduates in research; translating research results to a range of classrooms, and working with the public. The linkage of these types of broader impact activities to research funding is the powerful leverage point of national cultural change.

While broader impact as a concept was part of the original NSF charter, this recent emphasis in policy began with the "Shaping the Future" report (1) which stated: "**Research directorates should expand resources for educational activities that integrate education and research."** Critically, this call to action was targeted directly to the NSF STEM (science, technology, engineering, and mathematics) research directorates, in contrast to this mission being assigned only to the Education and Human Resources Directorate from which STEM educational funding traditionally derived. In association with this evolution in policy came an array of programs providing funding incentives to STEM researchers who aligned themselves with this policy. Most notable among these was the NSF CAREER Award for junior STEM faculty that requires proposers to develop innovative and forefront plans of work in *both* research and education. This program replaced the former NSF Presidential Young Investigator program, which honored only research credentials, and thus the shift from the PYI to the CAREER Award was a very strong policy statement on the part of NSF. Other such programs include NSF Distinguished Teaching Fellows for senior STEM researchers, CAREER-like programs for post-doctoral fellows, and incorporation of the broader impact criterion into the prestigious NSF Graduate Fellows Program.

Even so, when it came to individual investigator research proposals, the impact of the broader impact criterion depended heavily on the opinions and fidelity of each review panel and their respective NSF program officers. In practice, the respect for – and consequently the response of proposers to – the broader impact criterion was highly varied and too often minimal. Thus in 2002 NSF Director Rita Colwell delivered *Important Notice 127* (2) which said: **Effective October 1, 2002, NSF will return without review proposals that do not separately address both merit review criteria within the Project Summary. We believe that these changes to NSF proposal preparation and processing guidelines will more clearly articulate the importance of broader impacts to NSF funded projects.** While the tension with review

panels continues today, this proclamation was a strong statement that was heard by all.

Resistance to the broader impact criterion was not solely the result of disagreement with the principle of linking funding for disciplinary research with broader impact. Many principle investigators (PIs) simply did not have the training and experience to adequately respond to the broader impact criterion, even when they wanted to. Consider for example the CAREER awards. The typical STEM professional education in the U.S. has minimal attention focused on development of education skills. In most cases, exposure to teaching in graduate school involves 1-2 semesters as a teaching assistant, often largely unmentored. Post-doctoral positions represent an extended hiatus from teaching. Thus, many new faculty find themselves unprepared to write a well conceived and reasonable broader impact proposal for a 5-yr scope of work. Similar challenges continue to face most PIs at all career stages.

Importantly, these challenges very often involve limits in capacity, but not in ideas or commitment to broader impact (3). Thus, programs like the ***Center for the Integration of Research, Teaching and Learning*** **(CIRTL; www.cirtl.net)** view the NSF broader impact criterion as an opportunity to develop that capacity for the integration of research, teaching and learning.

At the institutional level, CIRTL is strategically positioned to enhance *both* the *research mission* and the *teaching mission* of U.S. research universities by providing PIs with the capacity to effectively address the broader impact funding criterion. Support in developing broader impact plans during the preparation of research proposals enhances their chances of success in obtaining research funds. And while the initial motivation of PIs sometimes lies primarily in the desire and professional requirement to obtain research funding, we find more often than not that with the development of capacity comes the motivation to engage more deeply in integrating research, teaching and learning. Furthermore, providing graduate students, post-doctoral researchers, faculty, and staff with the skills to carry out their plans leaves a legacy of implemented and evaluated broader impact products that benefits learning well beyond the duration of the proposals themselves.

Ultimately, we envision the NSF broader impact criterion – and similar initiatives beginning at other U.S. federal agencies – as a means to change the national culture of STEM faculty. Through the training of graduate students and post-docs, CIRTL is poised to shape a future faculty capable of responding to this national call for broader impact. A decade from now we envision that present STEM graduate students will be leaders of a national faculty for whom the broader impact of their research programs is taken as a given, and that they will have the skills and abilities to make it happen.

