Socialization to interdisciplinarity: faculty and student perspectives

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Abstract Socialization has become a common framework through which to understand the doctoral student experience; however, the framework has predominately been used as a lens through which to understand traditional, single-discipline doctoral student experiences. Interdisciplinary doctoral programs are becoming increasingly common in both the United States and elsewhere but relatively little empirical research exists about this distinct experience. Through multiple interviews with 18 doctoral students and their 35 faculty members, we discuss differences in the socialization process for these students in regard to knowledge acquisition, investment, and involvement. Implications for practice and future research are included.

Keywords Interdisciplinary doctoral education · Socialization · Qualitative

Introduction

Socialization has been utilized as a common framework through which to understand the doctoral student experience (e.g., Austin 2002; Weidman et al. 2001). Defined as the process through which an individual learns to adopt the values, skills, attitudes, norms, and knowledge needed for membership in a given organization (Tierney 1997), socialization has been found to be a critical factor in graduate student retention and completion. In fact, unsuccessful socialization in graduate school may be related to graduate student attrition (Council of Graduate Schools 2004).

Socialization at the graduate level encompasses two separate processes, including socialization to the discipline and profession, and socialization to the role of graduate student (Golde 1998). As disciplinary experts, faculty members become the main arbiters of the socialization process (Weidman et al. 2001), whether through interactions inside and

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outside of the classroom, through advising roles, or through mentoring relationships. And, while scholars have studied the experiences of doctoral students in relation to their socialization to particular disciplinary cultures (e.g., Gardner 2007; Golde 1998), relatively little attention has been given in the literature to the socialization experiences of students in interdisciplinary doctoral programs or the faculty who socialize them.

Interdisciplinary programs are those that incorporate two or more disciplines (National Science Foundation 2009). Given the fact that socialization to one disciplinary context, culture, and its related norms is a highly complex process for students (Becher and Trowler 2001), socialization to multiple disciplinary norms and practices is therefore an inherently more complex process (Holley 2009). As interdisciplinary doctoral programs continue to grow, such as those encouraged through the National Science Foundation's Integrative Graduate Education Research and Training (IGERT) program (National Science Foundation 2007), and greater emphasis is placed on interdisciplinary research and collaboration in US colleges and universities (Klein 2010), a deeper understanding of the process of interdisciplinary doctoral student socialization is warranted. At the same time, a doctoral student's socialization is inextricably tied to his or her doctoral advisor (Weidman et al. 2001). Therefore, a fuller understanding of doctoral student socialization in interdisciplinary programs cannot occur without an equal understanding of doctoral students' advisors in these programs. The current study sought to understand the socialization experiences of 18 doctoral students and their 35 faculty members involved in one large interdisciplinary doctoral program at one institution.

Socialization to interdisciplinarity

The National Science Foundation (NSF) defines interdisciplinary research as:

> A mode of research by teams or individuals that integrates information, data, techniques, tools, perspectives, concepts, and/or theories from two or more disciplines or bodies of specialized knowledge to advance fundamental understanding or to solve problems whose solutions are beyond the scope of a single discipline or area of research practice. (National Science Foundation 2009)

While the ideas of interdisciplinary research or interdisciplinarity are not new concepts (see Lattuca 2001 for a discussion of the history of interdisciplinarity; Klein 1990), empirical research about these concepts is scarce. Instead, previous scholars have focused primarily on anecdotal examples of the barriers to such efforts, such as issues of language, differences in research methods, and structural and institutional practices and policies (see Holley 2009 for a synthesis of this literature). Therefore, while interdisciplinarity and efforts to encourage more interdisciplinary research and collaboration have been promoted widely in US colleges and universities (Klein 2010), many challenges stand in the way of such efforts that are not easily overcome.

To illustrate, faculty members are socialized to disciplinary norms and conventions during graduate school (Becher and Trowler 2001). Disciplines provide an extensive history, set of norms and practices, values, and habits of mind (Clark 1987) as well as a sense of identity and the epistemological tools and mindsets that allow one to pursue scholarship within the discipline (Holley 2009). Faculty members, to gain entree to and be successful in a given discipline, must demonstrate a level of adherence to these cultures and expectations (Becher and Trowler 2001). In turn, faculty members pass along these norms, values, and habits of mind to their students through the socialization process

(Weidman et al. 2001). From this perspective, if one chooses to engage in interdisciplinary research or collaboration once firmly socialized into one discipline, he or she has many challenges to overcome. Moreover, the longer one is entrenched in this discipline the more difficult it may be to move outside of it (Strober n.d.).

This exposure to interdisciplinarity, then, may be best suited to the graduate school enterprise. Others would argue, however, that a traditional graduate education is the time to specialize and become an expert in one discipline rather than several. Metz (2001), while advocating for interdisciplinary experiences in graduate school, nevertheless cautioned: "Clearly, such endeavors are even more difficult for graduate students who are still in the process of comprehending and adopting the disciplinary equipment of their field. The cognitive task is formidable" (p. 15). Amey and Brown (2004) explicated the difficulties of socializing students to interdisciplinarity and the possible timing of such socialization, postulating that a critical developmental juncture must occur when the student is able to "objectify and assess" their disciplinary frames of reference before moving into interdisciplinary work.

