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# The Discipline of Identity: Examining the Challenges of Developing Interdisciplinary Identities Within the Science Disciplines

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THE DISCIPLINE OF IDENTITY: EXAMINING THE CHALLENGES OF DEVELOPING  
INTERDISCIPLINARY IDENTITIES WITHIN THE SCIENCE DISCIPLINES

By

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Thesis

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## The Discipline of Identity: Examining the Challenges of Developing Interdisciplinary Identities within the Science Disciplines

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Conducting scientific research that integrates multiple disciplines is an increasingly important, and yet challenging endeavor. This study employs the construct of identity to characterize and examine the obstacles to successful interdisciplinary work. It is argued that identity provides a useful lens into the process of scientific investigation, because as a construct, it has been shown to influence the way one sees oneself, others, and the practice of “good science.” It is therefore assumed that scientists’ identities may be an under-examined, mitigating factor in whether they develop an interest and aptitude for interdisciplinary collaboration.

This study qualitatively examines 20 postgraduate students participating in a number of potential Ph.D. programs, both traditional (mathematics, biology, computer science), and interdisciplinary (an NSF-funded Integrative Graduate Education and Research Traineeship program). In-depth interviews and participant observations are used to obtain firsthand accounts of the participants’ experiences in their respective programs, to understand how they construct their identity amidst that experience, and to solicit their attitude towards interdisciplinary work.

Results indicated important differences between the traditional science students, and those in the interdisciplinary program. Although all postgraduate students reported experiencing high pressure to be successful, and ambiguity as to how to accomplish that success, the interdisciplinary students in particular reported a felt need to commit to either a traditional science identity, or to an interdisciplinary science identity. Consequently, the IGERT students developed varying levels of attachment towards being a traditional scientist, versus being an interdisciplinary scientist. Additionally, the students exhibited tendencies to express their identities in context to one of three preferential frames: Social-relational, Occupation-based, or Research problem-based. Those who expressed their identities as Research problem-based also tended to display stronger attachment to their interdisciplinary identities. This research suggests practical feedback for overcoming the barriers to interdisciplinary work, while also offering insights into the identity work that accompanies the competing discourses of traditional sciences versus that of emerging interdisciplinary science.

## TABLE OF CONTENTS

Chapter 1: Introduction, Rationale and Literature Review	1
Introduction	1
Rationale	3
Literature Review	10
Interdisciplinary Literature: A Problematic Imperative	10
Organizational Identity: A Poststructuralist-Discursive Approach	13
Structurational Model of Identification	15
Multiplicity of Identity	16
Organizations as Discursive Formations	17
Identity as a Method of Organizational Control	18
Summary of Review of Relevant Literature/Research Questions	22
Chapter 2: Methods	25
Participants	25
M-EID Program	25
Traditional Programs	27
Data Collection	28
Semi-structured Interviews	28
Interview Guide	30
Procedure	30
Participant Selection	31
Data Analysis and Interpretation	31

Member Checks	32
Chapter 3: Results	33
Introduction	33
The Interdisciplinary Imperative	33
The M-EID Strain: Competing Identities	38
Investment of Credibility	41
Investment of Expertise: Deepen or Broaden?	43
Defining Interdisciplinary Science	45
Incompatible Research Interests	50
Responding to Tension: Degrees of Attachment	53
Factors Influencing Attachment	58
Preferential Frames of Identity Construction	61
Social-Relational Identity Frame	63
Occupational-oriented Identities	65
Research Problem-oriented Identities	68
Summary: Preferential Frames of Identification	71
Systemic Benefits of the M-EID Experience	74
Cross-Disciplinary Cohort	74
Exposure to Cross-Disciplinary Theory	75
Summary of Results	77
Chapter 4: Discussion and Implications	78
Theoretical Implications	79

Practical Implications	81
Selection	84
Conclusion	86
<b>References</b>	<b>88</b>
<b>Appendix A: University of Montana consent form</b>	<b>94</b>
<b>Appendix B: Interview Guide</b>	<b>96</b>

## CHAPTER ONE: INTRODUCTION AND RATIONALE, REVIEW OF RELEVANT LITERATURE

### Introduction and Rationale

In his 2005 book *The World is Flat*, New York Times columnist Thomas Friedman contends that America is facing an impending quiet crisis. This crisis, as Friedman explains, centers around a diminishing quantity and quality of scientists and engineers being educated to sustain the American domination of innovation in industry and technology. The reduction of trained scientists and engineers, Friedman predicts, will be felt in 20 years, and this qualifies as a crisis because in a world of globalization, with the economic playfield flattening worldwide, the U.S. stands to lose its' competitive edge in an increasingly important economic capital: the production of knowledge. As Friedman puts it, "America, as a whole, will do fine in a flat world with free trade – provided it continues to churn out knowledge workers who are able to produce idea-based goods that can be sold globally" (p. 230).

As the "premier Federal agency supporting basic research at the frontiers of discovery" (NSF 06-48, p. 1), the National Science Foundation (NSF) is ultimately responsible for the quality and quantity of scientists that America produces. In its Strategic Plan for the years 2006 – 2011, the NSF echoes Friedman's sentiment regarding the economic and political imperative to "maintain the U.S. position at the forefront of discovery and innovation" (p. 2). At the heart of the NSF's Strategic Plan lies one central theme: the need for increased collaboration across the science disciplines. In fact, first and foremost among the NSF's Investment Priorities is "Discovery [through

the] promotion of transformational, multidisciplinary research” (p. 6). Furthermore, every year since 1996 until the present, NSF directors have given public addresses – most at university campuses – preaching the importance of collaboration and cross-disciplinary integration in the research efforts of students and professionals alike. Through its funding efforts, the NSF has proven that this emphasis on interdisciplinary effort is not just idle talk. In FY2006, the NSF spent over \$660 million on cross-cutting programs, more than ten percent of its annual budget. Clearly, the NSF’s answer to Friedman’s “quiet crisis” is to invest heavily in promoting cross-disciplinary collaboration among America’s future generation of scientists and engineers.

However, throwing money at an impending problem, especially one with such potentially high stakes, does not guarantee a solution. Interdisciplinary collaboration has proven increasingly problematic as more attention has been placed upon it. Thus far, researchers who participate in, or study interdisciplinary efforts have reported difficulties framing research questions (Wear, 1999), finding a common theoretical framework (Wear, 1999), communicating expertise across disciplines (Naiman, 1999), and agreeing to epistemological methods and values (Lele & Norgaard, 2005), among others. Ultimately, not all who attempt an interdisciplinary approach to problems that confront multiple disciplines are successful. As Lele & Norgaard (2005) suggest, “surely most [interdisciplinary] efforts fail before they get seriously underway because the participants from different intellectual communities never recognize the barriers created by their separate ways of understanding and approaching the problem” (p. 975).

Yet, simply identifying obstacles that individual researchers must overcome may be an overly simplistic and shortsighted view of the problem with interdisciplinary work. It would be irresponsible to leave interdisciplinary collaboration to those who happen to have the aptitude for overcoming the barriers individually. Sociologists (e.g., Hagoel & Kalekin-Fishman, 2002; Gieryn, 1983) have argued that scientists and engineers are largely products of the disciplines who produce them, with higher degree programs serving as the means through which students are instilled with disciplinary values and practices through socialization. Hence, we must acknowledge the possibility that disciplines may be producing scientists with values that preclude or hinder interdisciplinary work. The problem may in fact be systemic instead of individual if disciplinary socialization has the effect of steering students away from an appreciation and aptitude for interdisciplinary collaboration.

#### Rationale

This study attempts to examine more closely the challenges and problems of interdisciplinary work, with particular focus on the systemic effects of disciplinary training on the scientists it produces. More specifically, this is an exploratory study which seeks to explicate the identity-related messages that effectively instill discipline-specific values to science students. Furthermore, it assumes that disciplines, as they instruct students how to practice science, may also communicate embedded attitudes that affect how those students view interdisciplinary work. In other words, as science students learn what it means to be a good researcher in their respective fields, this study assumes they are also receiving messages that situate them with regards to the

potential of interdisciplinary collaboration. My primary goal here is to find and analyze those discipline-provided identity messages, as experienced by the students themselves, and to explore the effects of these messages on how the students perceive themselves, their work, and the prospect of cross-disciplinary collaboration.

In order to examine the effects of discipline-related training on students, I study two separate groups of postgraduate science students. One group is comprised of interdisciplinary students, while the other group is rooted within one scientific discipline. The interdisciplinary group consists of Ph.D. students who participate in an NSF-funded program at the University of Montana. The Montana Ecology of Infectious Diseases (M-EID) is an NSF Integrative Graduate Education and Research Traineeship (IGERT) program, one of approximately 125 NSF-funded interdisciplinary programs nationwide. The program began at the University of Montana campus in the fall of 2006. At the time of data collection for this study, the program had 14 graduate trainees, each with backgrounds in mathematics, computer science, biology, or ecology. Because it is well-funded and focuses on cutting edge research, the fellowships offered are competitively chosen, and draw Master's level students with strong academic backgrounds. These M-EID students are ideal for this study because they enter the program well-accomplished in academics, with strongly established academic identities and, most importantly, they are drawn together into a program that demands they work collaboratively. Additionally, each student is housed within their "home" discipline, and is assigned an academic advisor from their home department, who is not necessarily associated with M-EID. Hence, they are located within two distinct programs: first, in

their traditional science discipline alongside other standard Ph.D. candidates; and secondly, the M-EID program, where they are required to problem-solve with an interdisciplinary approach. These M-EID trainees are therefore situated at an important intersect of potentially competing demands: to be disciplined scientists in their respective fields on the one hand, but also to be a productive interdisciplinary collaborators on the other.

The second group of subjects included in this study are Ph.D. students who study within one specific science discipline. The purpose behind including these students in the study is to compare and contrast the respective experiences of the interdisciplinary IGERT students with those from traditional single-discipline Ph.D. programs. Including single-discipline students allows for a more clear distinction of how the education, values, and overall experience of interdisciplinary students may differ from those in traditional single-discipline programs. Ultimately, this study aims to expose and examine the effects of discipline-specific training on science students. Studying both groups helps reveal potential differences between the two, both in the identity-related messages they may receive, but also in how they view themselves and the practice of “good science.”

As it explores the relationship between discipline as producer and student as product, this study draws upon and potentially extends a theoretical framework centered on organizational discourse, identity, and control. Discursive identity has become an important and well-articulated theoretical concept in communication studies, providing insight into organizations as discursive constructions (Deetz, 1998;

Fairhurst & Putnam, 2004), highlighting concertive control in discourse (Tompkins & Cheney, 1985; Barley & Kunda, 1992; Barker, 1993 & 1999; Alvesson & Wilmott, 2002), and locating individuals' agency amidst organizational identity-related control (Trethewey, 1997; Holmer-Nadeson, 1996; Ashcraft, 2005; Ainsworth, Hardy, & Harley, 2005). This study builds upon the discourse-identity-control line of research, and potentially holds theoretical implications in at least three ways.

First, it offers an opportunity to focus the critical and analytical lens on academia itself and, in particular, on how knowledge-production is practiced within academia. Thus far, communication scholars have examined discourse, identity, and control primarily within organizations in the commercial and public service sectors, including labor-intensive companies (e.g., Collinson, 1992), knowledge-intensive companies (e.g., Barker, 1993, 1999; Kinsella, 1999; Larson & Tompkins, 2005), human service organizations (Trethewey, 1997; Holmer-Nadeson, 1996; du Gay & Salaman, 1992) and among professional workers (Bullis & Tompkins, 1989; Ashcraft, 2005; Kuhn & Nelson, 2002). Yet, academic disciplines, as culturally prominent producers of knowledge, are under-represented in communication studies scholarship. This study examines scientific disciplines in higher education as organizations that control students by specifying acceptable standards and practices that qualify them to be credible scientists. For this reason, this study would extend and articulate communication theory to better understand knowledge-producing groups, even as they constrict how that production is practiced.

