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**Contractor Annual
Report and Summary
of the Cross-Site
Monitoring of the NSF
Intergrative Graduate
Education and
Research Traineeship
(IGERT) Program**

Final Report

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IGERT Annual Report

Executive Summary

Introduction

In 1998 the National Science Foundation launched the Integrative Graduate Education and Research Traineeship (IGERT) program, a major initiative aimed at Science, Technology, Engineering, and Mathematics (STEM) graduate education. IGERT was developed to meet the challenges of educating U.S. Ph.D. scientists, engineers, and educators with interdisciplinary capabilities, deep knowledge in chosen disciplines, and technical, professional, and personal skills to become leaders and creative agents for change in their own careers. The program is intended to catalyze a cultural change in graduate education, for students, faculty, and institutions, by establishing innovative new models for graduate education and training that transcend traditional disciplinary boundaries. It is also intended to facilitate greater diversity in student participation and preparation, and to contribute to the development of a diverse, globally engaged science and engineering workforce.

The IGERT Program builds on current research on STEM graduate education, which calls for graduate programs to increase the versatility (and therefore the career options) of doctoral students, stresses the importance of interdisciplinary work, and suggests programmatic improvements (such as exposing students to a broad base of state-of-the-art research tools and methodologies, providing instruction in ethics, and fostering an international perspective). Institutions awarded an IGERT grant currently receive up to \$640,000 per year,¹ the bulk of which is distributed as traineeships to approximately 15 students each year who take part in a new interdisciplinary or multidisciplinary STEM graduate education program.

This report is the third in a series of annual IGERT reports from the contracted evaluation of IGERT (OMB 3145-0812), and differs from earlier reports in that it combines our findings from site visits to the first three cohorts of IGERT projects (1998, 1999, and 2000) with broader summary survey data collected from *all* IGERT project PIs and students (1998-2003 cohorts) through annual web-based surveys beginning in the spring of 2000 (OMB 3145-0136). The report describes the perceived impact of IGERT participation on students, faculty, and institutions, as reported through web survey responses of PIs and trainees, and through site visit interviews with students and faculty taking part in the project and with associated department chairs and university administrators. We are limited in our discussion to the reported experiences of our respondents within their IGERT projects. Although we have no measure of how different their experience might have been absent IGERT support, our observations nonetheless provide an in-depth view of these projects and their impacts as perceived by their participants.

Project Characteristics, Leadership, and Management

NSF program guidelines for IGERT intentionally allow considerable flexibility to design projects that build on disciplinary strengths, promote research at disciplinary boundaries, use innovative learning

¹ Based on the 2003 increase in student stipend from \$21,500 to \$27,500. The 2004 Announcement (NSF 04-550) expects 38 awardees, each of whom may receive up to \$3.0 million plus additional funds for one-time research support and for international travel.

strategies, and adapt to institutional settings. The 100 IGERT projects funded through 2002 span 38 states and sixty-six universities, including twenty-three universities that house multiple IGERT projects. Most projects are discipline-plus models that supplement departmental or interdisciplinary degrees with IGERT requirements, but a handful have developed new interdisciplinary degrees. About a quarter of the projects involve consortial arrangements with industry or other partners that contribute facilities and resources. Slightly less than half of the projects have additional funding sources outside the IGERT grant.

IGERT projects average 15 trainees per project, with fewer trainees in newer projects and a greater number in more mature projects. Although they all have similar training goals for their students, projects vary widely in design and scope. The number of departments and research units involved ranges from one to more than ten, resulting in leadership challenges and management tasks that are many and demanding. Even research universities with traditions of strong support for interdisciplinary research may have institutional structures and policies that pose significant barriers to changing graduate education. Taking on these challenges requires effective and creative leadership—to design an intellectually compelling project, to secure necessary resources and institutional support, and to move from idea to reality by attracting others to the enterprise. PIs have different strengths and styles that influence project implementation, ranging from the PI exercising sole leadership with practically no faculty involvement, to a formal management team with the PI serving as an equal member. Most projects receive support from non-faculty administrative staff, and PIs draw on a variety of other resources to manage projects: co-PIs, other affiliated faculty, technical staff, internal evaluators, post-doctoral fellows, and graduate students. Faculty commitment to IGERT projects varies; a few projects have struggled to find ways to sustain faculty involvement, but most benefit from faculty excitement and commitment to IGERT activities, even at the expense of adding to their existing loads (for example, by teaching IGERT courses as overloads).

