NEW MODES OF MULTIDISCIPLINARY DOCTORAL EDUCATION: THE CASE OF THE WATER AND SOCIETY IGERT

BY CHRIS M. GOLDE

&

HANNA ALIX GALLAGHER

UNIVERSITY OF WISCONSIN-MADISON

A paper presented at the 24th annual conference of the Association for the Study of Higher Education, November 19, 1999, San Antonio, Texas

INTRODUCTION

In recent years there has been increasingly vocal criticism that Ph.D. programs are turning out students who have overly specialized knowledge and minimal intellectual breadth, and who are thus unprepared for a wide range of careers. This is of concern because doctoral programs serve the critical function of training the next generation of professors who work in the academy and researchers who shape future scholarship (Council of Graduate Schools, 1990). Additionally, people with Ph.D.s often take leadership roles throughout society. People who can work with colleagues trained in a variety of fields, and who can work on difficult problems that require skills from many disciplines, are in great demand. Universities are, however, notoriously slow to change and most doctoral programs are still encouraging students to pursue highly specialized training.

Nonetheless, there are efforts that counter the dominance of highly specialized, disciplinary doctoral education programs. There are a variety of inter- and multidisciplinary programs on many campuses at the undergraduate, as well as graduate, levels. While the literature contains descriptions of programs, there are few critical assessments of these programs, especially at the graduate level. Particularly scarce are evaluations that analyze the experiences of students and the challenges faced in the process of creating such programs. With this paper we seek to address this gap.

BACKGROUND

CRITIQUES OF DOCTORAL EDUCATION: CALLS FOR CHANGE

The American system of doctoral education is internationally recognized for providing excellent, highly-specialized training that prepares future researchers and professors. This educational system has, however, come under criticism for giving students a narrow range of experiences, thus leaving them ill-prepared for the current job market. In particular, leaders of business and industry have emphasized the need for new Ph.D.-holders to be able to work in interdisciplinary settings and on interdisciplinary research teams. National leaders in science policy, for example, have called for scientific training that enhances "such attributes as versatility, a willingness to pursue a broad range of career options, . . . and the ability to work in groups and integrate science and technology to meet the needs of industry and other sectors" (Good and Lane in Nowak, 1997, p. 1). Similarly, the Modern Language Association called for humanities Ph.D.s to apply their skills in settings beyond academia (Modern Language Association, 1998).

The most prominent recent critique of traditional doctoral education, the 1995 National Academy of Sciences COSEPUP report, focused its attention on the sciences and engineering. The report documented the narrowness of research focus for Ph.D. students in the sciences, described how that ill-prepares students for the growing market of applied research careers, and drew a link to the declining academic job market in science and engineering fields (Committee on Science Engineering and Public Policy, 1995). The report issued a clarion call:

> Graduate education should prepare students for an increasingly interdisciplinary, collaborative, and global job market and should not be viewed only as a byproduct of immersion in an intensive research

> experience. . . . What is needed is not additional specialization. We need a graduate system that is well tuned to the central feature of contemporary life: continuous change. … Our objective, therefore, is a breadth of experience so that graduates can keep career options open and have the capacity to switch career tracks both at the beginning of and throughout their professional lives. (Committee on Science Engineering and Public Policy, 1995, p. 83)

The Ph.D. is, at its core, a research degree, designed to prepare students to become scholars. At the conclusion of the degree program, "the student should have acquired the knowledge and skills expected of a scholar who has made an original contribution to the field and has attained the necessary expertise to continue to do so" (Council of Graduate Schools, 1990, p. 1). One strategy, then, for creating interdisciplinary researchers is to teach doctoral students to do interdisciplinary research by placing interdisciplinary research at their center of doctoral programs.

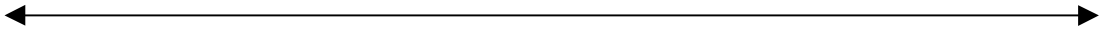
INTER- AND MULTI-DISCPLINARY DEFINED

In describing research that crosses disciplinary boundaries, two terms, "multidisciplinary" and "interdisciplinary" are generally used. Multidisciplinary research involves bringing several disciplines to bear upon a single problem. People bring separate theories, skills, data, and ideas to bear on a common problem, which is often broken into constituent parts that team members can tackle individually. It is frequently a cooperative process, where a scholar from one discipline seeks help from others in different disciplines to answer a question (Heberlein, 1988; Laslett, 1990).

Interdisciplinary research, by contrast, involves bringing together people and ideas from different disciplines to jointly frame a problem, agree on a methodological approach, and collect and analyze the data. Both interdisciplinary and multidisciplinary research are based on the traditional disciplines, but interdisciplinary research also involves some sort of "synthesis or integration" (Newell,

1984, p. 126). These are not mutually exclusive categories; rather they are two points on a continuum that defines ways to conceptualize and conduct research, as shown in Figure 1. In this paper we adhere to these conceptual distinctions, while recognizing that the boundaries between them are fuzzy. We use the term "cross-disciplinary" to include the terms multi- and interdisciplinary together.