Engaging STEM Principal Investigators with Broader Impact

CIRTL's approach to helping researchers effectively address the broader impact criterion is based on three core ideas (referred to as the "CIRTL Pillars"):

1. Using familiar systematic and reflective methods of disciplinary research to develop, implement, and advance learning experiences and outcomes ("Teaching-as-Research"; TAR) (4, 5);
2. Cultivating communities of learners who generate new knowledge together about teaching and learning though mutual support ("Learning Community"; LC) (6);
3. Discerning and valuing the diverse ways of knowing that have the potential to enrich

every learning environment and be inclusive of a broader audience of learners ("Learning-through-Diversity"; LtD)

These three foundational concepts have proven to be a powerful approach to developing and implementing broader impact projects and, equally importantly, to engaging STEM faculty. When these concepts are applied to a broader impact plan, they can guide the developer to consider who they will be impacting, how they can broaden their audience, how they can create a sense of community among their diverse participants, and how they will evaluate their outcomes and improve their approach.

Programmatically, we typically engage with PIs within a month of proposal due dates. The CAREER and NSF Graduate Fellowship programs each have annual deadlines that are largely discipline-independent and for which there are many applicants. Thus we work with new faculty and graduate students, respectively, in a workshop mode, followed by individual consultations as requested. Other proposal deadlines, ranging from those for individual investigators to large centers, are distributed throughout the year, and so most of our guidance is provided through individual consultations.

At the initial stage of their interaction with CIRTL, PIs are seeking rather specific assistance with their proposals (in contrast, for example, to a broader professional development experience). We have found that the following sequence of thinking is effective both for the PIs and for the success of their proposals, and we use it as a framework for our guidance. Here we cast this approach as presented to a PI, annotated by the reasoning behind each step:

1. ***You*** *must have an idea for broader impact of your work.*

   Critically, CIRTL does not take ownership of the PI's broader impact "challenge". To do so would not lead to the PI moving toward a deep conceptual integration of research, teaching, and learning. Such conceptual change can only happen through the commitment, enthusiasm, and action of the PI for his/her own idea. In fact, our experience has been that most PI's have excellent ideas for broader impact that span pedagogical approaches, enhancing the success of underrepresented groups, informal education (outreach), and more. What they often lack is the knowledge and capacity to achieve them. CIRTL's role is to provide the requisite skills and knowledge to the PI and his/her team so as to realize the broader impact idea.

2. *CIRTL will provide you, your graduate students, and/or your post-docs with abilities to effectively implement your ideas.*

   This is a critical conceptual change for a PI. Typically the PI of a project is expert in the disciplinary work being proposed; a lack of expertise is what makes the broader impact aspect of a proposal uncomfortable. The presence of a program such as CIRTL permits the PI to acknowledge that lack of expertise and yet still credibly propose to achieve the broader impact goal. From the point of view of proposal review, the existence of a program like CIRTL provides immediate credibility that the principal investigator can in fact develop the capacity to accomplish the scope of work being proposed.[1] In some

[1] This approach might be contrasted with an alternative strategy in which PIs hire teaching and learning centers or outreach collaborators to "take care of" their broader impact activities for them. Arguably these strategies differ in

cases, principle investigators propose working with several programs on campus to enhance idea development, expand their capacity to implement and disseminate the work and achieve the broadest impact possible.

3. *Propose, and request funding, to support members of your research team as they develop the abilities to carry out the broader impact plan.*

Perhaps surprisingly, it is important to explicitly encourage PIs to request funding for their broader impact work. Often this is an oversight of PIs who are inexperienced with "education" funding initiatives; they don't recognize their broader impact work as legitimately fundable activities. At other times it derives in part from the reasoning that the budget for a given proposal is capped and so the funding is a zero-sum situation. While occasionally true, typically it is not. Furthermore, a broader impact scope of work without associated budget lacks credibility, which can hurt the review of a proposal.

4. *Teaching-as-research assistantships can provide opportunities to implement your idea and integrate it permanently into the institution.*

The NSF is very concerned about the institutionalization of the innovations that it funds. The concept of a graduate or post-doctoral "teaching-as-research assistantship" – with funding in the proposed budget - provides the means to take a proposed broader impact project to completion, and at the same time provide training to future faculty. This approach is precisely analogous to the way that disciplinary research is done, and bears the consequent credibility. For example, at UW-Madison, graduate students and post-docs collaborate with their PI to develop innovative instructional materials for STEM courses. As part of their teaching-as-research assistantship, they then have the opportunity to implement the materials in a classroom, evaluate the resultant student learning, revise the materials, and in some cases publish their outcomes.

