Essential Competencies for Interdisciplinary Graduate Training

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Summary Report

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About the IGERT Program and this Study

The IGERT Program

The Integrative Graduate Education and Research Traineeship (IGERT) program represents a substantial investment by the National Science Foundation to improve the quality of graduate education, and ultimately, to increase the number of graduates better prepared to address our nation's 21st century scientific and technological needs. The IGERT program supports education and research that integrates multiple disciplines by drawing purposefully from different disciplines' approaches both to research and to emerging research questions that the scientific community has had neither the knowledge base nor technology to address. IGERT further emphasizes the preparation of skilled graduates who can communicate complex ideas to laypersons and work well in team settings.

The IGERT program's specific objectives are to:[1]

1. **Educate Ph.D.-level scientists with the depth and breadth of knowledge and skills to become leaders in their fields;**
2. **Catalyze changes in graduate education by establishing models for collaborative research across disciplinary boundaries; and**
3. **Promote diversity among participating students and the professional science and engineering workforce**

The program meets its goals by providing grants to institutions of higher education to support U.S. citizens or permanent residents in science, technology, engineering, and mathematics (STEM) fields who are seeking interdisciplinary graduate research training in emerging interdisciplinary science and engineering areas. Funded IGERT projects offer their graduate trainees both financial support and a wide range of interdisciplinary research and educational enrichment experiences. Most IGERT projects are led by a Principal Investigator (PI) in a single discipline, often in partnership with other co-PIs from collaborating departments or institutions working in common interdisciplinary fields. The projects' PIs design a set of educational and training activities that include interdisciplinary courses and seminars, cross-department laboratory experiences, team-based research projects, and off-campus internships, among other activities.

About the Study

The National Science Foundation (NSF) contracted with Abt to conduct a study focused on the first broad goal of the IGERT program by exploring the ways in which institutions are preparing Ph.D. students to conduct interdisciplinary research. This study builds on a series of studies Abt has completed that examine other important aspects of the IGERT program.[2]

An important first step for the Abt study team was to delve deeper into the literature on interdisciplinary research to learn whether specific sets of knowledge, skills or abilities—also referred to as interdisciplinary "competencies"—have been identified as essential for conducting interdisciplinary

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1 Objectives are from Program Synopsis in IGERT Program Solicitation NSF 08-540. See http://www.nsf.gov/pubs/2008/nsf08540/nsf08540.htm

2 For more information on prior IGERT evaluation studies, please see the Abt Associates website's IGERT report page at: http://www.abtassociates.com/sitesearch.aspx?searchtext=IGERT&searchmode=anyword

scientific research in particular. Based on an in-depth literature review, and close consultation with NSF and the study's advisory committee, the study team identified six core competencies essential for conducting interdisciplinary research:

1. Depth of knowledge in one discipline or field of study
2. Ability to recognize the strengths and weaknesses of multiple disciplines
3. Ability to apply the approaches and tools from multiple disciplines to address a research problem
4. Ability to work in a team with individuals trained in different disciplines
5. Ability to communicate research based in one discipline or field of study to academic researchers trained in different disciplines
6. Ability to communicate about interdisciplinary research to both general and non-academic audiences

The study uses this group of competencies as a starting point to understand whether IGERT participants perceive this set, and perhaps others, as important for conducting interdisciplinary research, and how IGERT projects develop trainees in these six areas. The study's key research questions are targeted explicitly on whether and how this group of competencies is the focus of IGERT projects.

Study Research Questions

1. **Whether and in what ways do IGERT participants (PIs and trainees) perceive the knowledge, skills or abilities drawn from the literature as important to conducting interdisciplinary research?**
2. **What activities do projects implement to develop trainees' interdisciplinary research capacity, as characterized by these knowledge, skills or abilities? How do projects assess trainees' development as interdisciplinary scientists?**
3. **How helpful do trainees perceive their IGERT training to be in developing their capacity to conduct interdisciplinary research as characterized by these six areas?**
4. **How confident are IGERT trainees of their knowledge, skills, and abilities in these six areas?**
5. **What challenges do trainees encounter with the IGERT traineeship?**

The study team collected data directly from two key respondent groups: IGERT Principal Investigators (PIs) and IGERT trainees, from a set of 40 IGERT projects initially funded in 2007 and 2008. Data come from interviews with 39 of the 40 PIs and from 431 trainees across the 40 projects. The study examines, within the IGERT context, the mechanisms identified in the literature as salient to the development of interdisciplinary research skills. It provides insights about how IGERT projects are designed and implemented, from PIs' perspectives, and about how trainees experience the project elements intended to develop their skills, and ultimately, their capacity to conduct interdisciplinary research.