Figure 1: Continuum of research strategies



Single discipline-based Multi-disciplinary Inter-disciplinary

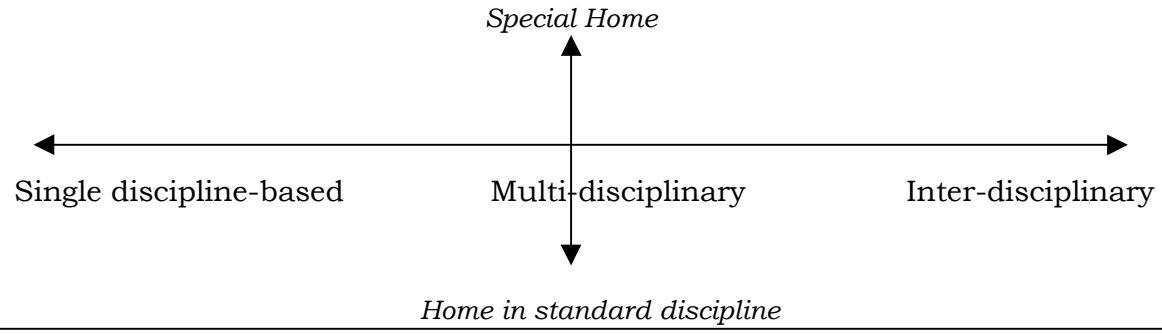
Some faculty members and their students conduct interdisciplinary research from within traditional disciplines. Evidence for the success of much of this work lies in the development and institutionalization (in the form of academic departments) of new disciplines, such as neurosciences, women's studies, and materials science. In addition, mechanisms to foster multi- and interdisciplinary research have been created within universities. A number of interdisciplinary degree programs have been created at the undergraduate, master's and, to a lesser extent, doctoral level (Fallon, 1978; Hellweg & Churchman, 1979; Lange, 1984; Masten, 1979; Miller & McCartan, 1990). Many of these programs are in environmental fields (e.g., Bryant, Crowfoot, Gregerman, Kaplan, Nowak, & Stapp, 1987; Christensen, 1987; Perrine, 1982). Research centers, such as the federally-funded Engineering Research Centers, Area Studies Centers, or problem-centered Centers (e.g., Environmental Studies, Poverty Research), on the other hand, often take a multidisciplinary approach to research. Taking another approach, the University of Wisconsin-Madison has recently committed to hiring "clusters" of faculty whose research dovetails in the interstices of

traditional disciplines (Christianson, 1999). In short, cross-disciplinary research is considered the source of many of the most exciting and fruitful findings.

CATEGORIZING DOCTORAL PROGRAMS

This continuum of research can also be used to categorize doctoral training programs (see Figure 2). The vast majority of doctoral programs fall under a single discipline, e.g., history, biology, or anthropology. The strengths of this mechanism are clear paradigms for inquiry, established criteria for evaluating research, and well-developed mechanisms for teaching and advising. Although many programs require students to minor in another department, the minor typically requires only a few courses and rarely adds significant breadth to the students' doctoral program. Thus discipline-based doctoral programs are often criticized for encouraging students to become over-specialized.

Figure 2: Continuum of doctoral programs



At the other end of the continuum are interdisciplinary programs. As described earlier, interdisciplinary research involves merging the paradigms and techniques of two or more disciplines to form a new way of defining and investigating problems. It implies a high level of interaction between disciplines and often involves developing new paradigms

of inquiry and understanding. Ultimately, interdisciplinary doctoral programs are institutionalized as free-standing academic departments and doctoral programs. Prominent examples in the 20th century are biochemistry and computer science.

The least understood position in this continuum is the nebulous middle: multidisciplinary doctoral programs. Frequently, multidisciplinary doctoral programs are organized so that students take courses in several departments to gain a broad understanding of a problem from multiple perspectives. One example of this is environmental studies programs. These students are typically housed in a center or special program. One common critique of this strategy is that students often get a shallow understanding of each traditional discipline (e.g., Schneider, 1999). An alternative strategy—as depicted in Figure 2—for organizing multidisciplinary doctoral education involves locating students in traditional disciplines, but bringing them together around a set of problems and teaching them to collaborate and communicate across disciplinary boundaries. (This is the model that faculty members follow in research centers, such as area studies.) This approach builds on the strengths of disciplinary-based education, while providing a broader multidisciplinary intellectual environment. It is with the latter model that this paper is particularly concerned.

APPLICABLE LITERATURE

Two literatures seem particularly suited to provide insight into understanding the strengths and struggles of creating and implementing multidisciplinary doctoral education programs. The first is the literature on interdisciplinary research, which generally written by established scientists whose research has evolved in interdisciplinary directions. This literature points out some of the pitfalls and struggles experienced in the process of doing IDR. Whether these struggles would be felt by

doctoral students as well, is an open question. The second literature is that on doctoral education. This literature reveals the features of the system, and their underlying catalysts, which serve to keep the current system of discipline-based research firmly in place. This literature raises questions about how realistic it is to institutionalize cross-disciplinary doctoral programs.

