



CHAPTER 2

Transformative Achievements in Education – IGERT Trainees

The integration of cutting edge research and education provided by all IGERT programs is the epitome of the NSF vision of “advancing discovery, innovation and education beyond the frontiers of current knowledge, and empowering future generations in science and engineering.”

– NSF Strategic Plan

The NSF strategic outcome centered around learning with its six investment priorities forms the foundation for both the IGERT solicitation and the information collected in the annual reports of all IGERT projects as applied to education. Indeed, at the heart of IGERT are two of the sub-goals of the NSF goal of learning: integrating research and education to build capacity and to prepare a diverse and globally engaged STEM workforce.

- One-hundred twenty-two (122) of the 136 IGERTS reported 328 educational achievements for their IGERTs directly addressing the sub-goals in the form of new degrees and unique courses, workshops, and seminars for trainees and other university students. New degrees, certificates, and courses are a result of the integration of research with education in which the interdisciplinary nature of the research calls for new paradigms in education, and are summarized in Table 2.
- Tables 3-5 summarize the range of training in communication preparation, preparation to conduct research, and developing professional skills applicable to careers in industry, government, or the private sector.
- Two-hundred four (204) trainees reported internship experiences. Of 116 IGERTs that have reported industrial and governmental partners or collaborations in the past, 21 (18.1%) reported active ties in 2006-2007 with industry ranging from industrial provision of facilities for research, research collaborations, and exchange of personnel. Thirty-nine (39) (33.6%) of the 116 IGERTS reporting active partnerships or collaborations in 2006-2007 report having partnerships with nonindustrial organizations including government labs and agencies, universities, foreign entities, and nonprofit organizations.
- Of the 136 IGERTs reporting in 2006-2007, 43 (31.6%) have reported a total of 82 international experiences.

The IGERT 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 in a fertile environment for collaborative research that transcends traditional disciplinary boundaries. It is also intended to facilitate diversity in student participation and preparation, and to contribute to a world-class, broadly inclusive, and globally engaged science and engineering workforce.

IGERT Solicitation

The remainder of this chapter will provide detailed information on:

- Evidence for the integration of research and education
- Training preparation for communicating their STEM research and experiences
- Career preparation experience
- Preparation to conduct research
- International experiences

The examples will describe how the reporting 136 IGERT projects for 2006-2007 have addressed the

investment priorities as described for learning in both the NSF Strategic Plan and the IGERT Solicitation: integrating research with education; forming partnerships with industry, government and nongovernment organizations; and preparing a global workforce.

NSF Investment Priority: Integrate Research with Education and Build Capacity

Graduate courses, seminars, workshops, new degree and certificate programs from IGERT

One-hundred twenty-two (122) of the 136 IGERTs submitting an annual report in 2006-2007 (89.7%) reported 328 educational achievements including new courses, seminars, degree programs, and certificate programs. (See Table 2.) Many of these educational achievements were developed by IGERT trainees.



Table 2: New Courses, Degrees, Certificates, Workshops, Seminars, Conferences & # Trainees Involved With Course Development

# New courses	# New degrees or certificates	# Workshops, seminars, conferences	# Trainees reporting involvement with course development
80	16	81	573

Examples of the integration of research and education include:

□ An IGERT developed new courses to integrate nanostructure fabrications, atomic scale characterizations, and materials theory into a cohesive interdisciplinary research program about the interfaces and defects that play an important role in the performance of modern electronics. The courses were required for trainees but open to all graduate students, exposing many students to interdisciplinary research. The courses included

nanostructure characterization techniques, theory of inorganic nanostructures for device applications, and ethics. (0549417: Shih, University of Texas Austin)

□ Two new courses were developed to train students to investigate biological systems spanning wide temporal and spatial scales from atoms and macromolecules to cells, organs, and organisms. These courses require facility in applied

mathematics and computer science. The courses are a bioinformatics course that pairs computer science and math students with biologists, and a statistical analysis of genomic data course that enrolls computational biology, computer science, math, and biology graduate students. (0333389: Shelley, New York University)

□ A new doctoral degree curriculum has been established in Wind

Science and Engineering to produce professionals who, through careful planning, effective public policies, and good engineering, may be able to reduce losses caused by hurricanes, tornadoes, and other violent storms. Graduate students will take courses in meteorology, engineering, system theories, economics/risk management, GIS, statistics, and leadership/ethics with a 4-month external lab rotation. (0221688: Mehta, Texas Tech University)

□ The combination of interdisciplinary science education with entrepreneurial and business training on how polymer science and medicinal chemistry can synergistically extend the methods of making and evaluating new materials, new bioactive agents, and new applications of biomaterials is so successful that the University of Southern Mississippi now

offers a graduate minor in Technology Commercialization and the collaborating University of Mississippi offers the same program as a certificate. (0333136: Wicks, University of Southern Mississippi)