Second, this study may provide insight into a particular issue currently facing communication studies scholars: how to bridge boundaries of multiple intellectual communities and/or disciplines working separately within the field. I use the term “communities” here to stress that the challenge of interdisciplinary work can also exist on a level that problematizes the very concept of discipline. My point, in short, is that an academic discipline is not synonymous with, or identified by the phenomena studied; it is rather more defined by the rules of practice that govern the knowledge-production of a particular community of scholars. Turner (2006) defines an academic discipline as “an organized perspective on phenomena that is sustained by academic training or the disciplining of mind” (p. 183). This distinction results in the potential of multiple disciplines operating in the same field of study; that is, multiple potential means of practicing knowledge-production by groups who study the same phenomenon. Communication studies scholars have already begun to recognize this point, as evident in recent discussions in *Management Communication Quarterly* (see forum discussions in MCQ volume 19, issue 2; MCQ volume 19, issue 4; MCQ volume 21, issue 2) debating how the study of organizational communication can be more inclusive of disciplinary practices that differ due to geographic and cultural distance. The discussion engages a number of international scholars who all study organizational discourse, power, and resistance, yet who identify with multiple disciplines (Barker, 2005; Taylor, 2005; Pritchard, 2005; Pritchard, 2006; Cooren, 2006; Ashcraft, 2006). In recognition of the “outsider” status that one scholar faces when corresponding with those from another discipline, Taylor (2005) asks:

How do we deal with what amounts to, not just different scientific explanations, but contrasting paradigmatic bases grounded in tacit cultural assumptions? Can we really keep the dialogue open? Can we continue to flourish in an in-but-not-in/out-but-not-out global village? Doesn't the very logic of science, and its discipline, work against us? (p. 305).

These are the very questions that this study attempts to answer amongst science students. I argue here that the obstacles facing cross-disciplinary science students are the same obstacles that scholars from different academic communities face, even those within the same field of study. The findings of this study have relevance for both. Finally, this study offers the opportunity to examine how students make sense of, and handle the tension created by potential paradoxes within the discursive formation that informs their work. Students who are encouraged to do interdisciplinary work are likely to hear conflicting messages from their professors and advisors. First, that their discipline has a very structured and specific means of obtaining knowledge, which must be rigidly followed in order to ensure credibility. Second, they may hear a seemingly contradictory message that one should participate in a cross-disciplinary collaboration, where epistemological methods are contested and potentially compromised. Students are consequently forced to reconcile these competing demands, and how they do so holds implications for how they perceive their connection to particular disciplines. This study aims to uncover and understand the multiple discourses that are relevant for cross-disciplinary science research and, in doing so, to find potential tensions created by discourses that conflict by offering competing identity-related messages.

Thus far, I have introduced the significance of this study, established a rationale, and highlighted potential theoretical implications. In the following sections, I will

elaborate on the theoretical framework through a review of literature relating to interdisciplinary work, written primarily by those who practice it, followed by an introduction to discourse, discursive identity, and organizational control. I will then briefly discuss the research questions guiding this study and finally, I will introduce the methodology.

## Review of Relevant Literature

### **Interdisciplinary Literature: A Problematic Imperative**

To date, the body of research discussing interdisciplinary work is primarily written by those who practice it, and therefore tends to be a firsthand description of both the importance of cross-disciplinary collaboration, but also the challenges it presents. Discussion of interdisciplinary work has thus far been initiated in broad array of fields, such as health sciences (Choi & Pak, 2006), biotechnology (McMahan, Martin, & Hugenholtz, 2007), biomedicine (Aagaard-Hansen, 2007), conservation biology (Daily & Ehrlich, 1999), natural resource sciences (Freudenburg & Alario, 1999), watershed and landscape management (Naiman, 1999), sociology (Larson, Nerlich, & Wallis, 2005) and political science (Moran, 2006). The diversity evident in the examples above reflects the “grassroots” nature of the interdisciplinary movement across academic disciplines. Conducting a review of interdisciplinary literature presents its own problems, because researchers in each field have begun recognizing the importance of cross-disciplinary work for the progression of knowledge within their fields, and therefore they discuss their endeavors in somewhat isolated circles. As a result, interdisciplinary essays tend to be spread amongst a multitude of databases and are often not easily obtainable, due to being published in relatively newly-formed journals (i.e., *Ecosystems*, *Ecology and Society*, or *Interdisciplinary Science Review*).

Articles published in each field tend to be a call for greater participation in interdisciplinary research, while recognizing some ambivalence among peers regarding

the prospect of cross-disciplinary collaboration. Many insist that the future progress of their field depends on interdisciplinary solutions. For instance, Naiman (1999) writes, “Understanding this [ecological] situation and reliably predicting its implications demand an interdisciplinary perspective, and that is one of the greatest challenges facing the next generation of ecosystem researchers” (p. 292). The imperative behind collaboration results from the recognition of the inherent social aspects involved in science and, in particular, management science. As Wear (1999) suggests,

Many of the world’s critical problems involve human interactions with nature and their long-term implications for environmental quality and the sustainability of resource/ecological systems. These problems are complex... The separate efforts of social and natural sciences are unlikely to fully illuminate the fabric of or fashion solutions to environmental problems. Rather, much might be gained by truly interdisciplinary research. (p. 299)

Immediately upon pointing out the imperative of interdisciplinary work, however, researchers tend to offer guidance in overcoming obstacles. Many write with an overall purpose similar to Lele and Norgaard’s (2005): “to help researchers who do choose to engage in interdisciplinary work by identifying the barriers to interdisciplinarity in a way that makes them easier to overcome” (p. 967).

The barriers to interdisciplinary work have been identified primarily as epistemological and methodological differences between researchers from different academic communities. In a particularly detailed account of challenges encountered in cross-disciplinary collaboration, Lele and Norgaard (2005) point to differing values regarding what is important to study and, connectedly, the underlying assumptions that different disciplines bring to the research situation. Wear (1999) adds that differences in

language use prevent researchers from easily understanding each other, since specialization in language tends to produce narrow interpretations of common metaphors (p. 300). Pickett, Burch, and Grove (1999) echo the above problem of conceptual framework differences, but also point out that interdisciplinary approaches require inductive reasoning, which is not as critically stable as deductive reasoning.

A few scholars of interdisciplinary research touch on another problematic aspect that remains relatively under-researched: the social dynamics of collaboration. Pickett, Burch, and Grove (1999) list the “group process” as one of four obstacles to successfully collaborating, yet only conclude that it should be nurtured. With more insight, Daily and Ehrich (1999) stress that an important step in interdisciplinary work is “to choose collaborators from among those who are respected in their home disciplines, whose contributions to joint work one can trust” (p. 278). This statement hints at an underlying dynamic present when researchers bring differing values to a research project: the problem of trust and credibility. If credibility is a discipline-specific construct (Turner, 2006; MacMynowski, 2007), then collaborators from different research communities, insofar as they represent their discipline, are put in the difficult position of deciding when to compromise their own ideals and values at the behest of another’s. Currently, this clash of values and vagueness of credibility plays an uncertain role that potentially influences the likelihood that individuals can successfully participate in collaboration. To summarize, existing interdisciplinary literature spans a broad spectrum of academic fields, journals, and databases. For the most part, essays tend to be written from the perspective of a researcher who has attempted an interdisciplinary approach personally,

and seeks to share the lessons learned from the experience. They do so out of the recognition that an interdisciplinary approach is essential to engaging the problems, as they view them, presently salient for their field of study. Though these practitioner-assessments of interdisciplinary collaboration commonly point to methodological and epistemological differences as the primary obstacles to successful collaboration, they only briefly introduce the potentially complex and problematic issues related to social identity, disciplinary representation, and conflicting assessments of credibility. The following section reviews literature that examines in more detail the inherently social aspects of disciplinary representation and identity.

### **Organizational Identity: A Poststructuralist-Discursive Approach**

In order to relate the importance and role of identity for interdisciplinary work, it is first necessary to briefly introduce how communication scholars have viewed and articulated identity conceptually. A poststructuralist conception of identity begins with the philosophy of Michel Foucault (1977; 1980), who rejected the idea that humans have stable, homogenous, essential personalities that remain intact through time. Rather, Foucault asserts that we only understand ourselves and others according to the subjective roles we fill within relevant social-historical discourses. Relevant discourses today might include gender, education, profession, and family, among others. To describe ourselves in relation to education or family is to draw upon resources of context and meaning provided by those discourses. For this reason, communication

scholars (e.g., Mumby & Stohl, 1991; Scott, Corman, & Cheney, 1998; Kuhn & Nelson, 2002; Alvesson & Wilmott, 2002) view identity as a construct of discourse. Significantly, since discourse is symbolic, “Poststructuralists locate identity, and the meaning it implies, in language use” (Holmer-Nadesan, 1996, p. 50).

A key aspect of Foucault’s (1977, 1980) perspective on discursive identity is that discourses, and therefore, the subjective identities within them, are never stable but instead shift and evolve over time. These shifts and changes might occur for two reasons. First, the discourses themselves that are salient and relevant for a person are likely to change over time, due to either cultural or personal developments. For example, for a student who enters college, discourses of professional and career development become increasingly important, and he or she is likely to become increasingly interested in available identities within discourses offered by major and minor fields of study (see, for example, Hughes, 2001). Another reason for changes in relevant discourses may be larger-scale cultural shifts on a broad, technological level. For instance, with the invention and increasing popularity of the internet, millions of individuals have become occupied with maintaining online identities, through websites such as “Facebook” or “MySpace.” Because of regular changes either personally or culturally, the discourses upon which individuals are dependent for identities will shift over time.

The second way that identities shift is within the discourses themselves. A discourse may remain stable, but a person’s role within it may change. In family discourse, for example, a person may get married and have children, and therefore,

their relative identity within the discourse changes as new roles of spouse and parent are assumed. Similarly, a person's role within occupational discourses change when higher education degrees are achieved, usually resulting in higher pay and status. Consequently, there are a number of potential developments in a person's life that can change their status within discourses that themselves remain relevant.

### *Structurational Model of Identification*

Given that identities clearly shift and evolve over time, scholars have further sought to better understand the mechanisms and processes through which these changes occur. Drawing on Anthony Giddens's (1984) structuration theory, Scott, Corman, and Cheney (1998) develop a structurational model of identification that provides a useful means of nuancing our understanding of discursive identities. First and foremost, Scott, Corman, and Cheney (1998) introduce identification as the means through which the process of identity development is both accomplished and observable. Briefly, identification is viewed as a communicative act, or an accumulation of acts, that express membership of a group, or as Scott, Corman, and Cheney (1998) contend, that "illustrat[e] one's attachment" to a collective (p. 303). Identification, in this sense, may take a wide array of forms. For instance, a graduate student may demonstrate identification to their academic department, or discipline, by verbally asserting their connection to the department, but then also by attending departmental meetings, serving on committees, or by writing a paper that responds to existing research within their discipline. In this way, identification illustrated in these actions is a

process through which an identity is assumed and affirmed within an academic discipline. In summary, the structurational model of identification asserts that identities are assumed and practiced through identification, which is observable in communication. But most significantly, the model describes how communicative acts themselves can be a committal step in establishing social identities; participating in the discursive practices of a group is the means of establishing and affirming an identity within it.

