

Chapter 7: Conclusions and Directions for Future Research

This study examined the impacts of the IGERT program in achieving the following program goals:

- **Educating U.S. Ph.D. scientists and engineers** who will pursue careers in research and education, with the interdisciplinary backgrounds, deep knowledge in chosen disciplines, and technical, professional, and personal skills to become, in their own careers, leaders and creative agents for change.
- **Catalyzing a cultural change in graduate education**, for students, faculty, and institutions, by establishing innovative models for graduate education and training in a fertile environment for collaborative research that transcends traditional disciplinary boundaries.
- **Facilitating diversity in student participation and preparation**, and contributing to the development of a diverse, globally-engaged, science and engineering workforce.

The success of the IGERT program in achieving these goals was examined through its impacts on students, faculty, institutions, and recruitment. Overall the IGERT program has had the most observable impact in the goal of developing interdisciplinary graduate education experiences for participating students. This may be because the bulk of program funding at each project site goes directly to support individual students and the costs associated with their education, rather than to faculty members or participating departments.

Educating United States Ph.D. Scientists and Engineers

The IGERT program has successfully created new, innovative, integrative interdisciplinary educational experiences for doctoral students across the nation. IGERT students report significantly broader and more interdisciplinary educational experiences than non-IGERT students. IGERT projects have organized around interdisciplinary themes, resulting in opportunities for IGERT students to work with students and faculty in other disciplines, take courses in other departments, conduct laboratory research in a variety of disciplinary settings, and work in interdisciplinary teams. IGERT students gain breadth of skills and knowledge, often taking “bridge” courses to bring them up to speed in other disciplines or conducting a series of laboratory rotations with faculty in various fields, while still developing deep knowledge depth in their chosen doctoral field. The majority of IGERT projects aim to develop students with mastery of one field who can work with scientists in other fields and use the techniques of multiple disciplines.

IGERT students are being prepared for a wide range of careers, with both academic training as well as experiences familiarizing students with careers outside the academy in industry or public laboratory settings. More IGERT students than non-IGERT students have worked on research projects with government laboratory scientists, industrial scientists, or faculty from other universities. IGERT students are also more likely to have opportunities to conduct off-campus internships lasting a month or more. These experiences leave IGERT students feeling more prepared for a broad range of careers, and ready to work in both academic and non-academic positions.

Finally, IGERT students are receiving the professional skills relevant to working in the 21st century. Significantly more IGERT than non-IGERT students report having received coursework or formal training in research ethics, professional speaking skills, communicating to the general public, and communicating outside their own discipline. IGERT students have engaged in many more team-oriented research and educational projects, including teams comprised of individuals from multiple disciplinary backgrounds. As a result IGERT students feel far more prepared to conduct research in an ethical manner, work in multidisciplinary teams, and communicate with people outside their own field.

Catalyzing a Cultural Change in Graduate Education

IGERT participants report evidence that the IGERT program is helping catalyze a cultural change in graduate education. IGERT projects have established innovative models for graduate education and training that transcend traditional disciplinary boundaries. IGERT faculty report much higher levels of interdisciplinary collaboration, research, and teaching than do non-IGERT faculty. While part of this difference may be a function of pre-existing differences between the two groups, there is evidence that participation in IGERT increases the interdisciplinary behavior of faculty. The act of organizing around an IGERT grant provides faculty members with increased opportunities for interdisciplinary collaboration, and many faculty members report that their IGERT participation has impacted their own professional lives, making both their teaching and research more interdisciplinary. Faculty report that the act of formalizing IGERT projects often energizes and catalyzes interest in the interdisciplinary theme. The existence of IGERT projects on campuses may also provide some protection to younger, untenured faculty members, who may otherwise feel less secure about branching out into interdisciplinary work before having earned tenure within a disciplinary department.

IGERT projects are catalyzing change within their host institutions through the creation of new courses and degrees, and the modification of policies, requirements, and programs. Both IGERT and non-IGERT faculty perceive that their institution's support for interdisciplinary research is stronger than that for interdisciplinary teaching. Still, nearly all IGERT PIs report that their institution's support for interdisciplinary graduate education has increased since their IGERT grant began, and that this increase is due in part to the presence of the IGERT grant. It is reasonable to hypothesize that, over time, the presence of IGERT interdisciplinary educational activities and programs will act as a catalyst to increase support for interdisciplinary graduate education. The ultimate impact of IGERT grants on institutional culture may depend in part on the ability of projects to sustain programmatic elements beyond the funding period. PIs are confident that they will be able to maintain opportunities to study multiple disciplines and access to disciplines and expertise outside of students' home departments for students who continue in IGERT-related programs. It may be this shift in educational philosophy—rather than other more tangible project elements—that remains, and which may have the greatest impact on the surrounding institutional culture.