□ Access to a wide range of researchers in the field of nanoparticles is made available to trainees through a seminar offered by an IGERT with a research focus on nanoparticle science and engineering that addresses the development of enabling computational and characterization tools that will form the foundation for research in application-oriented areas focusing on new materials, devices, and the environment. In addition to this opportunity to develop leadership skills interacting with leading scientists in the field, trainees also participated in a symposium with the Industrial Partnership for Research in Interfacial and Materi-

als Engineering (Iprime) consortium, developing communication skills by giving oral and poster presentations to visitors from industry and academia. (0114372: Kortshagen, University of Minnesota Twin Cities)

□ Through an interdisciplinary program on optical science and engineering, trainees entered the Colorado Photonics Industry Association Poster Competition. Trainees attended the annual poster exhibit and learned about the latest in photonics research. Trainees also attended an optics seminar, where a diverse array of speakers from industry, academe and business furthered the trainees' global and interdisciplinary education. (0333453: Anderson, University of Colorado Boulder)

NSF Investment Priority: Prepare a Diverse and Globally Engaged STEM Workforce

Professional preparation in communication, skills to conduct high quality research, and skills applicable to careers in government or the private sector

Table 3 summarizes the extent to which IGERT trainees have had the opportunity to gain skills in various

methods for communicating science and technology. Numbers are “number of trainees” out of

1,519 reporting a given experience in the 2006-2007 reporting year.

Table 3: Professional Preparation in Communicating Science and Technology

Training and coursework in professional writing	Training and/or coursework in professional speaking and/or presentation skills	Presentation made at the IGERT institution	Professional conferences attended	Poster sessions and/or presentations outside the IGERT institution	Oral presentations outside the IGERT institution
324	430	1,032	1,018	676	705
21.3%	28.3%	67.9%	67.0%	44.5%	46.4%

Table 4 illustrates the range of skill to which IGERT trainees have been exposed to examples of the breadth of training required to conduct high quality research. Data are “number of trainees” reporting for each theme.

Table 4: Professional Skills to Conduct High Quality Research

Training/coursework in responsible conduct of research	Training/coursework in research methods	Training/coursework in state-of-the-art instrumentation	Participation in research projects within your own discipline area but outside your dissertation research
572	581	555	793
37.7%	38.2%	36.5%	52.2%

A key part of IGERT is to give graduate students uniquely trained in transformational interdisciplinary research the opportunity to gain professional skills to help them use their scientific training across a broad range of career options. Table 5 summarizes examples of such experiences for IGERT trainees in 2006-2007.

Table 5: Professional Skills Applicable to Careers in Industry, Government, or the Private Sector

Participation in any interaction between academic research and industrial applications or between academic research and public policy development or application	Training/experience in communications across disciplines and with different audiences (including the general public)	Education interactions (e.g., courses, workshops, seminars) with industry professionals or with government or other public-sector professionals	Research interactions (other than internships) with industry professionals or with government or other public-sector professionals
347	563	379	310
22.8%	37.1%	25.0%	20.4%

NSF Investment Priority: Prepare a Diverse and Globally Engaged STEM Workforce
Partnerships and collaborations

One-hundred sixteen (116) of the 136 IGERTs reporting in 2006-2007 indicate collaborative arrangements of various types during the life of the IGERT. Table 6 summarizes the data for active industrial and nonindustrial collaborations for 2006-2007.

Table 6: IGERT Collaboration Arrangements for 2006-2007

# IGERTs with partnerships with industry	# IGERTs with partnerships with nonindustrial organizations
21 (18.1% of 116 reporting IGERTs)	39 (33.6% of 116 reporting IGERTs)

Examples of the efforts of IGERTs in preparing a diverse and globally engaged STEM workforce through partnerships with industry and nonindustrial organizations include:



□ An industrial partnership with Aptima, a company specializing in solving the problems of human performance in today's complex sociotechnical systems, resulted in trainees conducting collaborative research in the area of computational analysis of social and organizational systems and becoming conversant with the role of scientists in industry. (9972762: Carley, Carnegie Mellon University)

□ An IGERT that is studying the functioning of regional systems through an integration of the tools and approaches of ecology, economics, anthropology, climate dynamics, and philosophy in a systems framework is partnered with British Petroleum (BP), an industry that operates about half of the oil fields in Prudhoe Bay, Alaska. BP supplies facilities for project activities and BP staff work with IGERT project staff on collaborative research and teaching, as well as supporting the research of a trainee studying the effects of anthropogenic resources on raven distributions. (0114423: Chapin, University of Alaska Fairbanks)