### *Multiplicity of Identity*

Scott, Corman, and Cheney's (1998) structurational model also provides a means for recognizing the complex, multiple, and fragmented nature of identities. A number of researchers (e.g., Kuhn & Nelson, 2002; Larson & Pepper, 2003; Tretheway, 1997; Holmer-Nadesan, 1996; Tracy & Tretheway, 2005) have pointed out that individuals do not simply participate in one discourse at a time; rather, have multiple discursive identities that are more or less salient at particular times and in particular environments. In any one setting, Holmer-Nadesan (1996) contends, "individual experience is complicated by the multiplicity of interpretations available in the form of competing social discourses" (p. 51). This point resonates with common sense; we all recognize that people tend to have multiple roles they fill during the day or week, including perhaps, student, family member, co-worker, church member, friend, runner, etc. The boundaries are blurred of where each identity is set aside and another is assumed, particularly in times when identities conflict. For instance, Pratt and Foreman

(2000) found that within organizations, individuals are often presented with multiple conceptualizations of their role, including that of family member to others in the organization, and yet in competition with them for open positions at other times. Amidst this ambiguity, individuals hold some room for choosing which identities they wish to act upon at any given time. Scott, Corman, and Cheney's (1998) structural model of identification addresses this complexity by suggesting that individuals have varying levels of attachment to particular identities. That is, as individuals are put into situations where they must choose a response or action, their choices represent indications of greater attachment to one identity over others.

#### *Organizations as Discursive Formations*

The concept of multiple identities further necessitates that organizations be viewed as sites of multiple intersecting discourses. While studying organizations, researchers have documented the relevance of both macro-level discourses such as managerialism (Barley & Kunda, 1992) patriarchy or class (Holmer-Nadesan, 1996), and micro-level discourses such as those particular to an organization's local culture (e.g., Tretheway, 1997). The current study will emphasize the university setting as a dynamic intersection of numerous potential discourses that may provide a myriad of possible identities for students. This view is consistent with Fairhurst and Putnam's (2004) description of organizations as discursive formations and, in particular, as formations that construct organizations that are in a "state of becoming" (p. 6). In short, this view recognizes that organizations not only have their own unique culture and discourses,

but are also subject to external discourses which individuals may reflect upon when choosing their own identities within the organization itself. Consequently, an individual holds considerable leeway in drawing upon discourses for identity construction, since identities from other areas of their lives may become relevant for how they view themselves within the organization.

### *Identity as a Method of Organizational Control*

In recognition of the multiplicity of identities that individuals may assume within an organization, researchers have looked at ways that identity may be controlled or managed in organizations. Scholars have looked at identity as a means of organizational control in two significant ways. The first involves rhetorically controlling potential identification targets, a method Alvesson and Willmott (2002) call “identity regulation.” Briefly, drawing on ideas introduced by Tompkins and Cheney (1985), Alvesson and Willmott (2002) argue that organizations influence the identity construction of the individuals within it through the media it produces. Management within an organization may more or less intentionally produce and monitor messages to members regarding organizational values, goals, structure, and procedures in a way that harmonizes with their preferred identities and, therefore, they may optimize the chance of positive identification. For instance, instead of using the term “supervisor,” which implies superiority of one over another, an organization might instead use the title “group leader,” which emphasizes a more level hierarchy in a teamwork relationship. Individuals may be more likely to accept this term to describe their work situation and

identification occurs. That is, individuals then view themselves in greater context to organizational values and goals.

Relatedly, the second way that organizations may control individuals using identity is through concertive control (Tompkins & Cheney, 1985; Barker, 1993; Barker 1999; Alvesson & Willmott, 2002). Also called “unobtrusive control,” concertive control takes identity regulation a step further by inviting individuals to participate in their own governance. Given only the end-result goal they should work towards, individuals are placed in a team and share responsibility for determining their own values, rules, and processes. Remarkably, as an organization seemingly relinquishes legitimate and bureaucratic control to self-governing teams, individuals respond by controlling themselves in a more rigid way than any other form of control (Barker, 1999). Tompkins and Cheney (1985) provide an explanation of how concertive control is effective. Briefly, if an individual participates in the development of group values and rules, then they already feel a sense of ownership of the group itself; identification is strong. If that individual views group values and rules as their own, then their decision-making is bound to serve the organization as a whole (Simon, 1976). Decision making is limited, according to Tompkins and Cheney (1985), because the very objectives, values, and rules that the individual has accepted as their own, combine to produce a narrow range of acceptable rational decisions. Decisions are, in this respect, “the process of drawing conclusions from premises” (Simon, 1976, cited in Tompkins & Cheney, 1985, p. 185). Not only is the individual bounded by the view that group values are his or her own, but the group also effectively supervises each member; a violation of group values or rules is

a violation of group identity. As Barker (1993) relates, the group members “create a value-based system of control and then invest themselves in it through their strong identification with the system” (p. 434). This type of control is also called “unobtrusive control” because the group members generally do not consider themselves controlled – if anything, they believe they are controlling themselves, which seems very natural to them (Barker, 1993). In summary, concertive control is a type of organizational control that tends to arise within self-governing teams. Similar to identity regulation, it is effective because it offers individuals a positive identity within the organization, one that is likely to harmonize with personal values.

To conclude, the communication studies literature reviewed in this section focuses on links previously established by researchers connecting discourse, identity, and organizational control. Identity is a useful means of understanding individuals’ behavior, because insofar as it reveals the way that an individual views oneself, it also places them in context to particular discourses that are more or less meaningful in their lives. To the extent that an individual demonstrates attachment to a particular identity, analyses of social discourses relevant for that identity will provide insight into the associated values and beliefs that are prescribed by those discourses. A poststructuralist view of identity recognizes the complex, emerging nature of identities. Within organizations, individuals hold considerable leeway in constructing an identity that suits their own interests, because organizations tend to be sites of multiple intersecting discourses. But just as identity seems to result from personal choice, it can also provide subtle means of unobtrusive organizational control. Research has shown that identity-

related control may be the most stringent type of control in practice, because to the degree that an individual identifies with a role in an organization, the greater he or she will participate in self-disciplining. With these aspects of identity established, the following section places the subjects of this study in greater context to the discursive identity theoretical framework.

## **Viewing the Science Disciplines through an Identity Framework**

The preceding review of relevant literature provides a theoretical framework that emphasizes the significance of studying attitudes toward interdisciplinary work among postgraduate students in the science disciplines. In particular, Ph.D. students in the NSF/IGERT-funded “Montana Ecology of Infectious Diseases” (M-EID) program are presented with an exciting but problematic opportunity to participate in cross-disciplinary research. Having established themselves in a “home” science discipline through undergraduate and Master’s degree programs, they are now presented with an imperative – important on both a local and national level – to collaborate with others from different disciplines. As such, the students are situated within the university at the intersection of a number of relevant discourses that inform their work, yet that also conflict in providing competing interpretations of their role and work. In pursuing their research through group work, the M-EID students will have to negotiate research questions, choose a theoretical approach, and agree on epistemological methods, while balancing their disciplinary criteria for how to conduct good research and, ultimately, for how to be a good scientist. Accordingly, my first research question focuses on explicating those potentially paradoxical messages that M-EID students in particular may need to reconcile and negotiate during their research:

**RQ1:** What are the primary identity-related challenges that the M-EID students are confronted with, particularly regarding interdisciplinary work?

Second, given that the M-EID students potentially hear messages representing multiple discourses from various sources, ranging from advisors, faculty, program guidelines, and peers, my next research question examines which of those messages are most influential for these students as they construct and verbally describe their identities:

**RQ2:** From which discursive sources do the M-EID students draw upon when constructing and explaining their academic identities?

Third, since prior identity-related research has established the relevance of concertive control in group work, my next research question seeks to examine the extent that the M-EID cohorts influence each other during identity-construction:

**RQ3:** What degree of coherence exists among identity-construction of the M-EID students as a group?

Finally, an important aspect of this study is to assess the influence of interdisciplinary training on students as it attempts to prepare them to succeed in cross-disciplinary collaboration. My final research question compares the identity-construction of the M-EID students with the identity-construction of students in single-discipline Ph.D. programs, to assess whether there are observable differences:

**RQ4:** What, if any, are the differences between M-EID students and single-discipline students, in how they construct their identities, especially with regard to interdisciplinary collaboration?

## CHAPTER 2: METHODS

Thus far, I have given the rationale behind this proposed study, and reviewed the related literature dealing with organizational discourse, identity and control. Last, I stated my four research questions. In the following section, I will introduce the methods I used to conduct this study, first by reviewing the participants, then by discussing my methodological approach, instruments, and procedure.

### Participants

To review, this study focuses on studying two separate groups of postgraduate science students. The primary group consists of Ph.D. students in The University of Montana's NSF-IGERT sponsored program, Montana Ecology of Infectious Diseases (M-EID). The M-EID program began a 5-year NSF grant in the fall of 2006. The participants of this program are chosen competitively because they have distinguished academic backgrounds, have earned Master's degrees in a science discipline relevant to the study of infectious diseases, and they have demonstrated an ability and/or interest for interdisciplinary work. These M-EID students represent ideal subjects for this study, because their program places them at the crossroads of two important disciplinary discourses: that of their "home" science discipline, and that of interdisciplinary collaboration and problem-solving. As such, they are confronted with the imperative of

becoming good, productive scientists in both discursive contexts. This study seeks to document and examine how this is possible for them, and their means of achieving it. The M-EID program is supported by 11 faculty “program leaders,” from six academic departments: Computer Science, Wildlife Biology, Organismal Biology and Ecology, Integrative Microbiology and Biochemistry, Mathematics, and Communication Studies, though additional faculty from the University of Montana teach courses offered for the M-EID students.

At the time of data collection, 14 M-EID Graduate “trainees” had entered the program, all with backgrounds in one of participating departments (with the exception of Communication Studies, which is not directly funded by the IGERT grant, and has a support-oriented role in the program). I requested the participation of all 14 trainees for this study through e-mails and phone calls, but four were unavailable or unresponsive to my requests. Consequently, ten M-EID students participated in this study. Those ten M-EID participants have the following departmental associations: one in Computer Science; one in Wildlife Biology; four in Organismal Biology and Ecology; one in Integrative Microbiology and Biochemistry; and three in Mathematics. Seven of these participants are male; three are female. Not all of these ten participants are still active in the M-EID program – two are now on “inactive” status. I chose to include these two inactive trainees in this study because their experience in the program is relevant to how they personally negotiated the challenges of interdisciplinary work, even if it led them to discontinue the program.

In addition to these ten M-EID trainees, I also solicited the participation of ten additional Ph.D. level, but non-M-EID students from the participating departments, making 20 total participants for this study. The reason for their inclusion is not simply to increase the sample size for this study, but because the non-M-EID students are also sources for discipline-rooted attitudes toward interdisciplinary work. From these students, I gain greater context for the discipline-specific perspectives of what it means to be a good scientist, and further, I gain additional accounts of how that perspective affects their attitude towards interdisciplinary work. In soliciting the participation of these ten traditional, single-discipline students, I sought to “mirror” the ten M-EID students in respect to departmental associations and gender. The ten participants from the traditional, single-discipline programs therefore have the same relative representation of academic departments: one in Computer Science; one in Wildlife Biology; four in Organismal Biology and Ecology; one in Integrative Microbiology and Biochemistry; and three in Mathematics. However, due to a limited number of available graduate students from those departments, I could not match the gender distribution of the M-EID students. Of these ten traditional, single-discipline participants, four are male, and six are female.

In summary, the participants for this study total 20 post-graduate students. Nine are female, 11 are male. All are affiliated with one of the participating departments of the M-EID program (Computer Science, Wildlife Biology, Organismal Biology and Ecology, Integrative Microbiology and Biochemistry, and Mathematics).