KNOWN PROBLEMS WITH IDR

Scholars and those who have participated in interdisciplinary research projects (the literature seems to favor writing by scientists) have noted several obstacles facing researchers conducting cross-disciplinary research. First, and perhaps most important, is the lack of existing conceptual frameworks within which to fit interdisciplinary research. Emerging interdisciplinary areas may not benefit from established theoretical frameworks, which can in turn slow the progress of the research. In addition, interdisciplinary research requires inductive approaches. There is no "cookbook" of procedures for tackling interdisciplinary research (Pickett, Burch, & Grove, 1999; Redman, 1999; Turner & Carpenter, 1999). As scientists look to standard disciplinary approaches, frameworks emanating from the social sciences are not give the same prestige or weight as those from the natural sciences. Thus paradigm conflicts, and attendant power struggles, can arise within interdisciplinary research teams (Heberlein, 1988).

Much cross-disciplinary research is done in teams, and another challenge facing those conducting multidisciplinary research is establishing an effective team. The first step is, of course, finding people with whom to collaborate (Heberlein, 1988). Once potential team members have been identified, they must blend into an effective team. The necessary elements of an effective research group include trust, respect,

understanding, and the ability to communicate. When a team is multidisciplinary, these components are more important, and establishing them is more time consuming (Daily & Ehrlich, 1999; Heberlein, 1988; Naiman, 1999; Pickett et al., 1999; Turner & Carpenter, 1999). Over time, of course, conflicts over power and control can arise among researchers, which requires group members to be ever alert to the interpersonal dynamics among the team members (Heberlein, 1988).

Third, those interested in conducting cross-disciplinary work may find it more difficult to find funding than those who are working in the center of an established discipline (Heberlein, 1988; Naiman, 1999; Turner & Carpenter, 1999; Wear, 1999). It is possible, with increased recognition of the value of interdisciplinary and multidisciplinary approaches, that funding problems may be easing.

Fourth, among authors, care must be taken to assure that the writing does not require knowledge of specialized citations, methods, or language in one's own discipline. Language is important because scientists speak in dialects that are specialized to their disciplines. Unfortunately, these dialects can at times sound very much like common language, leading the uninitiated reader to the mistaken conclusion that she understands what is being said. Thus, the time necessary to learn about other disciplines and their vocabulary can be another obstacle among interdisciplinary researchers (Naiman, 1999; Turner & Carpenter, 1999; Wear, 1999).

Finally, the norms of writing and reviewing research articles can be another obstacle faced by those conducting cross-disciplinary research. Finding appropriate places to publish nontraditional research is difficult. Traditional journals are often unwilling to publish cross-disciplinary work. Most journals that publish interdisciplinary work are relatively new and do not (yet) have large readerships or

world class reputations. For interdisciplinary research to be successful as science, and researchers to be successful as scientists, work must appear in reputable refereed outlets so that it receives the necessary peer recognition (Daily & Ehrlich, 1999; Heberlein, 1988; Turner & Carpenter, 1999).

In spite of these numerous drawbacks, many who write about their experiences in cross-disciplinary research find the experience to be very worthwhile. Many agree that the scholarship produced is often more innovative and groundbreaking. Another benefit is the opportunity to develop friendships (Turner & Carpenter, 1999).

How Might Doctoral Education System Constrain IDR?

Three interconnected features at the core of the contemporary American science doctoral education system have evolved together to push students into specialized disciplinary research. These features make multi-disciplinary programs particularly challenging. Here we summarize the arguments we made earlier (Golde & Gallagher, 1999).

First, academic departments—local manifestations of a discipline—are the primary locus of control for doctoral education. Departments have almost complete control and discretion to set admissions criteria, administer financial support, determine the curriculum, and set the standards for the various requirements that students must complete (exams, proposals, dissertations). Since departments are designed to foster knowledge within their discipline, and their reputation and resources flow from recognition within the field, it is in the department's interest to foster research that will garner accolades from within the field. This bias towards disciplinary, rather than interdisciplinary, research is expressed in departmental

policies. For example, dissertation committee members may be required to come primarily from within the department.

Second, students work for and with individual faculty members who can exercise enormous power over students' studies. The most important of these mentors is the advisor, who not only helps students design a course of study but also directs their research. In most of the physical and life science disciplines, students routinely become part of their advisor's research team and build their individual research on work done in the advisor's lab or group. The advisor's earlier research usually provides the intellectual foundation for the dissertation. As a result, a student has strong incentives to follow the research direction set by the advisor, typically located within the mainstream of the discipline. Furthermore, the advisor is often the sole arbiter of whether students have completed sufficient quality work to merit receipt of the degree. Consequently, the advisor can wield enormous control over many aspects of a student's professional life. The recent suicide of Jason Altom, at the time a doctoral student in the Harvard Chemistry department, and the issues he raised in his suicide note, provide dramatic evidence of this point (Hall, 1998). Unless the advisor is herself a cross-disciplinary scholar with ties across the university, students are likely to have little support for such research.

Lastly, further ties between advisors and students are created by the mechanisms that provide funding for research. Since WWII, the federal government has deliberately located most federally-funded research inside of universities (rather than in independent labs, as is the case in many other countries (Geiger, 1990; Gumport, 1993)) through research grants awarded to individual faculty members, who in turn use this money to fund their students' tuition and research expenses.

Combined, these organizational structures create barriers for students seeking to undertake cross-disciplinary research. Golde and Gallagher (1999) hypothesized five obstacles: finding a supportive advisor, locating a supportive intellectual community, mastering relevant knowledge in more than one discipline, reconciling conflicting methodologies, and overcoming fear of being unable to access traditional outlets for publication and academic employment. These fears stem from the experiences of the interdisciplinary researchers outlined earlier. Taken together, there appear to be many challenges—both those inherent in collaborative, cross-disciplinary research and those imposed by institutional structures and norms—facing programs attempting to prepare doctoral students for careers in cross-disciplinary research.