In addition to issues of timing for interdisciplinary work, the literature reveals a number of qualities, characteristics, and habits of mind that have been assumed to be connected with the cognitive and developmental tasks required to do interdisciplinary work, although very little empirical work has supported these assertions. Ivanitskaya et al. (2002) provided a useful summary of these characteristics, including humility, tolerance for ambiguity, flexible thinking, higher order thinking skills, ability to synthesize, and a general open-mindedness to new ways of thinking. In a study of interdisciplinary doctoral students in self-designed programs, Gardner (2012) found that self-direction and independence were the most prized qualities in both the students themselves as well as their faculty members.

While faculty members within existing disciplines certainly possess many of these interdisciplinary skills and abilities, less than 1 % of all doctoral degrees conferred since 1970 have been in interdisciplinary fields, growing from 109 in 1970 to 1,273 in 2009 (U.S. Department of Education 2010). In turn, the likelihood of a graduate student working with a faculty member with such an interdisciplinary degree is relatively low, calling into question the role of faculty in interdisciplinary doctoral student socialization. How does the traditional socialization process involving faculty passing on their knowledge to their graduate students (Weidman et al. 2001) change when faculty have been socialized differently than their current students? As pressures to produce interdisciplinary research continue through federal agencies such as the National Science Foundation (2009), the socialization and training to be able to produce such research becomes even more salient. In fact, Amey and Brown (2004) argue that very little interdisciplinary research actually occurs due to the inability to overcome the myriad challenges of conducting interdisciplinary research. Studying the experiences of graduate students and faculty engaged in interdisciplinary research training will assist in understanding how to best facilitate and structure the socialization process that needs to occur.

Conceptual framework: socialization

A widely used framework of socialization for understanding the graduate student experience is that of Weidman et al. (2001), who based their work on that of Thornton and Nardi (1975). As illustrated in Fig. 1, the Weidman et al. framework of graduate student socialization includes the core experience of the degree program, as framed by the institutional culture of the university; the socialization processes of interaction, integration, and
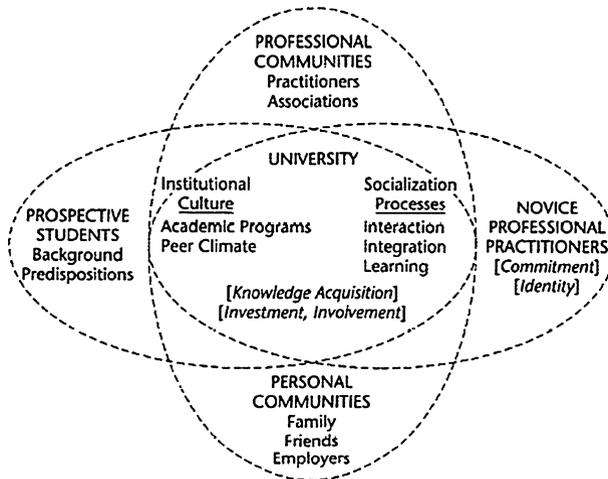
Fig. 1 Weidman, Twale, and Stein's graduate socialization framework

learning; and the core elements of socialization, including knowledge acquisition, investment, and involvement. Specifically, students are socialized through interaction with faculty and peers and integrated into the department's activities and the culture of their disciplines. At the same time, students are also influenced by their own backgrounds and predispositions, their professional communities, as well as their personal communities. As the socialization process unfolds, students transition to novice professional practitioners, wherein commitment to and identification with the chosen professional career occurs.

Several key terms in Weidman et al. (2001) framework merit definition. The idea of knowledge acquisition refers to the student's ability "to understand and acclimate to the academic culture, to meet faculty standards, and to perform role expectations" (p. 55). The concept of investment is defined as "the degree of time and energy that graduate students put forth in meeting program requirements" (p. 63). Involvement, on the other hand, encompasses the student's attachment to the program, the profession, and the discipline.

In her essay on the topic, Holley (2010) explored the intricacies of interdisciplinary doctoral student socialization using Weidman et al. (2001) framework of knowledge acquisition, investment, and involvement. Related to knowledge acquisition, interdisciplinary students are faced with increased challenges as they work to integrate multiple disciplines with their different languages, methodologies, and values. Regarding investment, or the time one commits to the discipline, profession, or research topic, the time is inherently multiplied for interdisciplinary students resulting in a longer socialization process than the traditional, disciplinary doctoral student. Involvement for the interdisciplinary graduate student is also more complex as this involvement with peers, faculty, and the institution automatically multiplied to account for each discipline.