Recruitment and Retention of Students and Faculty

Almost all projects use faculty contacts, non-electronic media, competitive stipends, and visits to campus as tools in recruiting students. The most successful recruitment of students to IGERT projects comes through personal connections faculty or other students have with prospective applicants. Overall, projects appear to attract high quality students, with faculty and administrators at several institutions praising IGERT trainees as the most talented, highly qualified students in their programs. Attempts to diversify IGERT student bodies along gender and ethnic lines have met with mixed results. Students from minority groups underrepresented in STEM fields (African American, Native American, and Hispanic) constitute 9 percent of trainees, and women constitute 35 percent of trainees. Projects have begun efforts to move beyond directly recruiting students from these underrepresented groups towards expanding the pool of prospective applicants by enlarging pipelines (e.g., summer research programs for undergraduates, long-term collaborations with minority-serving institutions).

Retaining original faculty and attracting new faculty to IGERT is essential to the health and growth of these projects. The key to sustaining faculty involvement is intellectual engagement; faculty frequently are drawn initially to these projects through their students, and stay because of the excitement of work on problems accessible only through interdisciplinary research collaborations.

Assessment and Evaluation

IGERT projects use a range of approaches to project assessment and evaluation (internal and external, formal and informal), with findings from these evaluations leading to important changes for many

projects. Project development and use of evaluation plans has increased over time; many projects did not initially plan for project-level evaluation but began such efforts in the wake of NSF's increasing emphasis on evaluation. One-third of projects employ an evaluator who is external to the university, and one-quarter of projects employ an evaluator from within the university, but external to the IGERT project. The key to successful program modification is a project management that is flexible and open to change, and those projects utilize feedback, either formal or informal, to modify and improve their graduate programs.

Impact on Students

The IGERT program encourages the development of a range of student skills, including research, teamwork, and communication across disciplinary, sectoral, and national boundaries. The common goal of training students as inter/multidisciplinary researchers binds the IGERT projects together, despite considerable differences in project disciplines, research areas, intensity of requirements, scope of involved departments, and mix of educational components. Although projects differ in the ways they attempt to introduce students to multiple disciplines and in their expectations for the degree of student mastery of multiple disciplines, IGERT trainees are virtually unanimous in reporting that their IGERT projects provide them with a much broader, more interdisciplinary education than they would have received in a traditional program. Students may earn interdisciplinary doctorates through new or preexisting programs in 16 percent of visited projects and an IGERT-related certificate or minor in 20 percent.

IGERT projects have combined course work, laboratory, and research experiences to create an integrated doctoral experience for their students, melding multidisciplinary themes into each educational experience. Interdisciplinary understanding is gained through IGERT seminars and sets of core courses, often team taught, that weave the disciplines together to form the multidisciplinary theme. Students' research experiences can include rotations through laboratories of various faculty as well as group multidisciplinary research projects. About two-thirds of the IGERT projects either require internships or offer them as an optional component.

IGERT projects have made progress towards program objectives. Topping the list of activities PIs believe to be most effective were those that bring students from different disciplines together: multidisciplinary trainee activities, from courses, seminars, or brown bags with individuals in other fields to participation in multidisciplinary research endeavors. Also highly rated are activities aimed at preparing students for careers outside of the academic world.

Site visitors found some IGERT projects more successful than others in providing rich, multi-disciplinary programs for their students. The more successful projects often require trainees and faculty to work together across disciplines, rather than simply rotating students through one faculty laboratory after another. They are more likely to directly address any shortcomings students may have in their cross-discipline academic preparation through "bridge" coursework. Such projects are self-reflective as well, seeking feedback and modifying their program to fit student needs. They also make good use of IGERT's funding flexibility, giving students freedom to explore research topics in ways not possible in the traditional apprenticeship model. Students report valuing the "real world" problems being addressed in some IGERTs, and almost uniformly report feeling well positioned to enter the job market—whether in academia or in other venues. Conversely, students in the IGERT projects that are struggling report less attention to these issues, less faculty buy-in, less research across disciplinary lines, and overall, a less cohesive multidisciplinary experience.