RESEARCH QUESTIONS

The model of multidisciplinary doctoral education in which students are located in traditional departments and then provided with mechanisms to work on common problems, is a relatively new strategy in doctoral education. It is certainly receiving focused attention, in the form of funding from the National Science Foundation. Several questions emerge when considering this model:

- Can the obstacles faced by interdisciplinary research scientists be overcome by doctoral students?
- Given the strong normative forces exerted by the existing system of disciplines and departments, what mechanisms help students become truly versed in many disciplines, while keeping students grounded in a traditional discipline?
- Can such an arrangement overcome the problems facing the "jack-of-all-trades" form of multidisciplinary doctoral education?

METHODS AND DATA SOURCES

Here we examine the questions raised above by examining one multidisciplinary doctoral program to which we have privileged access. This is the UW-Madison Social and Aquatic Systems IGERT program, a five-year program that has just entered its second year.

THE IGERT INITIATIVES: NATIONAL AND LOCAL

Partially in response to the COSEPUP report, in 1997 the National Science Foundation (NSF) offered about $50 million dollars nationwide for up to 20 five-year grants to create multidisciplinary Ph.D. programs under a cross-directorate initiative called "IGERT," for Integrative Graduate Education and Research Training. In the program announcement, the NSF wrote, "The challenges of educating scientists, mathematicians, and engineers for the 21st century mandate a new paradigm for training graduate students. . . . An effective multidisciplinary training environment is one that combines the strengths of various disciplines necessary to meet the challenges of a particular multidisciplinary research theme" (National Science Foundation, 1998). In the fall of 1997 the NSF received over 600 pre-proposals of which 17 were funded in the spring of 1998. The funded programs are as diverse as "Astrobiology: Life In and Beyond Earth's Solar System," "Program in Nonlinear Systems," and "Multidisciplinary Program in Inequality and Social Policy."

The University of Wisconsin-Madison received an IGERT grant for a program entitled "Human Dimensions of Social and Aquatic Systems Interactions," locally called the Water and Society IGERT (Social Aquatic Systems IGERT program, 1999). The goal of the program is to train students to better understand how people interact with the ecology of lakes and rivers. Ecological scientists now realize that the

sustainability of aquatic resources—clean, fresh water is essential for life—depends on interactions of social systems and ecosystems, and that such interactions are poorly understood (Nowak, 1997, p. 4). Consequently, the insights provided by social scientists are perceived to be particularly salient to this area of research, which has been previously dominated by researchers from the biophysical sciences. This program builds on existing cooperative research relationships between biological and social scientists at UW-Madison.

This program is notable among the IGERT projects funded the first year for two features: first it brings students and faculty together from the most widely disparate disciplines (social and biological sciences), and, second, it has an evaluation component incorporated into it.

The Water and Society IGERT program is designed to give students the necessary breadth to address complex environmental issues related to interactions between social and aquatic systems, while simultaneously avoiding many of the pitfalls of center-based multidisciplinary programs. Water and Society IGERT students follow the doctoral program in their home discipline, with the IGERT Program serving as a supplemental and enriching aspect of their training. This approach is intended to provide students with the disciplinary expertise necessary for success in scientific arenas both in and outside of academe, while at the same time offering training in collaborative, cross-disciplinary research settings. Seminars, collaborative research projects, and agency internships add breadth to students' training and give them experience in applied management, and expose them to theoretical arenas relevant to addressing cross-disciplinary research themes that are outside of their home

discipline. In particular, students are expected to "learn by doing," by participating in multidisciplinary empirical research projects in other disciplines (Nowak, 1997, p. 1).

The program is initially funded for five years, and two cohorts of trainees have been admitted; 10 trainees began in the fall of year 1, of whom two left school and one left IGERT, and 13 started in the fall of year 2. The current group of 20 trainees come from nine departments and programs in the social and life sciences: Sociology, Zoology, Oceanography, Limnology, Rural Sociology, Institute for Environmental Studies, Agricultural Economics, Land Tenure Center and Educational Administration. It is unlikely that another large cohort of trainees will start the program, although a few promising students may join the group. In addition, a postdoctoral fellow is funded through the grant, and this person is responsible for conducting their own research consistent with the IGERT themes, for the day-to-day administration of the program, and for providing intellectual mentorship and leadership to the trainees.

The evaluation component, dubbed the "wheel within the wheel," provides formative evaluation of the program. This paper is authored by the evaluators, as part of our research on the process of creating and implementing the program. One of us is a faculty member and sits on the executive committee; the other is an IGERT trainee and actively participates in student meetings and projects..