At the same time, the socialization experience is not always unidirectional or linear. While the majority of theorists of organizational socialization have traditionally seen it as a process wherein the new member receives knowledge from existing organizational members about how the organization operates (Merton 1957; Mix 1971; Van Maanen 1984, 1978; Weidman et al. 2001), more recently scholars have begun to see the socialization process from a less hierarchical perspective (Antony 2002). These new perspectives see socialization occurring bi-directionally, in that the new member is able to influence the

organization and its existing members much in the same way that the new member is influenced (Tierney 1997; Tierney and Rhoads 1994). For example, Antony remarked on how a less one-directional view of doctoral student socialization is imperative in interdisciplinary endeavors, saying, "Through such interdisciplinary work, students develop competencies that push beyond the parameters of the socialization their mentors or departments can offer. Such diversified socialization can contribute to students applying their knowledge to solving broader (i.e., interdisciplinary) problems, or working in new fields or sectors" (p. 375).

Given this complexity, it is perhaps not surprising that interdisciplinary doctoral programs seek and attract students with particular backgrounds and predispositions (Boden et al. 2011) and that their graduates "deviate" from the traditional, discipline-specific route of socialization and knowledge acquisition (Boden et al. 2011).Unfortunately, Holley (2010) and Boden et al. (2011) are some of the very few who have begun to look at the complex socialization process for interdisciplinary doctoral students, thereby leaving a paucity of empirical research that further examines these issues from students' or their faculty members' perspectives.

Methods

The research question guiding this study was, "What are the socialization experiences of faculty and doctoral students involved in one large interdisciplinary project?" The findings presented in this paper result from an ongoing study in which a large, $20 million, 5-year, federally funded interdisciplinary research project is being examined at one public, mid-sized, land-grant institution. This interdisciplinary project is focused on studying environmental sustainability and includes participation from faculty in over 20 distinct academic disciplines ranging from the biophysical sciences to the humanities. Faculty were drawn to the initial project as it was being written as a proposal to a large funding agency, either because of their own expertise related to specific pieces of sustainability or because, as many of them commented, "it fit with my values."

A significant part of the funding for the project was focused on supporting graduate students. Prospective students largely applied to work with specific interdisciplinary project teams under the grant's umbrella. In other words, students were not admitted into a specific interdisciplinary degree program but rather were admitted to work on an interdisciplinary team with two faculty members in different academic departments. The expectation was that interdisciplinary coursework and an interdisciplinary emphasis in their dissertation would ensue. Faculty came to the project all with stated experience in interdisciplinary collaboration, stemming generally from work conducted as faculty members, but the contours of this experience changed over time as they became more integrated in the scope of this project that required a heightened level of interdisciplinarity that none of them had previously experienced. In this way, both faculty and students were new to this form of interdisciplinarity.

Given the fact that the interdisciplinary project under examination is characterized as a "particular context within which the participants act," and that we were interested in better understanding the influence of this context on the participants' actions, as well as "the meaning of the events, situations, and actions they are involved with" (Maxwell 1996), qualitative methods were best suited for this study. After receiving informed consent, we conducted open-ended interviews with the 18 students admitted in Years 1, 2, and 3 of the project and the 19 faculty co-advisors who worked with them. While all of the faculty

members interviewed began in Year 1 of the project, the students were not recruited until later in that year and began formally in Year 2. In order to capture the evolution of the socialization process and their ongoing adjustment to interdisciplinarity, faculty were interviewed in Years 1–3 while students were interviewed in Years 2–3 of the project. The multiple years of data collection respond to past research that demonstrates that students' socialization is a developmental process (Gardner 2009).

Using an open-ended protocol, we asked faculty and students about their experiences in the project and their thoughts about interdisciplinarity. We audio-taped these interviews and all were transcribed verbatim. In the first round of interviews, protocol questions focused on students' and faculty members' expectations of, experiences with, and perspectives on interdisciplinarity. In the second round of interviews, we sought to understand the evolution of students' and faculty' expectations, experiences, and perspectives on interdisciplinarity, and specifically sought to assess how faculty were coming to understand their roles in such an interdisciplinary endeavor.

Student and faculty participants represented diverse disciplines in the biophysical and social sciences. Table 1 provides an overview of the participants. With the exception of four individuals, all other faculty participants were tenured and all had been at the institution for an average of 11.11 years.

For data analysis we utilized Glaser's (1978) constant comparative method. The steps of the constant comparative method, include: (1) Begin collecting data; (2) Find key issues, events, or activities in the data that become main categories for focus; (3) Collect data that provide many incidents of the categories of focus; (4) Write about the categories explored, keeping in mind past incidents while searching for new ones; (5) Work with the data and emerging model to discover relationships; and (6) Sample, code, and write with the core categories in mind. The steps of the constant comparative method occur simultaneously during data collection until categories are saturated and writing begins. Weidman et al. (2001) model of socialization then provided the framework for understanding the relationship of these categories to the interdisciplinary experiences of the faculty and doctoral students.