Impact on Faculty

The impact of IGERT projects on participating faculty reflects the goals of the program as a whole. PIs report that faculty are sharing mentoring responsibilities across disciplines, teaching new courses that cross traditional disciplinary boundaries, and participating on multidisciplinary dissertation committees. We see signs that IGERT is fostering among faculty a more collaborative culture in which new research problems are identified and fields are advanced. Although some barriers remain, IGERT faculty are generally invigorated, both personally and intellectually, by their projects.

At most IGERT projects, faculty report an increase in their contact with faculty from other disciplines, and several individuals at various sites reported that their own research was directly affected: it changed direction, they gained a student with new ideas, or they began working with another faculty member. Several faculty mentioned collaborating on grant proposals they would not have pursued (or been aware of) without IGERT's influence. At many IGERT institutions, students are the conduit for faculty interactions; thus co-advising or lab rotation arrangements for trainees represent mechanisms for bringing faculty together. Faculty report excitement at being able to work with the talented, energetic students who are the IGERT trainees. IGERT funding has the added benefit of making it possible for students (and associated faculty) to pursue research that does not clearly fit into a single department or is too exploratory yet to be a good candidate for research grant funding.

IGERT projects have been credited with attracting new faculty hires, individuals interested in the inter/multidisciplinary collaboration taking place in and around IGERT projects. Several institutions even dedicated faculty lines to new interdisciplinary hires.

In addition to generating new interdisciplinary research among faculty, the IGERT program has also changed faculty practice in training graduate students, and in some instances, their conception of graduate education altogether. Faculty interact with each other while team-teaching new IGERT course offerings or jointly mentoring doctoral students across disciplines. IGERT courses often contain students from a variety of disciplines, and the presence of "non-expert" students in their courses has affected faculty teaching methods because these students ask questions of a different nature. Faculty also report benefiting from sitting in on each other's courses and interacting within the context of seminar series offered for students. These venues provide fertile ground for faculty to exchange ideas with their peers in other disciplines.

In examining factors that support faculty engagement in these projects and those that raise barriers to success, we noted that strong institutional support seems to go hand in hand with greater faculty participation in the IGERT project. Some institutions view IGERT as a new model for graduate education, something that enhances the university's reputation in general, and/or something to emulate in other areas of the institution. Departmentally-oriented institutional policies, on the other hand, can limit faculty participation. Difficulties assigning course credit can inhibit team teaching or prevent otherwise interested faculty from taking on an IGERT-related course. In spite of these difficulties, committed faculty sometimes take on the course(s) as an overload anyway. We also noted that history makes a difference. In instances where collaborative efforts had already begun to take root before the PI(s) applied for the IGERT grant, faculty engagement is more reliable, and projects seem to mature more quickly than those where epistemological differences between the disciplines have not yet been adequately tackled.

Impact on Institutions

In their first years of operation, these IGERT projects have had an impact on their home institutions in two ways: by soliciting increasing levels of support from their institutions, and by altering mechanisms for graduate education. Institutional support for IGERT projects comes in the form of increased resource allocation, and in the form of modifications to institutional policies to better accommodate inter/multidisciplinary education. IGERT institutions have provided a variety of resources for project activities, including financial resources, staff assistance, and the dedication of space to IGERT project activities. They also have begun changing institutional policies that govern course credit, team-teaching, faculty hiring, promotion, and tenure.

In response to increasing university support for inter/multidisciplinary education, IGERT projects have sparked innovation in graduate education, including new courses, modified degree requirements, and in a few cases, entirely new interdisciplinary doctoral degree programs. Support for inter/multidisciplinary research and education may be catalyzed by the arrival of IGERT projects or be part of an ongoing institutional initiative. IGERT projects at universities with a history of inter/multidisciplinary endeavors benefit from a groundwork of supportive institutional policies and from faculty readiness to collaborate across disciplines. Other universities are using IGERT projects as springboards to develop cross-disciplinary endeavors. It is encouraging to note that projects have begun altering their institutional landscapes, for it is in changing institutional values that IGERT projects have perhaps the best chance of initiating permanent change in graduate education.