METHODOLOGY AND DATA SOURCES

It is the observations and insights we have gathered in the first 18 months of the program that serve as the primary data for this paper. We rely on the techniques of participant-observation, because we simultaneously participate in the program (on the Executive Committee and as a trainee) and study it. Thus our approach is neither

distanced nor disinterested. Instead, we are full participants in creating the project. This gives us total access to the project, but also has its share of pitfalls (Adler & Adler, 1998). One way that we maintain some critical distance is that we are not schooled in any of the disciplines embraced by the proposal. Instead, we are scholars of educational administration and higher education and bring expertise on graduate education (rather than ecology or sociology) to bear on IGERT. Thus we bring a very different set of lenses and concerns to bear—we are not concerned per se with the quality of the watersheds of Wisconsin, but with the experiences of the doctoral students and the administrative structures that support them.

We commenced our research from the inception of the program, and are thus in a unique position to study its formation, struggles, and evolution. We attended and tape recorded both Fall retreats, in which Professor Golde played a leadership role. We have been participants in all Executive Committee and trainee meetings. This gives us unique and valuable insights into the interactions between disciplinary cultures and the formation of the student, faculty, and 'IGERT-as-a-whole' communities. We meet regularly to discuss and analyze our observations.

In the spring of 1999, at the end of the first year, we conducted semi-structured interviews, each 25-75 minutes in duration, with all members of the executive committee and every student trainee. Our interview questions focused on how participants became involved in the program, expectations for the program, how participants conceptualized the multidisciplinary nature of the program, and how participants would define "success" for the program. Additional questions focused on the challenges and accomplishments of the program. Each interview was tape

recorded, transcribed, and analyzed for emerging themes and insights (Huberman & Miles, 1994).

Following the fall '99 retreat, we sent a short email question to all participants, asking: What did you learn on the retreat? The emailed responses are another source of data.

FINDINGS/ANALYSIS

Our findings are grouped into three categories. We start with a description of the project in the various phases that have unfolded to date, with an emphasis in the changing program requirements and structure. We then turn to three tension points that have emerged. We close with a short discussion of the benefits that participants argue that they are realizing. Following this overview, we turn to some analysis and implications for these findings, particularly in reference to the questions outlined above.

EVOLUTION OF THE PROJECT TO DATE

The program has had an evolving structure and set of expectations for students. In the proposal 12 program elements were identified, and each trainee was "expected to participate in this sequence of events, courses and activities" (Nowak, 1997, p. 21). These elements included: recruitment of quality candidates, orientation, co-location in offices, three seminars, an annual retreat, interdisciplinary research experiences, interdisciplinary graduate committees, an IGERT dissertation topic, internships in agencies, and participation in cross-disciplinary meetings.

Unlike many of the other IGERTs, the Water and Society IGERT admitted trainees and initiated the program with the start of the funding—whereas other

programs devoted the first year to planning and recruitment. This was considered possible because of the Principal Investigators' prior collaboration in the LTER (Long Term Ecological Research) program, a cross-disciplinary graduate program in existence for almost a decade, that has similar themes.

During the first year several of the aforementioned program elements were realized. Candidates were recruited from already enrolled or admitted students, particularly from among the faculty and departments represented on the Executive Committee. In addition, a retreat was held in the fall, at which expectations were created and outlined. In particular the expectations of an IGERT-related dissertation project and multidisciplinary dissertation committees were reiterated. Following the retreat, and under the leadership of the postdoctoral fellow, the students began meeting together as a group on a biweekly basis to read and discuss shared readings, and then began to design a joint research project. As the academic year ended, IGERT held a dinner bringing a dozen faculty members together with the trainees to discuss the proposed joint research project. On the other hand, during the first year no attempts were made at co-locating offices, organizing a seminar, arranging internships or providing a comprehensive orientation to the program.

As the second year has begun, the program is continuing to evolve. A second cohort of trainees joined the program, more of whom were first year doctoral students. All trainees are now meeting together in a seminar, one of the three outlined in the proposal. The seminar consists of a series of guest speakers from among the core faculty speaking on issues of scale, and small group projects by trainees. By the end of the first semester trainees are expected to form small interdisciplinary research

teams, and to formulate a testable hypothesis. In the spring, they will be expected to execute these projects, and then write up and publish their results.

In addition, a second retreat was held, with a more focused agenda. Before the retreat students received a collection of articles about interdisciplinary research, from Ecosystems (Turner & Carpenter, 1999). The group spent time getting to know one another, and began to establish respect and trust for one another. Both formal and informal activities fostered "getting acquainted." One topic of discussion was the expectations for trainees. The program was described as "a series of opportunities," and the specific requirements were de-emphasized. In response to the readings, the group spent several hours in free-wheeling discussion of several scientific issues: What are the obstacles to interdisciplinary research? What are the theoretical interfaces between social and ecological sciences?

In summarizing the accomplishments of the first three semesters compared to the proposal guidelines, we see that:

- Students have been recruited
- Two retreats and one group dinner have occurred
- Seminars have started
- Interdisciplinary research experiences have been planned
- and some students have attended cross-disciplinary meetings/conferences/workshops

The program has not yet met its original goals in:

- orientation
- co-location of offices
- interdisciplinary graduate committees
- agency internships

Furthermore, the description of the program as a "series of opportunities" and the current lack of emphasis on interdisciplinary components of the dissertation raise

questions about whether important elements of the program will fade into the background. Additionally, the postdoc left the university shortly after the retreat leaving the project without its operational leader.