Findings

Below we present the core elements of socialization with the framework of Weidman et al. (2001) as an organizing structure for the findings as they relate to the faculty and students' experiences: (a) knowledge acquisition, (b) investment, and (c) involvement. Each of these core socialization processes, Weidman et al. posited, is made up of the organizational structures, program processes, professional standards, curricula, and the roles of faculty and peers.

Knowledge acquisition

As a core element of socialization, knowledge acquisition includes both cognitive knowledge and skills required for success in the chosen profession or organization (Weidman et al. 2001). The interdisciplinary project examined here presents several interesting elements of knowledge acquisition that are noteworthy, including a comprehension of what interdisciplinary research and collaboration encompass, the need to learn new methods and methodologies, and the need to acquire and learn new language. Notably, not only were the doctoral students new to this interdisciplinary endeavor, but so were the faculty. All of the

Participants	Disciplines represented
Table 1 Students and faculty co-advisors by discipline	
Student 1	Wildlife ecology
Faculty 1	Marine policy
Faculty 2	
Student 2	Communications
Faculty 3	Policy
Faculty 4	
Student 3	Anthropology
Faculty 2	Forestry
Faculty 5	
Student 4	Forestry
Faculty 2	Ecology
Faculty 6	
Student 5	Communications
Faculty 3	Environmental policy
Faculty 4	
Student 6	Forestry
Faculty 7	Conservation biology
Faculty 8	
Student 7	Engineering
Faculty 9	Ecology
Faculty 10	
Student 8	Land resource management
Faculty 11	Policy
Faculty 12	
Student 9	Conservation planning
Faculty 2	Forestry
Faculty 6	
Student 10	Forestry
Faculty 6	Ecology
Faculty 13	
Student 11	Economics
Faculty 14	Psychology
Faculty 15	
Student 12	Wildlife ecology
Faculty 1	Environmental studies
Faculty 16	
Student 13	Economics
Faculty 1	Wildlife ecology
Faculty 11	
Student 14	Communications
Faculty 3	Policy
Faculty 4	
Student 15	Natural resources
Faculty 17	Economics

Table 1 continued	Participants	Disciplines represented
	Faculty 18	
	Student 16	Economics
	Faculty 17	Ecology
	Faculty 18	
	Student 17	Geology
	Faculty 10	Earth sciences
	Faculty 19	
	Student 18	Engineering
	Faculty 19	GIS
	Faculty 18	

faculty members interviewed in Year 1 of the project stated they had previous interdisciplinary research experiences prior to joining the project, but by Year 2, the faculty admitted that these prior experiences had only been within closely related disciplines. Only a few exceptions existed: two faculty members who were trained to be interdisciplinary in graduate school (hired in Year 2 of the project) and two other social science faculty members who talked about early socialization experiences in graduate school. In other words, as the project progressed, most of the faculty realized that what they had previously thought to be interdisciplinary research experiences in the past were mere collaboration or, at best, multidisciplinary experiences.

Therefore, the faculty members who had joined the interdisciplinary project all discussed feeling "open" to interdisciplinary research in Year 1 but, as time passed, found their understandings of interdisciplinarity to be rudimentary at best. For example, the faculty members, when asked about how they defined interdisciplinary research in the first year of the project, most frequently discussed what they saw as mere collaboration. Many of the faculty members remarked similarly to Faculty 22, who said, "It's work between disciplines," or Faculty 1, who remarked, "You need multiple angles to come to solve a problem." However, Year 2 of the project saw faculty members possessing a much more nuanced view of interdisciplinarity, at the same time realizing how much more difficult it really is from what they first perceived it to be in Year 1. Faculty 9 pointed out, "The definition [of interdisciplinary research] isn't the hard part. The hard part is really to make effective interdisciplinary research happen when people are using different languages and look at things in different ways." Faculty 3 also shared:

> Just having a team made up of people from five different, disparate disciplines does not constitute interdisciplinarity. You're even lucky right now if it constitutes multidisciplinarity – people kind of doing their same old thing alongside each other. I don't even think we've reached that, in many cases.

Students, however, came to the table with a much more discerning understanding of interdisciplinary research and collaboration—even in the first year of their experience. Whereas faculty members first described interdisciplinarity as simply collaboration among individuals, the students were more apt to discuss how the melding of methods, methodologies, and analytical techniques were necessary for interdisciplinarity to occur—thereby concurring with the NSF (2009) definition of interdisciplinary research. Student 11 remarked:

Interdisciplinary research is having a team of researchers where maybe two to four disciplines are represented and they formulate their research questions in a way in which the questions they ask are more meaningful and they're more representative of a how the natural world works. Nothing works in a vacuum; everything is connected within a system. I think the same goes for research. We don't do research in a vacuum.

Similarly, Student 14 commented, "I think of interdisciplinary research being really kind of a melding of the methods, a melding of thinking about a problem."