## Data Collection

Though this study seeks to explore the general identities and attitudes cultivated among the scientific academic disciplines, it's important that these descriptions and demonstrations of science students come directly from the students themselves. Students' own descriptions of their work and experiences are the only available means of gaining access into their particular sensemaking and the way they assign meaning to particular aspects of their experience. Importantly, the data I sought to collect from these students needed to be contextualized amidst the underlying values, attitudes, and beliefs of each student. Contextualized responses provide the possibility of nuancing the subtle differences in the meanings that students attribute to explanations for how they get their work done. This type of "thick description" (Geertz, 1973) necessitates a qualitative method of research, and in particular, in-depth interviews, where the participants' answers can be explored with follow-up questions, if necessary. I therefore used semi-structured interviews in order to achieve a contextualized response – that is, a deeper explanation of answers – from each student. Semi-structured interviews have become a useful data collection tool among identity-related researchers in organizational communication. Particularly, recent scholars have argued that interviews provide an ideal means of providing participants ample time and opportunity to demonstrate identification with organizational values and decisional premises (Tompkins & Cheney, 1985; Alvesson & Wilmott, 2002; Kuhn & Nelson, 2002; Larson & Pepper, 2003). In particular, Larson and Pepper (2003) use interviews to collect

“interview talk” (p. 537) which demonstrate the participants’ relevant narrative for how they construct their own identity amidst potential alternatives. In another study, Kuhn and Nelson (2002) use interviews to find “discursive resources” (p. 20), which participants use to make sense of their own experience within an organization. Interviews, then, are useful tools because as participants answer questions about their experiences and work within an organization, they in the process reveal the particular sense they make of those experiences, which itself is dependent upon identifications they’ve made within the organization, whether they are cognitively aware of it or not (Tompkins & Cheney, 1985).

Semi-structured interviews were also helpful because they provided a degree of flexibility that served two purposes. First, they allowed me to prepare an outline of questions that I asked all participants, to ensure that I gathered the same basic information from each interview. But second, I also benefited from the freedom that semi-structured interviews offer to depart from the script of questions if respondent answers raised relevant, but unforeseen issues that were important for this study. For instance, at times students voiced unexpected attitudes, values, and problems that were relevant to their experience, but not specifically targeted by the prepared questions. In such times, I temporarily set aside the prepared interview questions in order to pursue a fuller explanation of those unexpected responses. I therefore arrived at each interview with a “guide” of questions, which I made sure were answered in the course of the interview, but many discussions took on a life of their own, and this

freedom consequently provided the type of exploration of student experiences that I originally intended with this study.

The interview guide (attached as Appendix B) consisted of seven basic interview questions that solicited broad descriptions of science students' work and perceptions regarding "good" science. The interview guide also contains potential follow-up questions (as sub-points) that I used to get the respondents talking, in times when their answers were sparse.

### **Procedure**

Most of the participants were selected out of necessity, based on required factors. The first group of participants, the M-EID trainees, was targeted because of the interdisciplinary nature of their program. The ten traditional, single discipline students were solicited through two separate methods. First, when interviewing the M-EID students, I used the "snowball" method; I asked the interviewees if they knew any fellow graduate students in their home departments who weren't associated with M-EID. Four traditional students were identified and secured for participation in this way. Second, I used on-line departmental directories to find the names and e-mail addresses of graduate students in each department. I then sent out e-mail messages to those students, requesting their participation. The remaining six participants responded to those requests, and were chosen because they fit the criteria required to "mirror" the academic department affiliation and gender of the participating M-EID students.

After obtaining informed consent from each participant, I conducted all interviews in person, with one exception. One student, who had quit the M-EID program and was attending a distant university, interviewed using virtual meeting software via the internet. Otherwise, interview locations were negotiated depending on the convenience of the interviewee, but generally took place in meeting rooms on the university campus. Interviews ranged in length from thirty-five minutes to ninety minutes. No follow-up interviews were required. Once all of the interviews were completed, I transcribed them, assigning aliases to each interview to protect the identity of each participant.

Analysis proceeded in three phases. First, before interviews, I spent time with the M-EID students, both in and out of class. I attended a communication course they were all required to attend, and on one occasion, I assisted in teaching the course. I also spent time with many of the M-EID students in social settings, getting to know a couple of them as friends. Spending time with the M-EID students provided opportunities for casual and frank conversations, a means by which I learned about their program and general experience. Second, I conducted and analyzed interviews in depth, with focus on identifying common themes within and across the students' experiences. I paid particular attention to recurring identification targets and searched for consistencies in the way that students described themselves, their experience, and as they told their stories of how they came to choose their current programs and research projects. While identifying themes, I used a process of analysis based on a modified version of constant comparison method (Glaser & Strauss, 1967). I repeatedly tested the emerging

themes by examining the completeness and distinctness of the categorization and explanation suggested by the theme. For example, one apparent theme that emerged was the mitigating role that academic advisors played in a student's experience. After five or so interviews, it seemed to be the case that students who demonstrated a strong identification with his or her academic advisor also identified positively with their academic program. As this theme became evident, I tested it against the rest of the student interviews, to make sure it remained accurate, which it did. Consequently, the theme proves useful for understanding important factors that influence a student's experience. I chose constant comparison as a method of analysis because past research has established themes as an appropriate unit of analysis when contextualizing meanings that underlie identity references and decisional explanations (DiSanza & Bullis, 1999).

The final phase of analysis consisted of member checks (Lindlof & Taylor, 2002). Once again, my friendship with two M-EID students provided useful opportunities to receive feedback on the themes I found in interviews. I simply presented my ideas as "theories" regarding what it's like to be an M-EID student, and my friends could confirm or deny whether my idea resonated with their experience. Thankfully, they were always quick to point out times when they disagreed, and in those times, I re-examined my interpretive themes. The themes that emerged through member checks intact are presented in the following chapter, where I discuss the results of this study.

## CHAPTER THREE: RESULTS

### Introduction

In this chapter, I present my findings while answering the research questions specified in chapter one. Those research questions are:

**RQ1:** What are the primary identity-related challenges that the M-EID students are confronted with, particularly regarding interdisciplinary work?

**RQ2:** From which discursive sources do the M-EID students draw upon when constructing and explaining their academic identities?

**RQ3:** What degree of coherence exists among identity-construction of the M-EID students as a group?

**RQ4:** What, if any, are the differences between M-EID students and single-discipline students, in how they construct their identities, especially with regard to interdisciplinary collaboration?

### The Interdisciplinary Imperative

My first important finding is that the experience of M-EID students is not entirely removed from that of traditional, single-discipline Ph.D. students. All of the demands placed on the single-discipline students are also placed upon the M-EID students. Both groups share in the imperative to embrace identities defined by, and subject to the traditions of disciplinary science. However, the sharing is not reciprocal. My second important finding is that, while M-EID students remain subject to the discursive strains of disciplinary science, they alone carry a burden not felt by the single-discipline students. The M-EID students must also develop a supplemental capacity to negotiate the demands of becoming an “interdisciplinary scientist.” It is in this underlying tension, brought on by the demands of maintaining a disciplinary identity in the face of an

emergent interdisciplinary imperative, where the M-EID students are confronted with an uncertain future. In this section, I will first explain and characterize the identity demands experienced consistently by all twenty of the post-graduate science students interviewed for this study. Second, I will highlight the additional demands placed upon the M-EID students alone, with particular focus on the tension and strains caused by the unique imperative of interdisciplinary science.

### *Disciplinary Identities*

Examined as a group, the twenty postgraduate students interviewed for this study express a common experience that enables a composite sketch of the identity demands placed upon them by traditional academic disciplinary training. That experience can be characterized as a difficult process of simultaneously juggling the responsibilities of researcher, teacher, and student, a process complicated by uncertainty caused by the lack of a documented procedure for how to prioritize those responsibilities, which results in a frustrating trial-and-error learning process.

All students are expected to juggle three primary areas of responsibility, in order of importance: 1) to pursue research relevant to their discipline that will lead to publishable results; 2) to secure funding primarily through teaching assistantships, but potentially through grants; and 3) to complete all program coursework achieving good grades.

The single most frequent responsibility cited was the imperative to pursue research for their dissertation that contributes to disciplinary knowledge, and that will protect the reputation and prestige of their home department. Both M-EID and

traditional students reported that their ultimate purpose was to produce “good” science, by pursuing relevant research questions, by using sound scientific methods, and therefore arriving at results worthy of being published, or being presented at a regional or national conference. By practicing good science with visible output, they would protect and maintain the national or world reputation of their home department. One student summarizes this viewpoint when she states, “I feel like there’s a lot of pressure to produce good science, and to publish, that kind of stuff. I think, as a student in this program, it’s kind of part of our responsibility to keep up the good work that’s come out of this program; to add to that.” A separate student builds on this idea when he points out, “I mean obviously publications are our currency.” Overall, the suggestion is that personal and departmental prestige and credibility are the valuable commodities within the science community, and they are primarily built through the accumulation of publications. Because they are peer reviewed, publications are judged for the quality and relevance of the experiments or studies conducted for them. Although the graduate students are only just learning how to conduct experiments of their own, and to write up their results, they still feel the imperative to produce results near the same quality as their professors. Discourses of competition and credibility are therefore central to the experience of these students right from the start of their graduate careers.

This emphasis on competition and credibility is also evident in the students’ responsibilities in the classroom – both in teaching classes, but also in taking their own required classes. Teaching tends to be viewed as a potentially enjoyable, fulfilling aspect of their program, but also may be problematic because of how time-consuming it tends

to be. Time spent teaching or preparing for class is time taken away from research, and many students reported regret at having to invest that time. For example, one student summarizes her and her cohorts' feelings toward teaching when she says, "Teaching really... it takes a lot of time away from research, which people get pretty antsy about. But it's not difficult, you know, and it's rewarding." Despite the fact that teaching can be rewarding, many students seek "outside" funding sources, such as through an NSF grant, in order to free themselves from the time burden of having to teach in order to earn a stipend. Ultimately, the pressure of having to teach and invest time outside of research tends to outweigh the potential reward of teaching, and most students, M-EID and traditional alike, express a preference to not have to teach.

Although taking classes is generally not viewed as overly difficult, the students reported feeling stress as a result of coursework during the semester. Most students shared the sentiment expressed by one interviewee, who said, "Academically, I didn't feel it was challenging. I was happy to learn the stuff in our biology class but it didn't hurt my brain or anything. The math class was 85-percent review. So that wasn't academically challenging either." The stress primarily came from juggling class projects while finding and establishing a research program for their dissertation. All students were only required to take classes for the first two years of their program, but those two years are the most chaotic; students are asked to become oriented with the program, while teaching, and while learning to conduct research through class projects. Being invested in all of these varying directions makes it hard to find and establish a personal

research project for a dissertation. One student explained the most difficult aspect of his experience:

The hardest part was the – the extra time that doing all the coursework, you know, and ... putting the time into that kind of made it hard for me to put enough time into getting a dissertation going. And that was my personal problem. The biggest one I had was – the fresh air I really didn't get. I had a dissertation topic idea. But I didn't develop it hardly at all and it didn't really go anywhere. And that caused some friction with my advisor.

This quote not only establishes the difficulty of juggling responsibilities during the first two years, but it also demonstrates a universal challenge that confronts students: learning how to efficiently invest their time while negotiating an emotionally demanding, trial and error learning process. For most students, this was the most difficult challenge they faced. One student explains:

When I started graduate school, I started realizing that I was gonna have to get used to criticism and feedback that basically... I don't want to call negative. It can be constructive, but it's still like, 'This isn't good enough.' And how much you get... how much of that you get, consistently. And so, my advisors have been very supportive, but I felt like it was just really hard to deal with the constant, 'Yeah, this is good; not good enough. Yeah, this is good; not good enough.' And it's like, it's kind of like you're getting a skin built up. But it's really hard to build it. And I really struggle with that. It's that pressure to perform while also feeling like it's never quite enough.

Another student elaborates on the degree to which he was forced to flounder:

I feel like the hardest part is really... I feel like they almost expect you to already know how do research. And, let you flounder a lot, which I think is really hard for someone who in their life... you know, most of the people who come into this program, their lives have been achievers. You know, they're always at the high end... always doing well, always know what to do. And then you get into a program where you're not exactly sure of what to do, not sure if what you're doing is right... I think for me, that's been the hardest. And not... a lot of times I feel like I'm just alone working on something, and then I put it all together and present it to a

group of people, and then they tell me that 'You should have done this and this and this!' And, 'why didn't you do that?' And, 'This isn't good science!'