□ The goal of training a new generation of scientists capable of designing and implementing solutions to environmental problems within the framework of human culture, economics, policy, and the law is closely aligned with the purpose of the Nature Conservancy, a nonprofit organization that works around the world to protect ecologically important land and water. IGERT and the Nature Conservancy are exploring risk assessment and management of Great Lakes invasive species, partnering together to perform collaborative research involving staff and facilities exchanges. (0504495: Feder, Notre Dame)

□ The facilities of the Los Alamos National Laboratory were utilized for a trainee project involving the synthesis of novel uranium intermetallic compounds and characterization of their electronic properties by magnetic susceptibility, heat capacity, and electrical resistance measurements. The Los Alamos National Laboratory also provides personnel for collaborative research and teaching as well as the use of its facilities in this partnership. (0114443: Garrell, University of California Los Angeles)

□ A partnership with another Ph.D. granting institution is evidenced in Tuskegee's partnership with Cornell University. The two

institutions exchange faculty and students and participate in seminars and meetings to enhance Tuskegee's research and educational capability in the research area of materials science and engineering and to promote an increase in the number of underrepresented graduate students in that field. (0333380: Jeelani, Tuskegee University)



□ Ecole Polytechnique Federale de Lausanne in Switzerland is an example of a foreign-based partnership with an IGERT at the University of Texas, Austin. This IGERT has a research focus on cellular and molecular imaging for diagnostics and therapeutics. The two institutions collaborate on research and teaching, exchange facilities and staff, and host trainee internships, allowing trainees to experience scientific research with a global perspective. (0333080: Peppas, University of Texas Austin)

NSF Investment Priority: Prepare a diverse, globally engaged STEM workforce

Forty-three (43) (31.6%) of the 136 reporting IGERTs described 82 different funded international experiences, and a total of 98 IGERTS (72.1%) reported some type of international activity in the 2006-2007 reporting year. International activities range in scope from internships in foreign countries to volunteer activities to presentations at international conferences to conducting research in other countries.



Examples of international opportunities that help prepare a diverse, globally engaged STEM workforce are:

□ Research on the impact of conservation measures in Costa Rica resulted in not only an increased understanding of a foreign culture and its language, but the nature of the scientific enterprise in that culture. To aid in better international understanding and cooperation, trainees discussed their research findings with the local communities as well as presenting numerous papers at international meetings. (0114304: Bosque-Perez, University of Idaho)



□ A 10-month internship for an IGERT trainee at the University of Heidelberg, Germany, resulted in two talks, one to a collaboration of scientists working on understanding biological attachment and another to a European nanotechnology think tank, both about research on

the attachment of rat fibroblast to thermal responsive surfaces. This international experience provided the trainee with a global perspective on the practice of science. (0114319: Rudolph, University of New Mexico)

□ The opportunity to conduct research outside of the United States in the fields of geoscience, physics, tree-ring studies, and materials science in conjunction with archaeological theory and methods, has resulted in a trainee becoming a highly proficient interpreter of sedimentary sequences in cave deposits in Europe and Central Asia. These studies have resulted in an award-winning paper for the “Developing International Geoarchaeology” conference in Cambridge, United Kingdom. (0221594: Olsen, University of Arizona)

□ All trainees from one IGERT carry out their dissertation research in Latin America on issues relating to the use and conservation of unprotected tropical rain forests, providing them with the opportunity to work closely with indigenous populations, foreign government agencies, universities and other nongovernment organizations. (0221599: Zarin, University of Florida)

□ IGERT trainees teamed with faculty and students from Sichuan University and the science department staff from Jiuzhaigou National Park in China to conduct research for two weeks on the sanitation and wastewater treatment in the park. This led to research presentations at international conferences and an understanding of the intricacies of scientific research in China. (0333408: Hinckley, University of Washington)

□ Trainees conducted a survey of sites throughout Malaysia and Borneo to make a qualitative assessment of the conditions of coral reef sites spanning a gradient of forest conversion. The trip allowed the trainees to meet with researchers at Malaysian universities, government and nongovernment agencies, giving them a global perspective on a global problem. (0333444: Knowlton, University of California San Diego Scripps Institute)

□ An interest in understanding how humans create spatial patterns of vegetation within urban landscapes and how that structure impacts environmental and ecological processes led an IGERT trainee to produce a high resolution urban forest mapping classification scheme for Phoenix, Arizona. This technique has led to collaboration with worldwide scientists for use in other areas of the world and to a publication in the International Journal of Remote Sensing. (0504248: Redman, Arizona State University)

□ An IGERT trainee attended the Lindau Meeting, an annual, international gathering of Nobel Laureates and young researchers focusing on physiology and medicine. The meeting provided opportunities to network with the most accomplished international scientists in the world. The trainee will also collaborate with the winner of the 1991 Nobel Prize in Medicine and Physiology at the Max Planck Institute to develop new nanoscale imaging and sensing tools and apply them in the investigations of fundamental problems in cell

biology and neuroscience. (0549500: Osinski, University of New Mexico)