The NSF (2009) definition of interdisciplinary research includes the need for two or more disciplines to approach research through an integration of "information, data, techniques, tools, perspectives, concepts, and/or theories." It is this idea of "integration" that truly defines interdisciplinary efforts. As Repko (2012) stated, "Merely bringing insights from different disciplines together in some way but failing to engage in the hard work of integration is multidisciplinary studies, not interdisciplinary studies" (p. 17). From this perspective, it was not surprising how much emphasis was placed in acquiring knowledge of new research methods and methodologies in our interviews, not only as the techniques and tools pointed to by NSF (2009) but also as a way through which integration of information, data, perspectives and concepts could be reached. However, while discussed by both faculty members and doctoral students in our study, this acquisition of new methods and methodologies was discussed to different degrees. While the faculty members understood that different methods were necessary for attacking complex interdisciplinary questions, they were less likely to discuss their need for learning them personally, whereas the students discussed this desire to learn and understand these different approaches. Many students talked about learning methods as a way for them to "add tools to their toolbox." Student 6 explained, "There's not one solution to every problem, so I just want to be able to have that tool in my repertoire and be able to attack it if need be." At the same time, students were also more prone to discuss the "multiple ways of looking at problems" as part of this toolbox. Student 2 expressed, "I think that there are obviously multiple ways of knowing."

The faculty, however, were less likely to discuss approaching research from different approaches—even in Year 2. Faculty 8 was candid in responding, "I guess I've become less and less interested in this interdisciplinary research. Well, what really *is* interdisciplinary research? I don't do that. I do multi-disciplinary, at best. And I sort of think that's probably where it should stop." However, there were exceptions. Faculty 7 was one individual who discussed her excitement at learning new methods and new approaches: "I'm so motivated. I'm so eager to learn. For God sake, I'm taking multiple regression! If you have any idea how far outside of my worldview that is! I want to learn that language. I want to really get it. It's empowering. It's amazing for me." From this perspective, Faculty 7 sought to understand other disciplines' tools and techniques as an inroad to the integration necessary to do interdisciplinary research (NSF 2009).

Perhaps more than any other topic, language received the most emphasis among both faculty and students, a theme common in the literature on interdisciplinarity. Certainly, true interdisciplinarity requires that the individuals involved be adept in understanding one another in order to collaborate and synthesize concepts and results. While both faculty and students expressed the difficulties inherent in learning other disciplinary languages, it was once again the students who discussed being more open to this learning than their faculty counterparts. For example, Student 6 expressed her excitement and humility about learning

the languages of others disciplines, "You pick up their language quicker than you think and, if not, you can ask them, 'What does that mean? I don't know. I'm not sure."

Faculty, on the other hand, tended to focus on language issues more in Year 1 than in Year 2. They saw learning other disciplines' languages as a tangible step toward interdisciplinarity in Year 1. For example, Faculty 11 in Year 1 talked about language like many of her peers did: as an abstract hurdle to cross but one that would not necessarily be a difficult one: "Having a common language is an obstacle [to interdisciplinarity] but I think that's something we can kinda get over. I think that it's kinda basic." It was then interesting to see the almost entire lack of discussion of language in Year 2 by the faculty. The rare times language was discussed in Year 2 were as a source of conflict or a means to resolve it. Faculty 2 said, "I think we all need to have common ground and we don't have it. We can all throw around terms but it reveals a certain level of ignorance on our part." Faculty 3, a social scientist, was frustrated and exclaimed, "I'm accused of using jargon [by the biophysical scientists]. So, what you speak is plain English and what I do is jargon? I'm just tired of hearing that."

Regardless, everyone understood and discussed at length the time it takes to learn these new languages. Faculty 9 summarized it well: "We have to learn each others' languages. That takes time. Every time we step into one of these things when you move into a slightly different field you have to learn all the background that it includes. It does gobble up time."

Investment

As the second core element of socialization, investment refers to the development of role identity and commitment, usually through the amount of time dedicated to the task (Weidman et al. 2001). Investment is also made through connecting social status or reputation to the particular role or organization to which the individual is being socialized (Weidman et al. 2001). Also at this stage in the socialization experience the student is mentored by an expert in the particular profession, again resulting in investment in the role.

The underlying theme in the socialization process of investment, then, is time. Interestingly, in this study, the concept of time was the most often discussed issue and concern across both faculty and students involved in this interdisciplinary endeavor. While all agreed that the investment of time was necessary to be successful at interdisciplinary collaboration, students and faculty discussed their investment of time quite differently. For example, all of the faculty spoke at length about the myriad meetings that were a drain on their time. In the first 2 years of the project, in particular, lengthy weekly meetings were held to provide not only organizational strategies to the larger endeavor but also to provide foundational discussions for interdisciplinarity. As a result, Faculty 7, like others, stated plainly, "The meetings are killing me." While faculty members knew and understood that such meetings were necessary to learn others' languages, methods, and to discuss issues related to sustainability, faculty also were apt to express that this was just "one more thing" on their already full plates. Faculty 9 expressed her concerns thusly:

> One way we could all work to integrate our understandings is to do an exercise so that everybody's talking about the same stuff. But we don't have time to do it. We never have. We talk in meetings and you get glimmers of where other people are coming from but I still assume that everybody looks at these things the same way that I do.

