

d. Education and Training

Our project will be based on the ‘Discipline-Plus’ model of Doctoral education: each Fellow in our program will be admitted to one of the participating discipline-based Doctoral programs, and must complete all the requirements of that Doctoral program. In addition, each Fellow must complete several additional IGERT requirements, including a core of required courses, develop proficiency in GIS software use and in mathematical foundations of the field, attend a fall orientation camp, attend a weekly IGERT colloquium, participate in a cross-department research experience, and complete an internship. If our international research internship supplement request is awarded, the trainees will also be required to attend an annual international summer school (Vespucci Summer school, described under section i.2. below), and substitute an international research internship for the domestic internship requirement. These program elements are described below.

d.1 Coursework

Each IGERT Fellow is required to take four core courses that build the intellectual core of the program and provide basic training in research. These core courses also are an important medium for cross-department collaboration and for establishing social networks among the IGERT Fellows. Three courses from the current program will be retained with minor modifications and the fourth will undergo major revision.

d.1.1. Introduction to Geographic Information Science

This course introduces students to the foundations of geographic information science, and all IGERT Fellows are expected to take this required course during their first semester. The course is normally taught by the Project Director, and includes non-IGERT as well as IGERT graduate students. The course introduces students to ontology and representation of the geographic domain, to data structures, spatial data standards, computational geometry, spatial reasoning, data quality, scale, interoperability, visualization, the GIS software industry, and societal impacts. The course also familiarizes students with research agendas in GIScience, and with the history of the field.

d.1.2. Ontology of the Geographic Domain

One of the unique elements of our program is explicit attention to the ontological underpinnings of the field. As noted in the research section of this proposal, ontology deals with the nature of reality and its representation in information systems. This fundamental topic is integrated into the program horizontally and vertically, through this required core course and as a key area for research. The next phase of our GIScience training program still will require all students to take an introductory course in geospatial ontology, offered by the philosophy department. However, the course will be modified in order to strengthen its introduction to ontology as it is implemented in information systems.

d.1.3. Spatial Databases

Spatial databases are a fundamental component of GIS technology. All students in our IGERT program are required to take a spatial database course. Courses are offered in both the computer science and engineering department and in geography that fulfill this requirement.

d.1.4. Ethics and Professionalism

The fourth core course required of all IGERT Fellows is a new course in research ethics and professionalism. For the last five years, we have required IGERT Fellows to take a pre-existing research ethics course. However, we have found that this course has a very strong emphasis on medical research ethics. For this reason, we will develop a completely new course that will teach our IGERT trainees about research ethics, using examples from geographic information science and the environmental and social sciences. In the same course, we also will provide training in other aspects of professionalism for scientists and engineers, including business practices, intellectual property, grant writing, and presentation skills. The details of this new course will be developed during the first

year of a new funding period, supported by the grant's support of faculty release time for development of new curricula.

d.2 GISystems Proficiency

Although the core of our program is Geographic Information *Science*, not Geographic Information *Systems*, the research agenda in the field is to some extent driven by the strengths and deficiencies of current GIS software. Thus, all students in the program must be familiar with GIS software. Proficiency in the use of GIS also will improve the marketability of program graduates in most employment sectors and disciplines. The GIS proficiency requirement can be satisfied by transcript, by training, or by GIS courses.

d.3 Mathematics Proficiency

Familiarity with the mathematical foundations of Geographic Information Science is a new program requirement. Students will be able to meet the mathematics requirement by taking a new multidisciplinary course in mathematical foundations for GIScience, or by transcript. This new course will be developed under the program, and will be a team-taught course based in the Engineering School. Details of the proficiency will be developed before the first new students are admitted to the program.

d.4 GIScience Orientation Camp

Each trainee will begin the program by participating in a new program orientation of approximately 3 days, conducted off campus in the late summer just before the semester begins. This orientation will be held in the Buffalo area, and will include IGERT Faculty and new and continuing students in the program. The orientation will include presentations by faculty about their research interests, and will orient the students toward the major elements of the program, its goals and expectations, build group collegiality, and develop faculty-student networks both within and across departments.