TENSION POINTS

Our observations and interviews show that there are three tension points that have emerged in the first 18 months of the IGERT program. The first involves the struggles faced by trainees as they attempt to bridge their disciplinary differences. The second are some of the administrative and structural difficulties related to differences in the structures of doctoral education between the various departments housing the students. The third tension point relates to leadership for the program.

Bridging disciplinary differences

Scholars writing about the process of doing of interdisciplinary research focus on the intellectual and process obstacles, as outlined above. These two areas overlap, of course, as it is necessary to attend to process to overcome intellectual differences. We have found that, at least at this point in the process, there is more talk about bridging differences, than there are actual moments in which such bridges have been built.

Many of the students and faculty believe that IGERT will help them understand the 'language' of other disciplines. One natural science faculty noted, "I will know IGERT was a success if my students get lost in sociology without a passport and are comfortable and successful." The first step to this is recognizing the differences between the disciplines, and developing respect for practitioners of other fields. IGERT seems to be making good progress here.

Following the second year retreat one of the new trainees said:

> One of the most important things I learned from the retreat was how much of a boundary exists between the social and physical sciences. I had not imagined that the two disciplines were that distinct. In many ways, the future of science may hinge upon people like us cooperating and working together.

One ecologist said:

> I think personally I've learned a lot from trying to interact with the social scientists . . . To realize that sociology is pretty specific academic department that I really didn't know as much about as I thought I did.

A social scientist said:

> I have a seminar that meets every other week and we talk about natural resource issues, economics and natural resources. . . . I think IGERT has made me a little more sensitive to the fact that we really don't know a lot about what we're talking about, on the environmental side.

The second step is finding the ability to talk with one another. "Jargon" is the somewhat pejorative term given by outsiders to the catch phrases and linguistic shorthand of a field. Often insiders in a discipline become blind to their own use of specialized, precise terminology, and those from other fields experience this as exclusionary use of language. It is necessary to actually wade through the scientific jargon and reach an understanding about different uses of this jargon. Most trainees expect this to happen, but feel that it hasn't happened yet. There were some exceptions, as the social scientist continued:

> I think…a moment where what IGERT is about crystallized for me is this presentation by B., where suddenly I realized that, "Gosh, when I think about environmental quality I'm not talking about the same thing as what ecologists talk about when they talk about environmental quality." And I really don't know what I'm talking about when I talk about environmental quality. So that was an epiphany for me. . . . And that's pretty much what IGERT has shown me so far. . . Small facts, but it's kind of a big lesson.

Despite being mentioned in the literature, we were surprised at the significance of language differences, and the frequency with which trainees identified overcoming language barriers as a valuable outcome of the program.

The third step is more substantive: reconciling the different assumptions and methodologies of the various disciplines. We find that to date group has not yet really begun to grapple with it. We continue to believe that this barrier is significant because people talk about it, but in the absence of actually struggling with it, it is hard to understand it more clearly. An economist explained what he felt he would need in order to better understand other disciplines:

> I want them to. . . say, "In my area this is our approach. This is our world view. These are our techniques. This is what we like. This is what we frown on. This is what we think of economists' work." . . . [So far] no one's really walked me through the mindset of an ecologist to let me know how their worldview is different from mine. [To say] "This is why you guys are not talking the same language when you talk to each other."

A limnologist told us that he needed to understand the methodological assumptions of sociology more clearly. After reading some sociology papers, he felt frustrated.

> We ecologists are total snobs because we're driven on stats. If you say something you better have a stat to prove it. . . . One of the biggest things that I have a problem with is in reading sociology papers is that they say a lot of things without a lot of proof. And taking things on face-value is not what [ecologists] trained to do. . . . You have to understand you need to stop being a snob and you need understand that just because they don't have stats it's not always wrong.

At the retreat in the Fall of 1999 we began to understand why this step of working through disciplinary differences is particularly difficult for the trainees. Trainees are graduate students, and not established scientists. As such, they suffer not only a lack of scientific reputation which gives tenured faculty the freedom to pursue new and possibly risky directions (Heberlein, 1988), but they struggle to

explain and defend the conventional thinking and established paradigms of their own fields because they haven't mastered them yet themselves. Their very location as apprentices means that they can not easily break the mold, because they do not know what the mold is. Conversely, of course, they may have the freedom that comes with naïveté, not having fully internalized the idea that they can not do certain things.

Contending with departmental differences

The second set of tensions, faced primarily by the Executive Committee, and by trainees individually in their home departments, involves those stemming from the inherent differences in the ways that graduate education is structured and executed in the represented disciplines and departments. The various departments recruit students, match them with their advisors, and foster a departmental community in radically different ways. These norms spring from the prevailing cultures of the disciplines and pose a challenge to IGERT. This has emerged in two places: in recruiting trainees and in asking trainees to fit IGERT into their doctoral programs.

Natural science students (e.g., zoology, limnology) are recruited by specific advisors, with whom they are matched as part of the application process. Professors whose research interests are closely aligned with IGERT use the program to attract students specifically for IGERT. In contrast, within the social sciences departments (e.g., rural sociology) students apply to the department as a whole, often with minimal faculty contact prior to arriving at the university. Students usually choose advisors after several semesters and are therefore, not recruited specifically for IGERT; instead they hear about IGERT and join the program in their second or third year. As a result of these differing norms, there was an imbalance in the Water and Society IGERT between social and natural science students; in the first cohort only 1/3 of the

students came from the social sciences. In order to rectify this problem the social scientists made concerted efforts to look at the pool of candidates admitted to their departments and recruit appropriate students. In addition, they approached currently enrolled students and encouraged them to apply. Nonetheless, the recruitment strategies used by the ecological scientists gives them a privileged pipeline into the program. Despite a concerted effort to recruit more social scientists for the second cohort, the current mix of students continues to be 2/3 ecology students.