The common experience among the graduate students I interviewed was a sense of futility they felt when facing the expectations and scrutiny of faculty who seemingly take for granted their own experience and knowledge of sound experimental methodology. This latter quote also demonstrates the relevance of discourses of competition and meritocracy. This student reports that he's always been "at the high end" of academic performance, yet now feels as though he has been set up to fail. Furthermore, both of these students reported that this type of critical feedback came during colloquium presentations, with both faculty and graduate students in the audience. Whether the faculty intended the comments to be competitive commentary is beside the point: the students certainly interpreted the situations competitively.

In sum, all of the students included in this study share a common experience insofar as they confront the challenges of developing disciplinary identities. Disciplinary training demands that they juggle a few fundamental roles and responsibilities, including those of productive researcher, competent teacher or grant-earner, and apt learner, all of which are informed by discourses of credibility, competition, and meritocracy.

### The M-EID Strain: Competing Identities

The above portrait of a disciplinary science student is inclusive of both traditional, single-discipline postgraduate students, and interdisciplinary, M-EID

students. It is a shared sense of the identity demands placed upon them in a traditional, postgraduate program. An important conclusion from the above section is that the M-EID students are not relieved of the need to develop and strengthen their identities within their home discipline, despite the uniqueness of their program. The M-EID students are required to gain acceptance into a disciplinary program, they are assigned an advisor from that discipline, and they report experiencing the same pressures as the traditional, single-discipline students to establish themselves in that home discipline. Consequently, thus far the M-EID students have proven to be no different from their traditional, single-discipline counterparts.

However, the M-EID students did have aspects of their experience that were specific to them as a group, which were not shared by the traditional students. They reported a significant additional tension that no traditional student reported: the imperative to become interdisciplinary researchers. One student summarizes the unique responsibilities of an M-EID trainee this way:

I think the larger responsibilities as a grad student in M-EID are basically to... is to do your research, but also to take a more interdisciplinary approach to it, to make sure you're working with other people, that you're not just tied into your own department. And I guess that's the main thing that I see, to make sure that I'm approaching my research problem at an interdisciplinary level, and not just in the field... in the department where I'm working in.

This quote is insightful because it indicates the additional nature of the M-EID imperative: "to do your research, *but also* to take a more interdisciplinary approach to it." M-EID trainees must accomplish all of the goals of a traditional student, but must do so in a special way. Importantly, these unique demands that the M-EID trainees alone

feel are supplemental to traditional disciplinary demands, and at times may conflict with them. The tension produced by potentially conflicting identity demands has a profound impact on the way the M-EID students negotiate their experience, as many reported feeling pressure to prioritize one identity over the other.

In interviews, it quickly becomes apparent that juggling these unique interdisciplinary demands with those of the traditional disciplinary demands is a particular struggle for the M-EID students, especially when one considers the established ambiguity and uncertainty the students already felt over prioritizing competing demands for their time. In consideration of their interdisciplinary responsibilities, the M-EID trainees report pressures resulting from four primary areas of friction between these two competing identities. The first involves questions of credibility; the M-EID students often expressed perceptions of needing to establish their professional credibility by way of one identity vein over the other. Second, and related, M-EID trainees reported feeling a strain in where to focus their expertise. How they resolved to build their credibility had consequence in the scope of expertise they strove to foster within each identity vein. A third tension, also related to the previous two, strikes a more elemental chord in the M-EID experience: students felt a strain in learning to define what it truly means to be an “interdisciplinary” scientist. Finally, the fourth area of tension involves the potential need for compromise in their personal research agenda. Some M-EID trainees reported difficulty finding research projects that suited both veins of their identity. Consequently, settling on a research agenda relevant to interdisciplinary research potentially had the feel of “selling out” on one’s own home

discipline. In the following sections, I will explain and demonstrate in more detail these four areas of tension experienced by the M-EID trainees.

### Investment of Credibility

The M-EID students face one particular identity demand that traditional students do not: the question of program loyalty. As suggested earlier, M-EID students tend to experience a duality in the identity demands placed upon them. On one hand, they have been accepted into, and are funded by an NSF supported IGERT program, which emphasizes that they will be trained as interdisciplinary scientists, capable of engaging in the social collaboration necessary for finding and pursuing integrative research opportunities. On the other hand, they must also be admitted into a traditional “home” science doctoral program, which their background qualifies them for, and which carries its own disciplinary demands of scientific practice. They are therefore participating in two programs at once. Furthermore, the demands placed on them by each program may tend to assume exclusive rights to their time. Simply put, it’s not a given that a first year Ph.D. student will have adequate time to fulfill the requirements of two programs. And in fact, students often felt that they had to prioritize one program over the other, for reasons of time-management, but also for reasons more fundamental to identity: they grew concerned over how they would be seen, and judged, by academic culture at large. Specifically, students recognized that their professional future largely depended on the disciplinary credentials they would carry with them after graduation. When asked about the most difficult aspect of the M-EID program, one student responded, “I think the primary danger of the program is to not fully develop what I call an ‘intellectual

identity.' People who focus on working within one discipline have the advantage of establishing themselves in a research program. I worry that spreading my effort across disciplines means that I don't publish as much in biology, and I may not establish myself in biology as much as a straight biologist." This sentiment suggests that faculty established in a traditional science discipline may view interdisciplinary students with skepticism or doubt. The possibility is a real one; the fear inspired one student to change her home department from the Individualized Interdisciplinary Program (IIP) to Organismal Biology and Ecology (OBE). In the following exchange, I asked her why she made the change:

JP: So the minute I had a chance to get out of IIP, I did.

NB: And it sounds like you weren't happy being in IIP?

JP: It's not that I wasn't happy being in IIP. But being a straight biologist, I don't think it looks so good.

NB: How come?

JP: Well, it's hard to have a really interdisciplinary project in biology. I mean, I have a little tangent on that with [another M-EID student] in my project that brings the computational aspect into it, that brings the modeling aspect into it. But you know, how do you apply for a tenure-track biology position when you don't have a biology degree? I mean, you can call it anything you want. But you don't have a Ph.D. in biology. Or in ecology. Or in wildlife biology. You have a degree in interdisciplinary studies... with a focus in disease ecology? You know?

NB: So what use would an IIP degree have?

JP: Well, we tried to ask... Mary Poss [M-EID co-PI] about, like, "what does it really mean? Are we screwed because we're gonna have IIP degrees?" And...

NB: What did she say?

JP: She kind of hemmed and hawed, and... I don't think she liked the program. I don't think anybody... I think there are other reasons that people in DBS [Division of Biological Sciences] and Wildlife don't like IIP. And that's because people can't meet the requirements for those programs, and [they] get in to IIP. And then expect people in biology to be on their committees, and to help them with their projects, when they've blatantly not been accepted to those programs.

NB: Okay. That seems like quite a dilemma then.

JP: Well, especially if you're not made aware of that, and think, "well, I really want to do this, so I'm gonna apply to this program [IIP], because it gives me a means to do that." And then to have faculty members that refuse to help you. I'm not saying that all faculty members do it. And, you know, maybe... I've heard through the grapevine from a few people that there's more than one person that shares that sentiment.

The underlying issue apparent in this exchange is credibility – IIP students may potentially encounter distrust from faculty who question whether they can work in their field. The logic apparently follows that some faculty may therefore refuse to invest their time in students who have not been accepted into their program, and who may not have the appropriate background for such work. Students who encounter this type of attitude in graduate school can imagine it extending beyond graduation, to job searches, and potential rejections as a result. If during graduate school the student acquires the stigma of being an interdisciplinary student who could not gain acceptance into a biology program, then why would the student qualify for a tenure-track biology position? Consequently, many M-EID students feel compelled to focus more on developing a traditional disciplinary identity than an interdisciplinary (M-EID) identity.

#### Investment of Expertise: Deepen or Broaden?

The single most frequently cited difficulty of the M-EID program was the strain of taking classes in other disciplines. The frustration of learning new, unfamiliar subject

matter is understandable, but the M-EID trainees explained their frustration in context to a deeper strain, centered on the investment of their time. Students in traditional Ph.D. programs have the narrow focus of deepening their expertise in a single discipline, often within a specialized research area. In contrast, M-EID students are asked to forego, to some degree, the deepening of their home disciplinary expertise in favor of broadening their understanding of other disciplines. Instead of furthering research in an isolated vein of their discipline, M-EID trainees are asked to identify and pursue research that integrates disciplines. As one trainee explains, his responsibility is “to make sure that I’m approaching my research problem at an interdisciplinary level, and not just in the field... in the department where I’m working in.” Yet, identifying potential research that connects disciplines requires some level of knowledge of other disciplines. The problem of investing time in learning other disciplines is that one never knows if that time investment will end up paying dividends. The following exchange, with the same student quoted above, demonstrates this frustration:

NB: Okay. So... insofar as you’re aware of your responsibilities, have there been any that have been the most difficult for you to handle?

GR: In terms of the amount of energy required, it was certainly the math course in the first semester. Um, as I’m really trained in biology, and hadn’t taken math since high school. Even though I had gotten pretty far along in high school in math, it was... that was the hardest in terms of catching up to speed on everything, and learning the math. But more, learning the programming, really, more than the math concepts. It just took a lot of time.

NB: Yeah. So that... getting through that was the hardest...?

GR: Yeah, I think that was the hardest. That took a lot of effort and a lot of energy just to be able to get through.

NB: Yeah. Was it worth it?

GR: Uhhh. I think so. I'm not a hundred percent sold. But I think it would be... I think it will be good if I can get... I think there are certain things that could be changed about it. I think to be honest, the MAT... like, we focused a lot... it's sort of funny, because they... if I can backtrack here for a second. Basically, in the first year, I think they taught the course using three different [computer] programs. So they used MATLAB, and then they used R, which is statistical software, and something else. And basically everyone said, "It's too hard to learn three languages. You should just learn one." And sort of now, going through it... at the time, I was only... we only learned one. Because I felt like.. you know, I didn't really master it until the end of the semester. But now, I think that actually would have been useful to know R also. So... yeah... so yeah, I did get a lot out of it, in the sense that, um, learning to program and building stuff was... it was kinda cool. So, now I wish now that we'd done it in a different language, something else that I would had more applied use for.

Clearly, a large part of this student's challenge in his first year was catching up on the math he'd missed as an undergraduate, but also to learn programming languages that may or may not be relevant to his dissertation research. In the end, he surmises that his time would have been better invested by learning a language separate than the one he did learn. To some degree, all M-EID trainees are asked to learn subject matter with uncertain relevance, and therefore, all are subject to potentially fruitless toil. Importantly, none of the traditional students voiced this type of concern. In a traditional, single-discipline program, students are more assured that course material is applicable to their specialized research agenda.

### Defining "Interdisciplinary" Science

This tension over learning potentially non-relevant material connects to a third strain expressed by M-EID students, which itself is elementary to becoming an interdisciplinary scientist. M-EID trainees must wrestle with the question of what is

required to be a truly capable interdisciplinary scientist. That is, they must define for themselves the practice of interdisciplinary collaboration. The M-EID program is clearly set up for the trainees to take classes in multiple disciplines, which implies that interdisciplinary collaboration requires knowledge and expertise that spans across disciplines, but all of the trainees must determine for themselves how much expertise they're capable of acquiring in each discipline. In the following exchange, one student explains how he wrestled with this question himself, and how he eventually resolved it. I asked about the most challenging responsibility he felt as an M-EID trainee, and he responds:

BR: And then also about the interdisciplinary nature. Like, my perceptions of it. There's sort of like the -- okay, interdisciplinary education... does that mean that I'm going to learn a lot of computer skills and math skills, you know -- so I'm a biologist learning these skills or is it more like I'm going to learn to work with the people? So it's kind of an interesting....

NB: I see. So a... learn to collaborate on an interpersonal level sort of thing?

BR: Right.

NB: So what do you think?

BR: Well, going into it I thought it was more like -- I'm learning these skills, so I'm going to be getting the computer [knowledge] and including that in my research. But then the level they were teaching us was so high, you know, for someone who hadn't had the -- all the other math classes and computer classes --suddenly in these graduate level classes they would bombard you. But then you have to -- then I think -- I step back and other biology students step back and say "Okay, we're learning some skills and -- we're not mastering them, but we're learning, you know, about them and we're getting to know these people who can help us, so it's sort of the ...