Facilitating Diversity in Student Participation and Preparation

The IGERT program aims to facilitate diversity in student participation and preparation, and contribute to the development of a diverse, globally-engaged, science and engineering workforce. The IGERT program encourages diversity along a range of dimensions, including disciplinary background, viewpoints, training, ethnicity, and gender. The IGERT program has succeeded in increasing the number of American citizens enrolling in the nation's STEM doctoral programs,

individuals who have the potential to make strong contributions to the workforce. IGERT faculty members describe IGERT students as talented and enthusiastic. In spite of developing new doctoral programs, often from scratch, IGERT projects have been successful in recruiting women and minority students on par with national averages of the disciplinary fields represented in IGERT. Recognizing the importance of strengthening connections between IGERT graduate programs and earlier points along the educational pipeline, the NSF currently supports the IGERT National Recruitment Office, a stand-alone program dedicated to helping IGERT projects recruit individuals from underrepresented groups.

Directions for Future Research

The IGERT program represents a substantial investment in domestic graduate education, and new projects continue to be funded each year. As such NSF, the program community, and graduate education at large can benefit from continued evaluation and assessment of the IGERT program. As individuals begin graduating in larger numbers from IGERT projects, and grant funding draws to a close for many projects, there are several topics of investigation that might be of interest to the NSF and the graduate education community.

Assessment of Diversity Enhancement

Increasing the diversity of individuals entering STEM doctoral programs is an important goal of the IGERT program. One aspect of this diversity is enhancing access to STEM doctoral education for populations traditionally underrepresented in science (such as minority groups and women). Many IGERT projects have begun establishing recruitment relationships with programs or institutions that target individuals typically underrepresented in STEM fields. Future research could examine successful recruitment strategies, and the IGERT program's ability over time to recruit higher proportions of individuals from these groups. It could also examine how IGERT projects are broadening the pipeline, by forging linkages with Research Experiences for Undergraduates, undergraduate institutions, or other such connections.

Assessment of IGERT Graduate Career Outcomes

At the time this evaluation was conducted, only a handful of students had graduated from IGERT programs. By 2007-08 it is estimated that IGERT projects will graduate approximately 500 individuals each year, meaning that soon there will be thousands of IGERT graduates in the workforce. A longitudinal study of the career outcomes of IGERT graduates, to learn about their chosen career pathways, professional productivity and accomplishments, would be an important measure of the long-term impact of the IGERT program.

Assessment of IGERT Institutional Impacts

As the IGERT program evolves there will be opportunities to learn about continued institutional culture change and the lasting institutionalization of program elements. There are several possible methods of studying such impacts. First, this study primarily addresses questions of institutional impacts using data from IGERT participants. To learn more about the impact of IGERT projects on their host institutions, individuals external to the IGERT project but within the same institution could provide a useful perspective on IGERT and its impact.

Second, long-term institutional impacts and project sustainability can be examined after a project's funding has ended. While some of the IGERT projects examined in the Initial Impacts study had completed their funding period, many were just winding down. The current study provides baseline data on the perceptions of faculty and department chairs on institutional support for interdisciplinary graduate education. Future studies could collect data from other points in time, enabling a longitudinal analysis of institutional support and enabling conclusions to be drawn about the ways in which IGERT projects effect lasting change in their universities.

Assessment of the IGERT Model of Interdisciplinary Graduate Education

Finally, it would be possible to examine the IGERT model of graduate education itself. In what ways are IGERT activities "interdisciplinary" or "integrated"? What do these terms mean on IGERT campuses? How can the IGERT program help develop a broader understanding of what it means to engage in integrated and interdisciplinary graduate education? This study compared the IGERT model of education to that received in traditional single discipline programs. It did not examine other interdisciplinary graduate education programs, though there are other such programs scattered across American institutions. One could also examine the extent to which the IGERT model of education is the most effective means of reaching the goals of the IGERT program, or whether other interdisciplinary graduate education programs might better achieve the IGERT goals than does the IGERT program.