5. *Stress four outcomes:*
    - *The creation of an evaluated product.*
    - *The institutionalization of the product (see previous).*
    - *The dissemination of the product for broader impact.*
    - *The development of the future workforce/faculty.*

The need to produce an evaluated product may seem self-evident to those in the world of education reform, but it is a new idea for many STEM PIs, and a daunting one at that. Most research proposals do not include evaluation within their broader impact sections; those that do stand out as superior. The "teaching-as-research" concept casts evaluation within a model that is sensible to STEM researchers, and allows them to cross this bridge. It is also critical to address how each broader impact project and its outcomes will be disseminated for the benefit of the larger scientific community. In the case of CIRTL, this dissemination is made easier because of the **CIRTL Network**, presently a

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their goals. CIRTL sees engaging STEM researchers in the broader impact mission and providing them with the requisite skills to succeed as outcomes of comparable long-term importance as accomplishing their specific broader impact initiatives.

community of seven research universities across the US[2]. Broader impact projects developed, implemented and evaluated on any of these seven campuses can be easily shared throughout the network. Finally, by developing capacity throughout his/her research team, the PI is also immediately developing the future STEM academic workforce – a priority goal of the NSF. Indeed, this future faculty will consider broader impact as an inseparable component of their research programs, and have the skills and abilities to do so.

As one concrete illustration of how these approaches might be implemented in a proposal responding to the NSF call for broader impact, we provide here an excerpt from one successful CAREER award proposal:

I propose a number of educational activities designed to foster new ways of thinking, to effectively communicate the discovery process, and to leverage the NSF-funded Center for the Integration of Teaching, Research and Learning (CIRTL) for designing and evaluating my courses and enhancing professional development of my graduate students. CIRTL's Professional Development Program provides opportunities for graduate students to develop skills in classroom teaching, preparation of instructional materials, informal education, teaching to diverse student audiences, teaching with technology and internships. The graduate students involved in this project will participate in the Professional Development Program to increase their effectiveness in formal and informal instruction and apply what they learn in the activities described below.

Course on Environmental Colloid Chemistry. Such a course would represent an expansion of a special topics course I co-taught during the 2003-2004 academic year with faculty from the Department of Geology and Geophysics. I intend to participate in CIRTL's Instructional Materials Development to develop several problem-based learning modules for use in the class and involve my graduate students in the design, implementation and evaluation of the PBL modules. I will evaluate teaching effectiveness and student learning by conducting formative and summative assessments. In addition, I will have the course peer-reviewed by other faculty in my program.

Excerpt from successful NSF CAREER proposal
Department of Soil Sciences, University of Wisconsin - Madison

Outcomes of the CIRTL Approach to Broader Impact

CIRTL has proactively positioned itself to support the University of Wisconsin - Madison (UW)[3] research community in successfully fulfilling the NSF broader impact criterion. The short-term goal is to facilitate successful research proposals and broader impact initiatives. Positive review panel comments (see sidebars) are persuasive statements to PIs about the value of compelling

[2] The University of Colorado at Boulder, Howard University, Michigan State University, the Pennsylvania State University, Vanderbilt University, Texas A&M University, the University of Wisconsin – Madison.
[3] By design, CIRTL chose to use the UW campus as its initial laboratory for prototype program development. Similar program developments based on the CIRTL pillars are underway throughout the CIRTL Network.

plans and capacities for broadening the impact of the research. The more important longer term goal is to help UW PIs and their research team proceed on a path that deeply integrates their research, teaching and learning missions.

Through timely workshops and one-on-one consultations CIRTL staff work closely with PIs and graduate students to improve the design and presentation of their proposals and connect them with the wide range of existing campus programs and initiatives with which to partner. Over the past 4 years, CIRTL has offered seven broader impact workshops at UW. Over 150 graduate students and 43 faculty have participated in these workshops from across STEM disciplines. Each workshop is designed to provide participants with the opportunity to 1) discuss strategies for writing a successful broader impact proposal, 2) hear from panelists about successful proposals and the review process, 3) learn about resources on campus focused on effective integration of research and education, and 4) have time to work on their proposal drafts. Evaluation of these workshops indicates that participants find them valuable; this is also demonstrated by their ever-increasing attendance numbers. One graduate student participant noted "I thought it was very useful to understand the history of the "broader impact statement" so that we know how it relates to NSF's goals and how we can speak to those goals. I also liked hearing from actual recipients of the fellowships, who gave very helpful advice and made the award seem more attainable with the right preparation." Other workshop participants have commented on the value of new links to potential collaborators and organizations that they can leverage to build capacity.