d.5 IGERT Colloquium

All IGERT Fellows and other students in the associated institutional certificate program (described below under section e.2) will continue to be required to attend a weekly IGERT colloquium. The colloquium will continue the model developed under the initial IGERT program, and feature a mix of visiting speakers, research presentations by the Fellows, local faculty research talks, workshops on other aspects of interdisciplinary professionalism, and business meetings of the graduate student club GISMO (*Geographic Information Science Multidisciplinary Organization*). In the new program, we will also include at least one session per semester devoted to career development talks or activities. The colloquium is important in maintaining connections among students and faculty in the program.

d.6 Cross-departmental Research

One of the most successful elements of our current GIScience IGERT program is the requirement that students become involved in research outside their home departments; we will maintain this component in the new program. Each IGERT student will thus be required to obtain in-depth familiarity with research approaches in another discipline by spending at least one semester working on an active research project under the supervision of a faculty member, normally from another IGERT department. This activity simulates the laboratory rotation familiar in research training in medical and other large-scale laboratory sciences, an option not normally available in the social and environmental sciences. Most trainees formalize this cross-department research immersion by registering for 'independent study' with the faculty mentor.

d.7 Internship

All trainees in the program will be required to complete an internship. If additional funds to support international activities are awarded to this project, all trainees in the program will be required to complete an international research internship, which will fulfill this more generic internship requirement. (More detail regarding international research internships is presented in Section i.1,

below.) Otherwise, the majority of the trainees will fulfill the internship requirement domestically, with international research internships encouraged as funding allows or through supporting student efforts to acquire supplementary funding. Internships are intended to be career-enlightening experiences, conducted in environments different from that of a US research university, exposing students to alternative career paths. Students returning from internships will be asked to present their experiences and outcomes to the rest of the IGERT group at a weekly colloquium session.

In the past five years, trainees have completed a diverse range of internships, working as GIS experts in community-based projects, conducting ecological fieldwork, and working in the planning department of a town government. Internship hosts under for our current fellows, and who will be recommended to future students, include the U.S. Military Academy at West Point, the Town of Amherst, NY, the Buffalo Police Department, the Buffalo Neighborhood Revitalization group/the University-Community Initiative of the University at Buffalo; Syracuse Research Corporation and the U.S. Fire Service, among others. We have also well established links with other potential intern hosts, including Environmental Systems Research Institute (ESRI), Oracle, and Cycorp, Inc.

d.8 Typical Student Pathways

The typical student pathway through the program will vary, based on the individual trainee's background as well as the requirements of the different home academic departments. However, we have found that our past practice of individually tailoring programs, and providing flexibility as needed, has worked well in enabling our students to satisfy both home department and IGERT requirements, and maintain a steady progress toward their degree.

Students in the IGERT program will normally be expected to complete their four required core courses, and satisfy the proficiency requirements in GIS and mathematics within the first two years of their doctoral programs. For students in departments with structured course requirements, provisions will be made to allow the students additional time to complete the core courses. Since the core courses can be counted as electives by all participating academic departments, they will not necessarily add to the student's overall coursework load.

The cross-departmental research immersion is recommended for the student's second year, or the summer after the second year. This gives the student additional exposure to interdisciplinary research prior to completing their coursework or formulating their dissertation topics, thus allowing them time to pursue new avenues that may be opened to them due to the additional cross-training. The internship or international research internship is recommended for the summer after the student's third year of study. As mentioned previously, however, these are guidelines and each student's specific path through the program may vary according to individual needs.

The internship requirement (or international research internship requirement), as well as the cross-departmental research immersion requirement are supplementary to the requirements typically imposed by the home academic departments. Under our current IGERT program, however, we found that the quality of the students, coupled with the fact that they do not have work obligations as fellows, offset any additional burden imposed by IGERT requirements and they are making about the same rate of progress toward their degree as other students in their home academic departments.

d.9 Role of Diversity

Diversity is an integral part of all aspects of the program, and is addressed throughout this proposal. We plan to foster intellectual, disciplinary, and individual diversity. Specifically, we will make efforts to recruit and retain a diverse student body, and to provide programmatic support for students from underrepresented groups. We will also incorporate a personally and academically diverse group of faculty, and include representatives of various disciplines, professions, and backgrounds on our Advisory Board, whose members serve as supplementary mentors to our students.