Turning now to the participating trainees, they seem to be fitting IGERT into their standard programs in different ways, which seem to be related to the norms of their home disciplines. In the science departments, students are expected to take approximately five semesters of coursework. From the first semester, they work in their professor's laboratory to build the knowledge and research skills that will form the foundation of their dissertation. In the social science departments, students are expected to take seven to eight semesters of coursework, followed by several years of relatively independent research leading up to their dissertation. As a result of this structural difference, some social science students anticipate that IGERT will increase their time to degree. The natural science programs have more flexibility and so those students do not have this problem. This difference could also make it challenging for social science students to make a significant commitment to student research projects in their third and fourth years of study when they are still taking extensive coursework and preparing for qualifying exams. It will also be informative to see how dissertation topics evolve, and how well dissertations embrace the IGERT themes of the program.

The challenges of leadership

The final set of challenges involve the leadership of the program. To put the matter bluntly, the promise of the proposal has not, yet, been met. One reason for that is that there has not been consistent and focused leadership of the project. Instead, day to day management has devolved to the postdoctoral fellow, and in the absence of a postdoc, to the trainees themselves. The executive committee continues to provide leadership, but does so from a distance at monthly meetings.

Consequently, one consistent complaint on the part of the trainees, is that they do not see the core faculty—outside of their own advisors—very often. One trainee said, "I would like to see more interaction with the faculty; . . . we're trainEEs and we need our trainERs." This frustration was elaborated on by a trainee whose home department is a jack-of-all-trades multidisciplinary center. He, probably because of his location, feels these frustrations particularly acutely. Nevertheless, he speaks for many trainees when we asked about the responsibilities of program faculty to him as a student:

> They are responsible for assuring that I succeed as a graduate student. That I get the appropriate training; that I get the appropriate mentoring, and the appropriate opportunities for success. Whether that be to go to a meeting, or to have people on my committee, or to have people's ear. If somebody is on the committee for IGERT and that IGERT asks for their time, those people are responsible.
>
> [But] it's the people who aren't available. . . . They are not visible. There's no interaction; there's no communication, so far. Now, it is also incumbent on me to seek them out, and, when I do seek people out, yeah, they give you some time, but people are stretched a little thin. . . . But, hey, you took this on; take it ON.
>
> Maybe I'm asking too much of faculty. Maybe I expect too much of them….Especially when you're a [Center] student and you're not really under the wing of some department, people don't pay much attention to you. So I kind of expected IGERT to pay more attention to [me] and it hasn't.

As this student recognized, faculty members time is in extremely short supply. At universities like UW, faculty garner acclaim for bringing in research money, but they are not rewarded for program development or advising. As a result, faculty do not have significant time to devote to a project such as this one after the grant has been awarded. The Water and Society IGERT partially addressed this problem by hiring a full-time post doctoral fellow to organize the program, assist students on a regular basis, and serve as a liaison between students and faculty. Nevertheless, the trainees feel the absence of sustained faculty interaction, a support structure potentially more important for multidisciplinary students than for traditional doctoral students.

A second problem, connected with the prior one, is the needed for consistent leadership based on a clear program vision. This takes concentrated attention, and is aided by having clear plans in place. However, planning and structure conflict with three other espoused values that have evolved as the program has been implemented: responsiveness and flexibility, allowing students to help shape the program, and allowing the program to evolve. One trainee, when asked what the expectations of him were, replied:

> I think we are, as a group of students, really struggling with that. And the result is that we're sort of constantly being inundated by the faculty saying, 'well, you should do this,' and by the postdoc saying, 'I have another assignment for you,' and we're going about ten different directions.

Another said:

> That's a little disconcerting — to have a sense aren't completely figured out. But this project is evolving as we go.

A third, following the fall '99 retreat, and reflecting on the changes he has witnessed, said:

> I like the "entrepreneurial model" of this year - getting with smaller groups who may work together if they want to get something out of the program. Cause really the entrepreneurial model I think characterizes academic production. It also makes sense to me of the fact that the faculty is not very involved if we see ourselves as being entrepreneurs. I know this sounds a little jaded but I'm really not unhappy about it.

In short this is a dynamic (some would say chaotic) system, with which some are more comfortable than others. After the retreat in the Fall of 1999, one of the trainees said:

> I learned that the old cohort of students are becoming more comfortable with the chaos that IGERT often is (especially with the postdoc leaving, class scheduling, etc.).

Another said:

> I learned a little bit more about how the faculty conceives of IGERT. Particularly informative to me was a comment by SC that seemed to define IGERT as an opportunity more than a top down program.

The faculty are much more comfortable with this flexibility—witness the ever shrinking list of program requirements—perhaps because they have significantly more experience with the dynamic and evolving nature of research and training. What is less usual here is the extent to which that is visible to students. In spite of the advantages of allowing the program to evolve, such "flexibility" could become a major drawback if key program elements are watered down or lost completely.