Faculty 16 similarly explained, "I think that practically speaking our biggest issue is time. You know, for many of us, this is an add-on." It was therefore common to hear faculty, particularly in Year 2, discuss their involvement as a burden on their time. Instead, faculty expected the students to dedicate their time in lieu of the faculty. Faculty 11 stated, "I know we need a lot of meetings to make sure we have common language and a strong culture but at the same time if we schedule too many meetings up front we may drive away the very people that we're trying to bring in."

Students, in contrast, also discussed time but were more likely to discuss the time pressures on their faculty members rather than themselves. Student 5 stated:

> I do reach out to faculty in my own department, and, surprisingly, it's not my advisors because I feel like [the project], just as time consuming it is for us as students, is double that for [faculty]. Being a [department] student, the only person over there is [advisor name] and she's so busy so I don't ever see her. So, I built relationships with the people who aren't involved in [the project] and turn to them more than anyone else.

When students did discuss the time pressures they faced, they tended to discuss it in terms of the balancing of their time to their many different commitments. For example, students were housed in an academic unit in addition to their research assistant expectations related to the interdisciplinary project. This "dual citizenship" resulted in students trying to determine what percentage of their time should be involved in the research project versus their departmental or unit activities and events. Student 6 explained:

> My first challenge, just as a student, is the time commitment and responsibilities. Those two things coupled make for a stressed individual. And, if you don't know, right when you start any new school or any new department you're trying to learn the ropes, you're trying to get the paperwork done, you're trying to do all those things. So I felt for a while I was being pulled in different directions and I didn't really know where it was going.

Therefore, even while the students were brought to the university in order to be a part of the interdisciplinary project they still realized they had to manage their time and balance the expectations put upon them by faculty in both the project as well as those in their home departments. Faculty, however, were concerned about their time but really saw the onus of the investment process falling on students. Faculty 11's comment is illustrative in this vein:

> I don't expect individual faculty to be able to spend a lot of time trying to think about this stuff. If the students can go back and help their advisors, though, maybe more people having the same vision or consistent goals and understandings of the project will help.

Involvement

Involvement is the third core socialization element, encompassing participation in the professional role or preparing to do so (Weidman et al. 2001). This type of involvement is often practiced in concert with more advanced students and faculty, in the case of graduate student socialization (Weidman et al. 2001). Weidman et al. explained, "Graduate students do not passively respond to specific situations; rather, they actively exert clues to their behavior and continually evaluate themselves in the context of peers, faculty mentors, program expectations, and personal goals" (p. 18). The idea behind this socialization

process is that the student or novice will learn from those experts or more advanced individuals around him or her and either emulate those behaviors or work toward creating a new version of the professional role to which they aspire.

In terms of this socialization process, then, it was perhaps not surprising that students felt they were forging new paths and breaking new ground in terms of their interdisciplinary learning—and that, for the most part, they were doing this without the expertise of their faculty.

Student 6 explained, "I think interdisciplinarity is a learning process. Essentially, the faculty doesn't have all the answers." Student 4 similarly expressed:

> Yeah, I don't know that they even know; I don't know that the faculty members know. I think this is iterative, and they're learning with us. They don't have all the solutions and it's refreshing, you know, that they don't because interdisciplinarity is such a tangled beast. It's a tough thing to wrap your head around.

Therefore, many of the students realized that they would ultimately be the ones to really break the ground on this work, rather than the faculty. The students saw the constraints the faculty were under, including time and expectations from the funding sources, not to mention being mired in the tradition of their disciplines. Faculty, however, discussed no sense of being "mired" or pulled toward their disciplines—and, thusly, away from interdisciplinarity. Instead, toward the end of Year 2, Faculty 9 shared, "I think a lot of us have to pull back on this interdisciplinary stuff. It all takes time and a lot of meetings to talk things out. I think people are getting talked out."

As such, students talked about turning more to their peers than their faculty to help them through the interdisciplinary process. For example, Student 7 shared, "I'm probably going to lean more on my fellow students for moral support," which Student 8 echoed. Student 1 also forwarded, "For me, it's a lot of the grad students who have been going through it with me along the way," much like Student 2: "I think the fellow students are really a key resource, just for commiserating and sharing ideas and kind of recognizing that you're not alone in this and that everybody is experiencing, maybe different challenges, but similar challenges as well." Interestingly enough, when faculty and advisors were mentioned by the students, it was only after their peers—if at all.