Project Development and Growth

Mirroring the dynamic nature of the IGERT program, projects themselves evolve as they implement their plans and respond to changing circumstances and demands. There was evidence that projects transform in response to trainees' needs and feedback. Although most activities are implemented as planned from the outset, projects do expand the activities they offer after the first year. Overwhelmingly, any change occurs between the first and second years of implementation, with most projects offering features addressing specific trainee goals by their second year of activity. There is little change in project offerings from years 2 through 4, partly due to the large proportion of projects whose PIs report addressing a given goal or activity by their second year.

Institutionalization and Future Impact

Institutionalization of IGERT projects occurs along two fronts: making permanent innovative forms of graduate education developed by IGERT projects, and spreading IGERT-influenced ideas about collaboration across disciplines in research and teaching. Successful institutionalization in one area is not dependent on success in the other, though both may certainly occur. The steps taken toward institutionalization vary across projects. Sixty-nine percent of PIs across all cohorts reported having planned for the continuation of IGERT initiatives, concepts, or collaborations, with PIs of more mature projects more likely to report such plans.

Of the 57 projects visited, 15 projects appear likely to institutionalize their entire IGERT educational programs, either as free-standing programs or as part of a larger center or institute. In the majority of the remaining cases, participants are confident that at least some elements of IGERT training will remain: new courses, for example, or departmental requirements (like lab rotations). Unrestricted funding, a cornerstone of the traineeship program that allows students more freedom in exploring

research opportunities, will be harder to sustain. A few projects have begun the search for other sources of funding to continue student funding once NSF funding ends. Many projects are looking outside their home institutions, because they fear internal funding will not be available.

Much less tangible than weaving new courses into institutional programs or offering funding for students is the impact participation in IGERT has had on the way faculty and students think about graduate education and cross-disciplinary experiences. Many faculty emphasize IGERT's influence on how they think about teaching and research, and anticipate continuing to work with colleagues outside of their own discipline after IGERT ends. We also observed evidence that IGERT values, ideas, and behaviors have begun to spread to other members of these university communities. Non-IGERT programs at several universities have adopted IGERT-inspired components (e.g., common core classes, ethics courses, internships). New interdisciplinary institutional centers or institutes are also spreading, in part because of IGERT.

A project's ability to institutionalize itself appears to rest on four factors: institutional commitment (financial as well as ideological), adequate resources, faculty interest and leadership, and a compelling conceptual and intellectual base. Institutional commitment is key; to survive long-term, any novel educational program must find a way to fit within its supporting university's goals and missions. University administrators at more than half of these IGERT projects told us that IGERT fits well into their institutional plans to create more inter/multidisciplinary forms of graduate education. Projects also need adequate resources to maintain activities, and finding sufficient funding to continue after NSF funding ends was cited as the most pressing barrier to institutionalization across the board. Many projects have begun the process of seeking alternate resources necessary to sustain project activity. The third necessary condition for survival is sustained faculty interest and involvement. Difficulties assigning course credit can inhibit team teaching or prevent otherwise interested faculty from taking on an IGERT-related course, especially in the long term. Projects that successfully navigate institutional barriers to faculty involvement stand a better chance of surviving long-term. Finally, there are issues related to the project's research/education focus. No project will continue unless there is real interest on the part of faculty and students in its conceptual and intellectual base. This may be the most important factor for success—without interested students and faculty, there is no program. It is also true that a project's success in eliciting funding support is dependent to a large degree on the match of its research theme with the academic priorities of its home institution, internally, and on the "hotness" of the topic, externally.

Conclusion

Many IGERT participants believe that five years is perhaps too short a time in which to change the delivery and culture of graduate education. Still, IGERT projects have already had numerous impacts on students, faculty, and their home institutions. There are good prospects for some form of continuation of many of the IGERT projects, and little doubt that each of these projects, in some way, has had a positive impact on those involved.