It is important to note that this study is exploratory in nature, reflecting the current state of the field; there is neither a standard definition of interdisciplinarity, nor a commonly accepted set of outcomes that one might expect from interdisciplinary training and research. The study also draws only from PI and trainee self-reported perceptions and experiences, and only from a small number of purposively selected IGERT projects; as a result, the study's findings are not necessarily representative of all IGERT participants, projects, or grantee institutions.

Major Findings

Congruence about Skills Needed to Conduct Interdisciplinary Research

The six skill areas suggested by the study's literature review, and deemed critical for conducting interdisciplinary research, were confirmed by both PIs and trainees as the primary skills they each believe are important.

- Both PIs and trainees rated the six interdisciplinary competencies quite similarly; a substantial majority (85 percent or more) of both groups characterized four of six competency areas as important or very important.
- The two competency areas rated as important or very important by the largest number of PIs and trainees included the ability to communicate research in one discipline to researchers trained in others (95 and 99 percent of PIs and trainees, respectively), and the capacity to work in a team setting with researchers from other disciplines (92 and 98 percent of PIs and trainees, respectively).
- Nearly all trainees (99 percent) and PIs (87 percent) indicated that the ability to understand both contributions and limitations of different disciplines, and the capacity to apply multidisciplinary approaches and tools (86 and 96 percent, respectively, of PIs and trainees) were essential in an interdisciplinary research setting.
- Slightly fewer respondents, though still a large majority, of both PIs and trainees rated substantial depth of knowledge in one discipline and the ability to communicate interdisciplinary research to non-technical audiences as important or very important for conducting interdisciplinary research (89 and 70 percent, and 73 and 85 percent, respectively, for PIs and trainees).
- Both PIs and trainees suggested that other skills are also important, including intellectual curiosity and open-mindedness. Trainees commented that interpersonal traits and transferable skills were essential for conducting interdisciplinary research.

PI and Trainee Ratings: How Important Are Selected Skills for Interdisciplinary Research?

Interdisciplinary Competency	Important/Very Important	
	PI Ratings N (%)	Trainee Ratings N (%)
Ability to communicate research based in one discipline or field of study to academic researchers trained in different disciplines	37 (95)	427 (99)
Ability to work in a team with individuals trained in different disciplines	34 (92)	423 (98)
Depth of knowledge in one discipline or field of study	34 (89)	302 (70)
Ability to recognize the strengths and weaknesses of multiple disciplines	33 (87)	426 (99)
Ability to apply the approaches and tools from multiple disciplines to address a research question	32 (86)	412 (96)
Ability to communicate about interdisciplinary research to nonacademic audiences (laypersons)	27 (73)	367 (85)

Notes:
39 PIs were asked these questions. Number of PI responses to individual questions ranged from 37 to 39.
431 trainees were asked these questions; all 431 answered these questions.

Exhibit reads: Thirty-seven of PIs (95 percent) described "the ability to communicate research based in one discipline or field of study to academic researchers trained in different disciplines" as important or very important. A total of 427 trainees (99 percent) described this competency as important or very important.

IGERT PIs Seek Flexibility, and Then Use Distinct Activities to Prepare Trainees

PIs reported that they look for specific qualities and experiences in prospective IGERT trainees, including a strong academic background, interest and commitment to interdisciplinary research, prior research experience, and a flexible approach towards interdisciplinary academic research. Once trainees begin to participate in IGERT projects, PIs translate program goals into structured activities, and the trainees experience a wide array of graduate school learning experiences.

- PIs prioritized several concrete activities that most serve to develop trainees' capacities to conduct interdisciplinary research: interdisciplinary courses, laboratory and field experiences, and interdisciplinary team research projects. While not as common across projects, outreach activities represented the chief avenue through which PIs develop trainees' capacity to communicate research to non-technical audiences.
- The vast majority of trainees reported that they had participated in the following four IGERT activities: courses and seminars in multiple disciplines (97 percent), interdisciplinary courses (95 percent), hands-on laboratory and/or field experiences in disciplines related to the IGERT project (84 percent), and interdisciplinary team research projects (82 percent). Just over half (60 percent) indicated that their IGERT training helped them gain depth of knowledge in a single discipline.