BENEFITS

Here we outline some of the benefits from participating noted by the trainees. One obvious benefit of the program was the funding given to trainees. Being a trainee provided a measure of stability that was a relief, particular for students in departments where funding is more competitive, or requires significant teaching. This is particularly noticeable when comparing the social science and biological science

students. Science students can expect to be fully funded for the duration of their degree, and they carry an expectation of moving from one funding source to another from semester to semester; this is a disciplinary and departmental norm. Regardless of the funding stream of the moment, they are expected to be active participants in their own research program and that of their advisor, which are typically quite intertwined. Such norms are not the case in the social sciences. Consequently, one social scientist confessed some unease that came with the funding benefit:

> To some extent I'm feeling like I'm missing out by not being a research assistant because there are a lot of practical skills that you learn when you're a research assistant. You know, the professor gives you a database and he says, "Go do this with it," You say, "Huh?." He says, "well, teach it to yourself." I am missing out on that. And I'm very sensitive that that might be important; in terms of practical training, computer skills, data base management skills, doing surveys, doing all the things that the other RA's are doing. I'm not getting that.

Conversely, one of the limnology students noted that the funding offered her more flexibility in dissertation topic selection than her colleagues might have. She said:

> What IGERT does for me is that it provides me funding that doesn't require me to work in a specific system. Other funding that I would have gotten through Limnology would have [included stipulations.] "Now you are an LTER student and you have to work on those lakes," and "now you're funded by the Wisconsin River Project and that's what you have to work on." So this gives me more freedom in choosing the topic.

Another benefit that several students noted was simply the existence of the program at all. A zoologist said:

> It's a rare opportunity. . . To work on economics and social science questions and still be an ecologist and be supported by your professors. Not have them say, "You shouldn't be doing that. You're in the zoology department."

A third benefit was the connection with other trainees and the relationships that were being built. Following the 1999 fall retreat, one trainee said:

> I think we are becoming tighter and more comfortable with each other. We seem, in large part, to know and accept each others strengths AND weaknesses. There was a lot of the kind of ribbing on each other that can only be easily and naturally accomplished if trust exists. I learned that there are some really neat people in the group and that I enjoy. However, I also learned that by patience, cooperation, and friendship (all benefits of the IGERT program) we can break down these barriers and do constructive work together.

IMPLICATIONS

While much of this discussion may be idiosyncratic to the people and the disciplines involved, we believe that the challenges faced by the Water and Society IGERT are likely to be faced by other efforts to create multidisciplinary doctoral programs in which students are based in traditional departments. This undertaking is not simple to implement. Good intentions and a commitment to a shared problem are not enough. There are significant challenges that are best overcome by thorough planning, ongoing evaluation and a commitment to allocating time towards building community.

We began this paper by identifying four of the challenges to interdisciplinary research which is discussed in the literature: the absence of conceptual frameworks for research, the difficulty in establishing a team, language problem, and difficulty in finding publication outlets. Of these four, the struggles around language are the most prominent for trainees. It is the challenge most commonly identified, and the one which they are beginning to wrestle with. Team building is the least problematic, in the sense that it has been given concerted attention. As a consequence, trainees are clearly developing mutual respect and the ability to work together. A respectful but intellectually questioning relationship has also been modeled by the members of the Executive Committee. The final two obstacles: frameworks for research and

publication outlets have not yet emerged. We anticipate that the first will emerge as a struggle, once the student research teams begin to try to operationalize their work. The second, publication, may not be a problem. Should these student teams bring a project to completion, the faculty will be in a position to help them find publication outlets; however, such publications may not be as critical to their careers as for junior faculty. The choice of publication outlet may thus be easier.

The structural obstacles posed by the normative doctoral education environment that we identified earlier include: finding a supportive advisor, locating a supportive intellectual community, mastering relevant knowledge in more than one discipline, reconciling conflicting methodologies, and overcoming fear of being unable to access traditional outlets for publication and academic employment. The first two of these are not problems in the program, simply because of its structure. All of the students are advised by faculty who are either on the Executive Committee or have made an explicit commitment to the program. Similarly, the program itself provides an intellectual community, so students are not in the position of trying to find likeminded souls around campus. The final two obstacles are ones that were discussed above.

Our data also showed us problems that were not foreshadowed in the literature. Most importantly, the data show us the necessity of a thoughtful planning process, in order to ensure that expectations are clearly set and consistently implemented. While this finding may seem completely obvious, it is our experience that faculty members are not the most administratively oriented group of people, and that steps that may seem obvious to an educator seem surprising to scientists immersed in their field. Furthermore, scientists are familiar with the ever-evolving nature of research, and are comfortable with the dynamic ambiguity that is inherent in university settings. Thus

the leadership team is comfortable with a level of uncertainty and flux that is not always comfortable to the trainees or conducive to assuring completion of program goals. The trainees experience this environment as chaotic, and believe it to reflect an underlying disorganization and lack of commitment to the program, and particularly to its training components.

We close by acknowledging that this analysis is probably premature. The program has just entered its second year, and many of the issues outlined above may be resolved over time. Or, they may be the initial fissures that become larger problems and crevasses that divide and challenge the program over time.

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