NB: So you're saying that you went about the program with the attitude that you could personally learn these other disciplines, or you could operate within them for yourself. But then the class – it became apparent in the classwork that it was so high, technically, that you probably couldn't and that you had to start depending on the other people a little bit more. Is that – is that sort of what I'm getting?

BR: Yeah. Right. I think that kinda makes sense. So it wasn't—it's not something I would just do on my own. "Okay, I have these skills now..." It's more like, "Oh this – now I have this research project and I need to do this analysis and I know the statistical method that I could use, so I'm going to collaborate with so and so..."

This student, who has a biology background, began with the assumption that he could eventually learn to be a capable mathematician and computer scientist through course work. He believed the course work would teach him enough so that he could personally add those components to his own research project. But eventually he had to abandon that hope by necessity, when the required level of expertise got to be too high, and he recognized that he would have to seek help when and where he needs it. Importantly, he did learn enough in those classes to help him know where to look, and how to ask for that help. Thus, he arrived at his own balance of personal expertise versus reliance on collaboration, to develop his working definition of interdisciplinary science.

Most M-EID trainees reported wrestling with this question of how to balance personal expertise with the need for collaboration, but not all resolved the question in the same way. The student in the above example acquired a basic understanding of other disciplines, but did not master them to the point of self-sufficiency. He simply resolved to learn enough to know how to ask the right questions for help. Other students, however, choose to foster their personal knowledge and expertise of other disciplines to a greater extent. A good example of this type of student is an M-EID

trainee in mathematics, who resolves to become as knowledgeable in biology as possible. He demonstrates his eager attitude toward learning biology in two separate discussions. In the first, he explains why he has two advisors, one in math and one in biology:

NB: Now, you said you have two advisors?

SS: I, okay... so on paper it's one advisor. But I call George my co-advisor.

NB: And who is George?

SS: George Haskell is a microbial geneticist. He works with... well, he works with a few things. He works with yeast genetics, he works with the pathogens, the infectious pathogen *psuedomonis*. So I've worked on both of those projects with him.

NB: How were you introduced to George? How did he know about you?

SS: Through Henry [my math advisor]. So, I took a ... I took my applied series with my Masters and started a project modeling continuous culture environments for microbial cells, and Henry... it was Henry who encouraged me to take that project, and he... after the class was over, he encouraged me to take it further and write it up. And that became my Masters project. And then he said, during my Masters project, he said "You really need to meet George Haskell. He does genetic experiments on continuous cultures, and you can work with him. He has a lot of these continuous culture vessels, called chemostaps. You can use them to collect your own data if you want, if you work with him." And I did, and I have been collecting my own data. It's been a great relationship.

NB: So even before you joined M-EID, you were already sort of merging disciplines.

SS: Yeah, I was... very much so. Before M-EID, I was already working in a lab, George's lab. I was already doing the applied math before that. Although, I wasn't... my biology background and my statistics background was a little weak. But...um.. I'm working on it.

There are two interesting aspects of this exchange that reveal the personal responsibility this student assumes for learning biology. First, his overall attitude

throughout the exchange demonstrates that he's eager to learn as much biology as possible, even investing his time while a mathematics Masters student in a biology lab. Furthermore, he admits his biology knowledge is "a little weak," yet ultimately concludes, "I'm working on it." Importantly, he shows no hesitance to keep learning, and professes no acknowledgment of boundaries of what he can or cannot learn. The second interesting aspect of the above exchange is the level of biology expertise already demonstrated by this student. He uses technical jargon in biology with fluency, and he off-handedly acknowledges that he collects his own data in a biology lab. These abilities are not representative of an outsider to biology. They show a significant achievement of expertise.

In the second exchange, he again reveals the high sense of responsibility he feels for learning biology. When I ask him to explain his responsibilities as an M-EID trainee, he responds:

SS: Ummm... that's a tough one. So, my responsibility is a few things. I would say primarily... my number one responsibility is to go through the applied math Ph.D. program, the math Ph.D. program. Uh, satisfy those requirements. But because I'm in M-EID, I also have to show an active interest in, um, interdisciplinary science, period, just that. Which I do, I greatly find interdisciplinary science amazing....

NB: Can I stop you just real quick?

SS: Yeah.

NB: When you say "active interest," is that your own term or is that something you heard from other people? And what does that mean?

SS: No, I think that's my term. I think that.... You're constantly asking yourself, you're constantly wanting to know more. I guess, "active interest" means like having curiosity....

NB: And actively pursuing...?

SS: Actively pursuing what you don't know. Because once you know something, I hate to sit there and read about it again. It's torment. If I understand something fully, I want to continue to move on to something I don't know.

Once again, the key attitude demonstrated in this exchange is the relentlessness with which he expects to pursue knowledge and expertise. His professed responsibility to the M-EID program lays in the way he defines interdisciplinary science, as "constantly wanting to know more," and "actively pursuing what you don't know." Clearly, this is a markedly different approach than the student who accepts a reliance on others for their expertise. In comparison to the previous example, this math student's attitude is on the opposite end of the spectrum. Instead of acknowledging what he may never learn, he is determined to eventually acquire the expertise himself. In the entire interview, he never mentions depending on others for their expertise.

So which student is correct in the way they perceive interdisciplinary work? This question has no single, consistent answer. The M-EID program does not provide a clear demarcation of the boundaries between personal expertise and reliance on collaboration. Consequently, students are left to define their own boundary, which they do in sometimes contrasting ways. In the process of deciding their own boundaries, they experience a tension that results from the lack of precedent set for them, while at the same time having so much of their work contingent on just where they eventually decide to place that boundary.

#### Incompatible Research Interests

The fourth area of strain expressed by M-EID trainees involves the practical

pursuit of a research agenda. Many of the M-EID students reported an awkward pressure resulting from program administrators' expectations that cross-disciplinary collaborative opportunities could be easily constructed. Whereas in a traditional science doctoral program, research projects need to be relevant in the one specific discipline, M-EID students are required to find a project that is relevant to at least two disciplines. Finding such a project, which ideally also appeals to the student's particular interests, can be particularly difficult. One student expressed this sentiment immediately when I asked her how she felt about interdisciplinary class projects:

NB: How was it working on class projects?

CR: Umm.... Kind of intense. We didn't really understand what we were in for. We had to pick a topic in like one day. We didn't know we would have to spend so much time on it. None of us were that interested.

NB: So it was kind of forced?

CR: Yeah, way forced.

The sentiment expressed here echoed the larger problem many students encountered as they searched for research dissertation projects. M-EID students are required to have an interdisciplinary chapter included in their dissertation, which must be co-written by a fellow M-EID trainee. This caused concern for some students, because they had difficulty finding overlapping research interests sufficient for co-writing such a chapter.

One math student explains his struggles:

So what happened was – I sort of got here and we started doing stuff and I started looking around and began to realize that in a more concrete sense that, you know, the – a biologist's or ecologist's sense of, you know, what constitutes an interesting mathematical collaboration is a pretty poor – frequently a pretty poor guide for what a mathematician thinks of as mathematical sort of collaboration. And so what ended up

happening is I spent a lot of time fruitlessly looking for someone here on campus who was doing disease research that required some sort of interesting statistical work.

He goes on to suggest that M-EID administrators fail to realize that many of the interdisciplinary collaborations in the M-EID program are not developed out of naturally overlapping interests, but are rather forced compromises. In this way, interdisciplinary work is not allowed to develop naturally.

This sentiment is important to recognize because it may influence the students' perception of how interdisciplinary science works. They may get the impression that interdisciplinary scientists are all forced to set aside their own research interests in favor of simply adding requested expertise to a project. Consequently, they may not view collaboration to be a desirable, personally fulfilling endeavor. In fact, the first of the two students quoted above subsequently left the program. The latter student graduated, but expressed a strong dis-identification with the M-EID program, voicing high levels of disenchantment and frustration during our interview. Although these students were the most vocal in their complaints against forced, unnatural collaboration, they were not the only students who acknowledged it as a problem. Consequently, it's not hard to assume that M-EID students' interdisciplinary identities may have been adversely affected by forced, artificial-feeling collaborations, to which students don't feel a sense of ownership and responsibility. In times when finding overlapping research interests is difficult for students, the imperative of interdisciplinary science may appear quite different from the goals of disciplinary research, and thus, they may feel a need to

compromise in one way or another in how they choose their research project. Again, such a choice becomes a test of loyalty between conflicting identities.

### Responding to Tension: Degrees of Attachment

To summarize, M-EID trainees reported four areas where they experienced tension resulting from the dual identity demands placed upon them. First, they expressed concern over how to build academic credibility. Being a credible disciplinary researcher means something different than being a capable interdisciplinary collaborator, and students often felt the need to choose one means of investing their credibility over another. Second, students recognized the cost, and at times, frustration, of investing their time in learning new disciplines. Acquiring expertise in other disciplines could be seen as an uncertain investment of their time, considering traditional students know with certainty that studying their home discipline is important and relevant to their future. Third, M-EID trainees have to figure out for themselves how much expertise to pursue in other disciplines, and when it is acceptable to rely on others for that expertise. In this way, how students come to view the boundaries of interdisciplinary collaboration may determine the responsibility they feel towards learning other disciplines. Finally, the trainees sometimes reported that finding research projects that truly integrated the research interests of separate disciplinary students was problematic. Some felt the need to place loyalty in either pursuing their own research interests, or in fulfilling the expertise requests for projects they felt little personal investment or interest in.

In response to the tension they experienced, M-EID trainees tend to develop varying levels of attachment to their interdisciplinary identity. Mostly, the students recognize the different levels of commitment they observe in their fellow students, visible in the availability and attitude of their cohort. In particular, attachment to the M-EID program is expressed through participation in M-EID functions, and in maintaining a presence in the M-EID computer lab or lounge. Some trainees grew frustrated at the lack of attachment displayed by other students. In the following exchange, one student expresses such frustration:

NB: What is the most difficult aspect of this program for you?

SH: I would say, this is just a personal issue, but I would say the most difficult aspect is getting people to realize that they all have responsibilities and to, like, respond to things when we send out an email or something. Saying, yes or no, you know, just tell me if you can or can't make it. You know, stuff like that. It takes two seconds. Just do it, you know.

NB: Yeah. So this sounds like an issue of interdependence with other people. Because you're in a situation where you are dependent on them for your research or whatever. And that's frustrating to you when people are unclear?

SH: Yeah. And even if it's just, you know, trying to get a Scholars In Residence put together... Because, you know, we're bringing in high-powered people and trying to make the program better, and trying, you know, to get good scientists to come here and talk to us. And then, like, nobody cares to respond to make this a good situation? For not only us, but also a good situation for the speaker we invite? You know, when we invite a speaker from clear across the country, and two people show up to their talk...

NB: No, that's not good.

SH: It's not cool. You know, I guess.... I feel it's the least you can do, to do your part to make this run smoothly.

NB: What do you think is the problem with those students who don't...

SH: I don't think they really care. I don't think that they feel the obligation that maybe they should. And maybe I feel too much obligation to the program. You know, for crying out loud, you're getting this wonderful stipend, you're getting to take classes in areas or in programs you wouldn't normally.

NB: Yeah. So it sounds like there is a varying level of commitment....

SH: And that's just my personal opinion. And maybe I'm just, you know, full of it, and it's not really happening. But... but it kinda feels like it's happening, and you know, if you're not gonna put in the effort, then quit. Because, that's not what the program needs....

Clearly, this student expresses a sincere sense of responsibility to the M-EID program, particularly in the way she shows a desire to protect the program against students who do not appreciate it, and do not work to improve it. She demonstrates a sense of ownership for the overall well-being of the program; in short, she is among the more strongly attached.