Faculty members, being the role incumbents in this socialization process, were not prone to discussing those they relied upon for support and mentoring even though few of them felt like they were experts in interdisciplinarity. As discussed earlier, the faculty members, while confident in their interdisciplinary abilities in Year 1, were less likely to express this confidence in Year 2. Faculty 8 said, "I was obviously confused about it [in Year 1]. I don't know now." Only the two faculty members who were hired in Year 2 of the project, and were specifically tasked with being interdisciplinary faculty, spoke of their own expertise in this regard. Faculty 17 spoke often about his lack of disciplinarity. He said, "I don't really know what it's like to be somebody who only does one thing and shuts the door on others. It's kind of odd for me," explaining further, "It doesn't behoove me to be disciplinary." These two faculty, then, highlight the differential expectations and socialization they brought to the project and to interdisciplinarity, in general.

Given this general lack of faculty expertise, it was perhaps not surprising that few students saw themselves emulating their advisors and seeking positions in the academic realm. Instead, students discussed either being undecided or unaware of the possible professional pathways for them. Student 11 shared a view of his professional future that many of his peers did:

I see two potential paths, well, three. One is do something for the federal government at some higher level in the EPA or USDA or other agencies concerned with land resource management – director of a lab, I don't know, something with an impressive title. Another one is get into NGOs somehow, you know, director of this or that, director of water research, director of aquatic sciences for the Nature Conservancy. I don't even know if the position exists, but you know something along those lines. And the third one, which is probably the least preferred option, but far more competitive and perhaps even the nasty option, is academia. It's a bit cutthroat and I'm not sure I'm cutthroat.

Discussion

"I definitely think the hope lies in the students." (Faculty 7)

In this study we examined the socialization of doctoral students and their faculty advisors to interdisciplinary research wherein we found it was more often the students that expressed the needed knowledge acquisition, involvement, and investment (Weidman et al. 2001) than their faculty advisors. Students tended to be more open to the learning they needed to do and were able to dedicate the time needed for the necessary investment and involvement in the interdisciplinary process as opposed to their faculty members. While this disparity between students and faculty may simply be a function of time and resources, we posit that this disparity also rests in the socialization these faculty members acquired early in their own graduate careers.

These faculty members, for the most part, were socialized to understand that their discipline and its respective methods, language, and world view were the most appropriate (and perhaps even the *only*) approaches to examine the problems they studied (Becher and Trowler 2001). Even those faculty who admitted to having earlier socialization to interdisciplinarity in undergraduate or graduate school, later admitted that previous experiences were nothing like the scope of interdisciplinarity required in this project. Therefore, asking these faculty members to not only *consider* but to *learn* new languages, methods, and perspectives is a challenging proposition, at the very least. Moreover, given that many of the faculty members involved in this project saw their involvement in the project as an "add-on" to their "regular work," their own involvement and investment in interdisciplinarity was obviously lacking. Without the time and resources to facilitate the tremendous learning that is required to conduct interdisciplinary research successfully, it is perhaps not surprising to see the faculty member's quote above referencing that the hope "lies in the students."

Indeed, students and the new faculty members were clearly less imbued with any particular disciplinary stance and more open to interdisciplinarity as both a concept and a way to approach doing research, echoing Lattuca's point (2001). Perhaps this openness is both a function of time and a function of their context. Certainly, these students were drawn to the interdisciplinary nature of the project and were obviously open to the learning process—both as students and as individuals invested in the values of the project. Nevertheless, the students exhibited a certain suppleness in their thinking that was not present in their faculty members' accounts. The few faculty members who were able to articulate their openness to the complexity of language, methods, and learning that comes along with interdisciplinary collaboration, interestingly, were those in the social sciences. This too is

perhaps not surprising given the lack of paradigmatic consensus exhibited in the social sciences. In other words, social science disciplines, like communications, are those that exhibit multiple worldviews (i.e., paradigms) and perspectives in relation to the conduct of research (Biglan 1973); whereas disciplines like the biophysical sciences often have one paradigmatic stance toward research and its conduct (e.g., the scientific method). It is perhaps that social scientists may have been more open to learning about and involving themselves in interdisciplinary collaborations simply by nature of their own disciplinary training, which afforded them the opportunity to consider multiple perspectives early in their education.

Therefore, it was interesting to see the students' openness to learning new methods and involving and investing themselves in the interdisciplinary endeavor—even those who were pursuing degrees in the natural and physical sciences. The timing of training to be involved with and understanding interdisciplinary pursuits is therefore noteworthy, and commented upon by both Amey and Brown (2004) as well as others. When is too soon and when is too late? For these students, perhaps learning about other disciplinary perspectives and methods too early in their PhD programs is problematic if they are unable to simultaneously gain expertise in their particular major field. At the same time, it is apparent from some of the faculty members' accounts that involving oneself later in one's academic career may be too late, due to their socialization and entrenchment in their own disciplines. Student 6 exemplified the problematic introduction of interdisciplinary training too early in a problem: "I felt for a while I was being pulled in different directions and I didn't really know where it was going." This lack of direction can be problematic for a student who must complete his or her degree in an allotted time, especially when funding ends after a number of years. In this way, the findings of this study echo those of Gardner (2012), who found the need for highly self-directed and independent students to be successful in these more open and unstructured interdisciplinary graduate programs. While faculty did not discuss this "pulling" sensation in the same way that students did, it is perhaps because they did not have the time or resources to fully immerse themselves in the experience as the students did.