Most Frequently Reported Activities PIs Use to Develop Interdisciplinary Skill Areas

Specific Activity Type	Interdisciplinary Competencies				
	Strengths and Weaknesses	Application of Tools	Team Work	Communicate to Researchers	Communicate to General Audiences
Interdisciplinary courses	25	24	13	26	8
Laboratory/field experiences	14	17	7	4	3
Interdisciplinary team research	9	10	15	3	0
Outreach activities	3	0	4	1	22

Notes:

39 PIs responded to questions about the activities used.

Exhibit reads: Of the 39 PIs interviewed, 25 reported that their projects use interdisciplinary courses to develop trainees' abilities to recognize the strengths and weaknesses of multiple disciplines.

Trainees Find IGERT Activities Helpful, and Are Confident in Their Interdisciplinary Research Skills

- Trainees' reports on those activities most helpful in developing interdisciplinary competencies were remarkably consistent with PI responses: over four-fifths of trainees reported that interdisciplinary courses, laboratory and field experiences, interdisciplinary team research projects, and courses and seminars in multiple disciplines were helpful or very helpful. The same pattern was evident in both trainees' and PIs' responses about outreach activities as the mechanism for learning to communicate research effectively to lay audiences: 90 percent of trainees rated outreach activities as the most helpful activity for that skill area in particular, as did over half of PIs.

> **"The IGERT training helped me to get out of my comfort zone and learn about how interdisciplinary research is important as a new model for scientific research, thus giving me an understanding of life cycle analysis, economics, policy and conversion technologies."**
>
> ***- IGERT Trainee***

- The majority of trainees reported that they were confident about all six skill areas, ranging from over 90 percent confident or very confident about their ability to work in interdisciplinary teams and to communicate research in one discipline to researchers trained in other disciplines, to 71 percent who were confident or very confident about applying approaches and tools from multiple disciplines to address a research problem.
- Examination of differences in trainees' responses by gender revealed no significant differences. Trainees who indicated they were closer to graduation, however, were more confident about their capacity to conduct interdisciplinary research, and not surprisingly, had participated in a larger number of IGERT activities.

Trainee Ratings: How Helpful Are IGERT Activities in Developing Interdisciplinary Competencies?

Interdisciplinary Competency	Helpful/Very Helpful N (%)
Ability to communicate research based in one discipline or field of study to academic researchers trained in different disciplines	381 (88)
Ability to work in a team with individuals trained in different disciplines	378 (88)
Ability to apply the approaches and tools from multiple disciplines to address a research question	372 (86)
Ability to recognize the strengths and weaknesses of multiple disciplines	370 (86)
Ability to communicate about interdisciplinary research to nonacademic audiences (laypersons)	305 (71)
Depth of knowledge in one discipline or field of study	261 (61)

Notes:

431 trainees were asked these questions; all 431 answered these questions.

Exhibit reads: 381 trainees (88 percent) reported that their IGERT training has been helpful in developing their "ability to communicate research based in one discipline or field of study to academic researchers trained in different disciplines."

IGERT Leads to Accomplishments, Some Challenges for Trainees

PIs and trainees also shared their perspectives about both project accomplishments and challenges.

- PIs attributed a number of accomplishments to IGERT, including helping to foster an intellectual community in which students collaborate to carry out meaningful research, engaging both IGERT and other students and faculty, and contributing to increased prominence of interdisciplinary research.
- PIs credited IGERT as a springboard for longer term institutional change, to generate new research directions for faculty, and in one case, to help establish an entire interdisciplinary department within the host university.

> **"When we have engineers and scientists and philosophers and Native American studies people in the same class, they learn to communicate with each other and develop a shared vocabulary and a dialogue develops around core concepts."**
>
> ***- IGERT PI***

- According to PIs, the two most common challenges faced by trainees are balancing IGERT-related and home department-related demands, and the steep learning curve associated with learning new disciplines. A minority of trainees reported similar challenges; the most frequently cited challenges were increased workload due to IGERT participation, and trouble balancing IGERT and home degree/department demands (28 and 17 percent, respectively).

Summary

There is evidence that IGERT PIs and trainees perceive the study's six interdisciplinary competencies similarly. PIs indicated that they rely on distinct training activities, and IGERT students described those activities as helpful in developing interdisciplinary research skills. The intellectual community that IGERT fosters was acknowledged by PIs—as both strengthening the presence of interdisciplinary exchange on their respective campuses, and creating a mechanism by which both PIs and students can engage in research that draws upon and integrates multiple disciplines in a structured setting.

This exploratory study's findings inform a collective understanding of how interdisciplinary research competencies are defined, operationalized and experienced in IGERT settings, and hopefully it also can offer insights and directions for future inquiry. The study findings may also provide useful program knowledge for NSF about how PIs conceptualize interdisciplinary training, and how trainees experience IGERT activities as vehicles for becoming interdisciplinary researchers.