On the opposite end of the spectrum, some students responded adversely to the strains of the M-EID program. They express their lack of attachment to the program verbally, but also demonstratively by distancing themselves from M-EID functions, or entirely from the program itself. One student with low attachment describes his experience in terms of disenchantment and misled idealism. Retrospectively, he tells the story of entering the M-EID program out of naivety:

NB: Well, what led you to make that choice [entering the M-EID program]?

SC: I'd say equal parts, the money and self delusion.

NB: [Laughs] So... what do you mean?

SC: I really was.... Looking back – I was really too easily – I’m not sure how to phrase this. I almost want to say naïve in terms of being – believing that my goals – my requirements and goals for getting a degree in statistics would mesh with the goals and requirements of the M-EID program. That I – I was trying to figure out how exactly statisticians, not just statistics, were being used in the program. Like, how do I fit in?

He goes on in his story to explain how he tried to find research within the M-EID program that truly interested him, but ultimately failed. He attributes this failure to the lack of labs where actual disease ecology work is being done. He explains:

SC: It’s not like there are labs doing interdisciplinary disease research. It’s, you know, it’s very sort of tangential. And a lot of [M-EID students] come in – and the connection that they have to a lab is not disease.

After relating some specific troubles he encountered during three separate attempts at finding a research project, this student ultimately concludes that he wants out of the M-EID program as quickly as possible:

SC: Because to sort of come full circle, the experience has made me so viscerally opposed to being in academia. I just – I despise it. I do not want to be a professor. I do not want to be a graduate student any more. And the role that M-EID has played in that is that it closed that circle. I was not positive that I wanted nothing to do with the research mathematician, the statistician – a professional statistician until probably the last year. It’s just I’ve gotten so fed up with school and M-EID and all this.

Undoubtedly, this student is on the opposite end of the attachment spectrum; his strong disillusionment and lack of attachment is not characteristic of other students. Yet, other students did express a more mild sense of detachment from the program. In the following exchange another student expresses a similar frustration that led her to quit the program:

KT: And I also felt a weird pressure to go on and do great things....and I was kind of thinking, with what? It was a little Rumpelstiltskin-y... that's the straw into gold one, right?

NB: Yeah! Why so?

KT: I think that the math and computer science people are not in a good position. Because the program was really built from a biology prospective. I think biologists can get an incredible amount out of the program -- they are able to do things they were relying on other people for. But the role for computer science and math people was a little more ambiguous. The glorious partnerships that [administrators] envisioned didn't seem to happen, I think because we were all interested in different things.

NB: So the biologists' interests take precedence because of the direction of the program?

KT: Well, yeah.

NB: Did you try to assert your own interests into the program?

KT: I definitely tried to assert my interest, but no one shared my interest. And there is no med school. And few people on campus are interested in infectious disease in humans. No one in Hamilton was working on tuberculosis, which is what I was primarily interested in.

NB: Okay, how long into the program did you know that you wouldn't stay with it?

KT: Well the first semester was infuriating, but I tried to come to the second one with an open mind. But by about a third of the way through I knew I wanted to leave... I just didn't see where this was going.

This student describes a process of decreasing attachment until she eventually left the program. Again, her experience is clearly in response to the particular frustrations experienced by M-EID students; specifically, the felt pressure to prioritize one identity over another.

All ten M-EID students interviewed demonstrated varying levels of attachment, with the students above representing examples of strong and weak attachment. In the following section, I examine potential factors that influence how students respond to the identity-related strains of the M-EID program.

### Factors Influencing Attachment

Though this study is qualitative, and therefore cannot isolate and quantify particular factors that influence a student's experience, I did find potentially important factors worth noting and that may warrant further investigation. Two factors in particular seemed to be thematically present in almost all of the interviews of M-EID trainees. Those factors, which I elaborate on immediately following, are first, the influence of academic advisors, and second, the students' identity construction tendencies which they seem to carry with them into their graduate program.

The role of the academic advisor is one of primary importance in the M-EID program, and in graduate school generally. The advisor fills a number of roles: a guidance counselor introducing the student to the graduate school way of life, a disciplinary ambassador providing the student with research articles matching their interests, a mentor, a research project provider and supervisor, a task master and motivator, emotional support person, among other potential roles (Crookston, 1972). More than any other person, the academic advisor is influential in how a graduate student experiences a Masters or Ph.D. program (Crookston, 1972). Yet, academic advisors vary in their ability to relate to students and provide guidance (Wrench &

Punyanunt, 2004). Particularly in the science disciplines, professors tend to be accomplished researchers who are often not naturally empathic communicators (Dannels, 2002). Therefore, they may not be apt to understand a student's experience from the student's eyes, and may not relate all necessary information. An advisor's lack of "people skills" sometimes can cause problems for students. At least three of the students interviewed related ways that advisors have been a hindrance for their success in graduate school, by not being available or by allowing students to struggle through a trial and error process that could have been prevented by precautionary advice from the advisor. One student elaborates on the importance of advisors and the potential problems that may arise out of the advisor-advisee relationship:

When I was a lab technician, I hung out with a lot of graduate students, and I almost made it like a hobby almost, of asking them what they did, how they did it, as far as their decisions in grad school. What they would do different. What they would look for in an advisor. And so I was really proactive in some of those things. And I also realized from the guy that I was working with, that I didn't want an advisor like him. He was a great boss, but not a good advisor for me, because he was super hands-off. And I just felt like I was gonna need more help, if I was a graduate student, than someone like that would give. And so I had some idea of... but I also didn't want someone micro-managing me. So I had some idea of what I wanted in an advisor, as well as the fact that you really do have to get along with them. So there was a... while I was a lab technician, there was a graduate student who ended up quitting the program, for a variety of reasons, and I think one of those was, not a very good... it was a mismatch between her and her advisor. And so I kind of saw how hard that was for her, and I just wanted to try not to do that.

This is a common sentiment expressed in student interviews. But also, the personal experiences that students related themselves demonstrate the importance of advisors in helping or hindering their progress academically. For example, one student told the

story of needing seven years to finish her Ph.D., and explained that her advisor was absent for a year, during which he asked that she set up new laboratory for him.

For M-EID trainees, advisors are particularly important because they may help or hinder the unique struggles confronting them. Specifically, advisors who are not involved in M-EID may influence students to invest more time towards one identity over the other. In the following exchange, one student describes this type of conflict:

NB: What were the hardest parts of the program for you personally?

PT: The biggest [frustration] I had was – the fresh air I really didn't get. I had a dissertation topic idea. But I didn't develop it hardly at all and it didn't really go anywhere. And that caused some friction with my advisor. Because – you know – she didn't view M-EID as like – she viewed that as just an aside, you know, it's not a part of my central program. It's just more or less a funding source that I can use and since I'm meeting their objectives it should be my primary focus. But I kinda felt like I went back to school because of the MEID program...

NB: That's sort of an interesting paradox. To what degree was your advisor involved in your primary research project? I mean was this sort of a collaboration that she worked with you on and had certain expectations for you to achieve throughout this semester? Did you guys set goals together? Or how was that relationship working?

PT: So she was more advising me and, you know, telling me what the deadlines are and how I should be getting a dissertation going and having me write a one page synopsis on what I want to do. It wasn't like she wasn't doing anything she shouldn't have been. It was more that I didn't feel I had the time to meet her expectations which weren't unusual.

NB: What was her attitude towards M-EID, in more detail? I mean – in these meetings, would you explain to her what your focus was? Like how did you explain what you were spending your time on? How did those conversations go?

PT: Yeah. She understood the demands and – I guess she kind of thought it was unrealistic – some of the expectations maybe, or just that they expected, you know, us to do all that and still stay with the department and she even discussed it with the Wildlife chairs.

This advisor doesn't express a malevolent attitude toward the M-EID program, but clearly she simply felt a responsibility to help this student through the Wildlife Ph.D. program, and she communicated that this should be the student's top priority also. In this way, she endorses a disciplinary focus, and any potential time conflicts with M-EID are not compromised. This type of attitude, which is understandable for faculty not associated with M-EID, puts students in a tough position of trying to stay on schedule with an advisor, yet at the same time find a way to fulfill M-EID requirements. To the degree the student tries to please the advisor, he demonstrates attachment to the disciplinary identity, and the interdisciplinary identity becomes secondary. Whether intended or not, this advisor advocates the student to resolve the conflicting identity demands by prioritizing one over the other.

In summary, it's important to recognize that students' experience in a Ph.D. program will vary greatly depending on the relationship they develop with an advisor. The information a student receives from an advisor, or the lack of information they receive, will heavily influence the roles and responsibilities the student assumes. As evidenced, this is particularly true for M-EID trainees. In the following section, I elaborate on the second important factor that may influence a student's attachment to disciplinary versus interdisciplinary identities: student identity-construction tendencies.

### Preferential Frames of Identity Construction

The second potentially important factor influencing student attachment to competing identities is the tendency of each student to rely upon particular preferred frames of identity construction. During interviews, the M-EID students tended to portray themselves and their experience in the program in perspective to their lives before, and outside of the M-EID program. In this way, they do not define their professional, occupational, or academic lives solely in context to their status as an M-EID trainee. Rather, they primarily relied on discourses outside of M-EID for identity construction. Consequently, their experience in the M-EID program tends to be viewed as just another potential source of identity construction, rather than a complete, all-encompassing identity which they must refuse or accept. For all students, their experience in the program is best understood as an extension of identity construction practices and processes that are specific to each person, and that seemed to be established before they entered the M-EID program. During interviews, as students told the stories of their academic careers, it became apparent that particular consistencies emerged in the way that individual students made important decisions impacting their professional and academic development. The students tended to exhibit decision-making that depended upon alignments of identification targets. Those alignments, which I call “Preferential Frames” of identity construction, are: Social-relational, Occupational, and Research-problem based.

My primary claim here is that all students – both M-EID and traditional – displayed a tendency for identity construction using one of these three preferential frames. During interviews, I sought narratives for how students arrived in their current

situations, including explanations for how they made important decisions along the way. During those narratives and explanations, students revealed particularly important identification targets that were influential in how they eventually made those choices. As those narratives and explanations accumulated for each student, tendencies emerged in the identification targets across multiple situations. Importantly, these preferential frames also remained intact for decisions and general explanations of their experience while in their current programs. In short, the approach to how individual students made important decisions, including what they identified as being important values for making those decisions, were remarkably consistent throughout their academic career. The following section provides descriptions and explanations for the three primary preferential frames of identity construction.

Social-Relational Identity Frame – The first preferential frame that became apparent for students is an identification alignment primarily focused on people. Students who exhibit a social-relational identity frame tend to relate their important decisions as socially motivated. That is, they explain their decision-making in terms of being influenced by particular people, or as a result of the desire to be around particular persons. For instance, one student elaborates on how she chose her undergraduate major(s):

I didn't have any idea what I wanted to go into. I knew I liked math, so I was taking math classes. And I liked chemistry, so I was taking some chemistry classes. I was... I came in undeclared. My chemistry professor was like, "Hey, you know, you're good at this chemistry thing. Maybe you should pursue chemistry." So I was like, "Okay." So, I added that as a major.

This student explains her progression from simply “liking” chemistry to declaring it as a major: that her chemistry professor told her she was good at it. However, she eventually dropped chemistry, and once again, she cites her relationship with professors as a motivating factor:

By my senior year of chemistry, I kind of had gotten burnt out, because I had taken two years in high school of chemistry, and another three in undergrad. And some of the professors were difficult to deal with, I think, class-wise, and out of class-wise. So I decided to stop the chemistry major two classes short of getting that.

At this point, being “burnt out” probably encompasses more than simply being tired of dealing with “difficult” professors. Yet, this tendency of explaining decisions in terms of being influenced by people continues. She reports on her choice of graduate schools:

Well, there’s two students here that were at my undergrad: [names removed]. They were both at [university] as well, a year ahead of me. So, they both applied here, and came here at the same time, and then they were like, ‘hey, if you want to apply next year, if you’re thinking about grad school, we’d love to have you here.’ You know, at the time they were more just class acquaintances – not really friends or anything. And I was like, ‘well, it might be interesting to go somewhere where I know some people that I’ve had in class before.’ They were like, ‘you can come visit, we’ll house you for the weekend, or whatever.’ And so I applied here, and I also applied at the University of [xxxxxxx], but they were really difficult to deal with. And so I came here.