Finally, it is important to note the interplay of student and faculty attitudes in this socialization experience. Weidman et al. (2001) explained, "Most faculty advise as they were advised during their own graduate student career" (p. 67). Given the fact that the majority of the faculty members in this study were socialized to one specific discipline or field of study, it is perhaps not surprising that they were not only unaware of how to conduct interdisciplinary research but, as the students pointed out, they were generally unaware of how to support their students completely in the process. If the purpose of the socialization process at the graduate level is to prepare the student for a professional career (Weidman et al. 2001), the lack of role models for students to emulate in this project is disconcerting. At the same time, perhaps this new generation of students being trained in interdisciplinary research will present the academic world with a new perspective in the socialization experience, seeing it much more in the bi-directional view offered by scholars such as Tierney (Tierney 1997) and Antony (Antony 2002). In this way, how much does interdisciplinary socialization depend on the "novice" learning from the "expert"? What does an "expert" look like in interdisciplinary research, particularly in light of the myriad combinations of disciplines that might exist in any given interdisciplinary collaboration? And, what is the best way and time in which to train individuals to do such work? Regardless, it is important to note that while students may be apt to lean on their faculty for the traditional socialization process, the faculty—also new to this experience—had no one to lean on for their socialization to interdisciplinarity. Without the commensurate time and

resources to fully engage in interdisciplinarity, moreover, the socialization that the faculty may have received from their peers is largely absent. In the following section, we discuss implications that stem from this study for policy, practice, as well as future research.

Implications

As detailed by the students and faculty members in this study, the learning, investment, and involvement required to be successfully socialized to interdisciplinary research are substantial. From this perspective, institutions, their administrators, faculty members, and students who seek to grow interdisciplinary collaborations on their campus should be cognizant of the difficulties inherent in these efforts.

First, it is important to consider the combination of individuals that are required to be successful in any interdisciplinary collaboration. Collaborative research is not in and of itself interdisciplinary research, despite what many faculty may think (Borrego and Cutler 2010). Ensuring that at least a minimal amount of faculty members are trained in interdisciplinary methods or have the time and resources to acquire such knowledge is imperative in a successful interdisciplinary collaborative experience. For faculty who are interested, providing professional development opportunities for them to learn interdisciplinary techniques and methods would also prove valuable. Without infrastructure and support, it is likely that faculty will ultimately only engage in multidisciplinary efforts, rather than interdisciplinary. While certainly there is a place and vital need for multidisciplinary collaboration, it is not clear that the faculty in this project reached their stated goal of interdisciplinarity. Moreover, these faculty members need to be available and open to training students in interdisciplinary methods and understandings as well. However, even with a critical mass of interdisciplinarily trained individuals, interdisciplinary work requires time, resources, and a strong commitment to make it work (Amey and Brown 2004; McCoy and Gardner 2012). If faculty members and students are not minimally supported in these efforts through resources, such as course releases and the like, they may ultimately be unsuccessful. We do not aim here to debate the need for interdisciplinarity or its future existence. It is clear that national funding agencies have made interdisciplinarity imperative and a number of institutions, such as Arizona State University, have gone so far as to reorganize to better facilitate its success. But to better train and prepare our faculty and doctoral students to do this kind of work requires an earnest commitment and the resources to support it.

Second, an imperative part of the socialization process at the doctoral level is the faculty-student connection and the opportunities that students have to learn from experts in their field. If faculty and administrators wish to grow interdisciplinary experiences for students, not only must there be those individuals with that expertise but there should also be professional support for students seeking careers in these areas. In other words, providing panels or visiting speakers who exemplify interdisciplinary training and professional positions will be good role models for the students and may provide helpful advice in their career paths, as well as provide models for faculty to follow in advising and research. Similarly, providing flexibility for doctoral committees to include this kind of professional expertise may be fruitful for students' training and socialization. Faculty can be provided with similar interactions with peers who have more experience and expertise in interdisciplinarity, if such expertise is unavailable at their institution. Providing faculty also with course releases and travel money to visit other institutions and to observe successful interdisciplinary endeavors may be fruitful in the same regard.

Finally, future researchers should continue to explore the nuanced experiences of those involved in interdisciplinary doctoral training and interdisciplinary research. Given the paucity of research in this area, this study was limited to examining one institution's interdisciplinary program. Future research should examine how different institutional settings, different disciplinary combinations, and different faculty and student demographics may influence the interdisciplinary socialization experience.

Certainly, the need for and growth of interdisciplinary collaborations will continue into the future. Better understanding and supporting these endeavors will ultimately result in more success for those involved and the outcomes of their work.

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