> A strength of the proposal is the broad impact that will result from the synergistic involvement of three graduate students simultaneously, all of whom are involved in the Center for Integration of Research, Teaching and Learning. These students are being trained in outreach skills and will participate in the application of Digital Data Maps, which will have wide use in teaching and research."
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> Panel review for successful NSF individual investigator proposal *Department of Geology and Geophysics, University of Wisconsin - Madison*

Table 1 provides a summary of types and numbers of grants for which the CIRTL has provided individual consultation over the past three years. Typically such consultations include assistance in developing broader impact ideas into proposal-ready plans of work, providing feedback on proposal texts, and providing letters of support when the PI intends to make participation in CIRTL programming part of their plan of action (as is typical).

Table 1: Individual Consultations by Grant-Type (2004-2006)

	# of consultations	**# of STEM departments**
NSF Graduate Research Fellowships	22	16
CAREER Award	28	14
NSF Research Grant, Individual Investigator	14	11
Other NSF Research Grants	10	16

When we asked new faculty applying for CAREER awards about these consultations, 65% of respondents indicted that writing their proposal in collaboration with CIRTL was either "better" or "much better" than their previous grant writing experiences. Participants have stated: 1) "My proposal was greatly improved by having collaborated with people with the education expertise that I lack.", 2) "Being able to leverage off an NSF-funded program gave my proposal more weight.", and 3) "It was very helpful to get immediate feedback and suggestions for improving the broader impact section. I also learned a lot about the programs available on campus, which I found very helpful." Participants also indicated that they did several things differently in their proposal as a result of the consultation, including: seeking out more formal support letters for their broader impacts objectives, improving the education component to their proposal, providing more specific details for their education objectives, writing a broader impact statement that more accurately reflected their educational goals, writing with a more "global" (college-wide) perspective, investing time reading published articles about active learning approaches, including more emphasis on diversity issues into their proposed plans, and including more details about implementation and assessment. Importantly, over half of the 2006 and 2007 CAREER recipients at UW consulted with CIRTL while writing their proposals. Proposal reviewers frequently commented on their plans to partner with CIRTL to achieve broader impacts.

> "[This proposal] describes a systematic program that will involve both graduate students learning to teach and undergraduate students learning organic chemistry, within a strong infrastructure at Wisconsin (… CIRTL, an NSF Center) dedicated to similar educational objectives… possibly the most important impact of the work will be the preparation of faculty-to-be for teaching at the university level. American faculty receive outstanding training in research, but … often never understand fundamental issues related to quality learning. Any project addressing these problems is significant."
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> Panel review for successful NSF CAREER proposal
> *Department of Chemistry, UW-Madison*

Closing Thoughts

The intentional, positive actions of CIRTL in response to the NSF broader impact requirement are a win-win for all involved. The enhanced success rate for UW proposals benefits the PIs and their research programs, and increases the flow of Federal funds to the university. The implemented and evaluated broader impact products leave a legacy of enhanced learning for UW students, for students at nearby colleges, for K-12 students, and for the Wisconsin community. And for the PIs themselves, these proposal consultations are their first interactions with CIRTL, but they are seldom their last. For example, all seven of the UW CAREER recipients from 2006 and 2007 who consulted with CIRTL are now active contributors to the learning community as program facilitators, course instructors, and teaching-as-research mentors. Such faculty and their graduate students and post-docs sustain and grow the CIRTL learning community by, for example, bringing in new ideas, by providing funding and mentoring for teaching-as-research assistants, by bringing CIRTL ideas to their departments, and by becoming campus leaders of both CIRTL and other new initiatives. Ultimately, these successful research-active faculty become strong and visible advocates for the integration of research, teaching and learning at UW.

These benefits to *both* the *research mission* and the *teaching mission* of UW have led to the CIRTL programs on the UW campus now being completely institutionalized, operating without funding from the original NSF grant. Thus CIRTL has leveraged the NSF broader impact criterion into a *sustainable* approach for institutional change toward the integration of research, teaching and learning. And equally importantly, through the integral involvement of graduate students and post-docs in broader impact initiatives, the CIRTL Network is poised to shape a future STEM faculty that is integrating research, teaching and learning at all colleges and universities throughout the nation.

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