Again, she makes a significant career decision based on her level of comfort with the people she believes she’ll be around in that location. Perhaps more revealing are the aspects of her decision-making that are absent: not once does she reference her field of study, potential research interests, or professional goals. The decision is all about people for her. Later in the interview, she explains how she chose her current research project, and once again, she chooses a project for which she has no personal investment

or interest, but rather simply accepts the project because a professor, whom she liked, approached her with the suggestion.

The student in this example demonstrates a preferential frame of identification targets centered on people. She apparently needs to identify first and foremost with the people she's around in order to make important career decisions. The other two preferential frames are Occupation-oriented and (Disciplinary) Problem-oriented. All students displayed identities that can be described as one of these three primary preferential frames of identification.

Occupation-oriented Identities – Some students discuss their experience and participation in their current graduate program primarily in terms of career goals and direction. Their explanation of their academic career tends to reflect a vision of an ideal work situation after they graduate, and their participation in a graduate program is viewed as a means to that end. They tend to have chosen an occupation goal early in their academic career, for reasons ranging from personal fulfillment or subject-matter interest, to the lifestyle it entails, or the geographic area it allows them to live in. Noticeably absent in their explanations are references to working with particular people, or helping to solve a particular problem they've encountered in their experience, academic or otherwise.

One student displays this type of preferential frame of identification in his explanations of his experience before and during his current graduate program. As he

told the story of how he ended up in his current program, I asked him to explain his thinking as he neared graduation for his Bachelor's degree. He reports:

Right, and so getting close to graduating, I was... interested in sort of going into a research laboratory setting. I had a chance to do, uh, a summer internship at the University of xxxxxxx, working in a research lab, which was really, really exciting, and really interesting for me.

Ultimately, this student ended up changing his mind about his ideal work situation.

Importantly, when he recognized that he did not want to work in a research laboratory, it was because he had found a potential occupation that he more strongly identified with: teaching. One summer, he had the opportunity to teach English and Biology to children in a third-world country. He reports the effects of that experience:

It really had a huge impact on, um, I think I knew where I was going, but it took me a long time to really realize that. And in fact, I mean, this was ten years ago... and it's still, I think shaping where I see myself going. Um, but, I'd say there were two main impacts that it had on me. One was that it was my first exposure to any sort of teaching. Uh, standing in front of a classroom, working with kids, with people, stuff like that. And I really enjoyed that. Um, second, it was my first real exposure to kind of the natural world, spending a lot of time outside... like I said, before this, I was thinking more in terms of the laboratory setting. And so it really got me interested in trying to incorporate some sort of ecological aspects to my future. And I wasn't sure what those were. Well, whether it would be, you know, working directly with the animals and plants, or doing something on a larger eco-system level. You know, I just wanted to tie in the natural world.

As this passage indicates, this student currently has set his sights on a career in teaching science to children in an outreach setting. Importantly, the discovery of his new career goal colors the way he sees his current graduate program. He endures the program only for the teaching experience, and tolerates what he sees as academia's tendency to be

detached from real-world social problems. This attitude is first evident when I ask him about his responsibilities. He answers,

Um, teaching. That's a very high priority. I mentioned that I've been doing this K through 12 outreach thing for several years now. Last year, I was a TA, next semester I'm going to be a TA. And, um, in all of those scenarios, I put very high priority on teaching classes, or working with students, by giving feedback to students. Um... tr... and then, then... the other priority, or goal is the research, and that it at least, in the sense of trying to sort of keep it together, and not fall apart.

Those are the extent of his responsibilities, as he sees them. Clearly, teaching is a very high priority. As for his research, he only wants to "keep it together." A little later in the interview, I asked him if he hoped to have his dissertation project published. His answer is again revealing:

Umm... I... I mean, it'd be great to have some of this work published. That's not, and I would never say this to my committee, or my advisors, but that's not my top priority. Um, for me, the best thing that could probably come from this, is to get together some data that could inform the park or management strategies of toads.

This attitude is a direct contradiction to the prevalent attitude amongst most graduate students, who highly value getting their work published. Clearly, his experience in his graduate program is viewed in context to how it can prepare him for his future career. He's even identified so strongly with the career goal of teaching and outreach, that he dis-identifies with the other areas of responsibility present in his graduate program. This student is therefore a clear example of a preferential frame of identification centered on an occupation or career goal. Nowhere does he reference particular individuals that have been influential in his career direction, nor does he specify a particular environmental or social problem that he wants to help solve. He simply knows the type

of work environment he feels connected to, and his academic identity is only existent in his mind as a function of that occupational goal.

Research Problem-oriented Identities – The final preferential frame of identification evident in interviews is the construction of research problem-oriented identities. Students who display this preferred frame tend to express motivation and decision-making based on problems they've encountered, either out in the natural world, or in academia. Fueled by an apparent curiosity about how a particular problem can be solved, these students view their academic identity as a quest to better understand or solve the problem. They also tend to take more responsibility and ownership of the eventual research project they choose to pursue. One student who fits this preferential frame describes his thought processes regarding whether to start a Ph.D. program:

So then I was thinking about PhD in the back of my mind and considering different ideas, including one idea was wildlife diseases and how the whole zoonotic diseases that goes from animals to humans – I thought that was an interesting area. And then just -- I read this Missoulian article about this new PhD program in Missoula... I thought- just – Wow! That's just perfect for me. You know, because it was all my interest.

Later, after he started the program, he eventually chose a research project with a different focus, but still within animal diseases. He explains his research in the following exchange:

NB: Okay. So can you tell me a little bit more about your project? I think you said diseases in – was it elk?

SC: Yeah. Parasites in elk.

NB: So can you tell me a little bit more detail about that?

SC: Yeah. So I thought it would be interesting to look at how areas where wolves are predating elk – and if they are – you know, people always say wolves take out the sick and the weak and that’s pretty much common knowledge. I don’t know how well – quantified it is but – so if they are actually going in and taking out the sick elk, are they doing that enough that they are reducing the transmission and so they are actually making the herds healthier. So the population of elk that are under constant predation, are they actually healthier than ones that aren’t – you know, when the wolves aren’t there?

What struck me about this student is that he never cited another person or occupation that influenced or directed him to pursue either of the research projects he mentions. In fact, during the interview he briefly mentioned a project looking at West Nile virus, but ultimately chose not to pursue it. I asked him about why he dropped it:

NB: Okay, now you mentioned that you had another project – the West Nile and that you abandoned—or you decided that wasn’t working out for you. So what – what led you to decide about taking on this new project?

SC: Um – I guess it was – the other one wasn’t going very well... and so I decided to, like, open up, you know, just consider other things. And then there was some – some talk with my advisor about a recent trip to Yellowstone where they were trying to get some funding for diseases research and that one area was predation. And so that sounded like – well that would be neat – that’s kind of what I’d like to do and then I started reading about it with that in mind. And then once I started reading and, you know, got excited about it and then I decided, yeah, that was what I wanted to do.

NB: Okay. So it’s mostly just your own – your own reading and sort of quest for “what could I study?” and nothing was in particular recommended to you or anything?

SC: Right.

NB: So you’re pretty independent about making that decision?

SC: Yeah.

The defining characteristic of this student's approach is the independence with which he investigates possible projects to pursue. His advisor offers a broad idea base of predation, and he then takes responsibility to research potential options that interest him, consequently finding possibilities that "excite" him. The role of faculty is to help refine his idea and consider potential challenges:

NB: Okay. Once you decided to study that, were there any modifications that you had to make to your focus?

SC: Yeah. I think so. I think—yeah, definitely, like – through conversations with people and – some of the ideas I had and they'd be like – well, that's going to be hard to do – or – have you thought about that? Definitely, there was some of that.

Consequently, it's clear that he needs to feel a personal connection with the research question he ultimately pursues. The students who demonstrated a Research Problem-oriented frame of identification tend to be self-motivated, self-directing, and they tend to be able to describe their research in "laymen's" terms, which clarifies the project's real world significance. For instance, another student with a Research Problem-orientation begins to offer an explanation of her research:

NB: Okay. So why don't you, if you would... give me... now that we've been talking about how to make sense of your research for other people, can you do that for me? What do you study?

AR: Sure. Very generally, I study two fields of biology, which is population biology, and physiological ecology. Um, I use within those fields, I'm studying this weird like history stage in primeal plants. So, you can think of herbaceous plants that a lot of the really pretty wildflowers in Montana – a lot of those are herbaceous. Long-lived plants... so they live a lot longer than we actually...

NB: What was that term you used?

AR: Herbaceous. It just means that they're not woody. So, like, shrubs and trees are woody. Herbaceous, or herbs, are not.

This student goes on to offer a detailed, articulate explanation of her project, with all of the technical terms defined for me. In short, she is easily capable of recognizing the everyday significance and application of her project. In explaining it, she translates the science behind her project into those everyday terms. This ability tended to be a hallmark of Research Problem-oriented students.

#### Summary: Preferential Frames of Identification

All in all, students were fairly evenly distributed among these three preferred frames of identification. M-EID students had a distribution of five Occupational, two Social-relational, and three Research problem-based. It's important to point out, however, that these preferential frames of identifications for key decisions are not exclusively employed by students; they are only preferences. That is, students do not only show identification reflective of one frame. At times, students expressed identification to people early in their academic career (in choosing a major as an undergraduate, perhaps), before moving on to a Research Problem-orientation as an upperclassman and graduate student. My argument is that students tend to favor one identification frame over the others, particularly when asked to explain important, pivotal decisions in their academic career. In this way, the preferential frames of identification are more of a ranking system, wherein students may be characterized as having primary and secondary preferences. For instance, some students displayed a

Research problem orientation first and foremost, with a secondary Social-relational frame evident also.

In summary, all students interviewed displayed a clear preference in frames of identification, all of which can be classified as Social-relational, Occupational, or Research Problem-oriented. Preferred frames of identification are potentially important factors in an M-EID student's experience, because those particular frames highlight potential targets that students prefer to identify with in their respective programs. If they fail to find suitable identification targets, consistent with their preferred frame, then they may become weakly attached to that identity. There are two clear examples already discussed above. To review, one poorly attached student ("SC") described himself as "viscerally opposed to being in academia," and wanted only to graduate as quickly as possible from the M-EID program. The second student ("KT") felt that interdisciplinary research opportunities were so difficult to find in the M-EID program that she characterized the experience as "Rumpelstiltskin-y." Both of these students demonstrate a history of engaging intellectually with research problems, and relying on that engagement as the primary motivation for their academic careers. Accordingly, both students upon entering the M-EID program, sought an intellectually fulfilling research project to identify with. However, neither found one, and both cited that disappointment as the primary defining aspect of their experience. By the same token, those students who found identification targets suitable for their preferred frames became strongly attached to their M-EID identity. For example, one mathematics student, who has already been discussed above ("SS") demonstrates a strong

attachment to the M-EID program, saying at one point, “because I’m in M-EID, I also have to show an active interest in interdisciplinary science. Which I do, I greatly find interdisciplinary science amazing.” During his interview, SS demonstrated a consistent Socio-Relational frame of needing to identify with people during his undergraduate and Master’s program. SS is also the student who has two advisors, one in math, and one in biology. He says of his situation, “Yeah, it’s wonderful. I have a great combination... our meetings are very productive... so it’s great.” He also told the story of how he connected with his second advisor, in biology:

He is a great guy; you can’t help but like George. I remember one of my first lab meetings that I had with him, I wasn’t really in the lab at the time, I just joined them in their meetings, and he turned to me; we went around the table and everyone’s describing what to say, and I was just there to listen. And he turned to me and said “when are you going to join us?” And I took that, you know, I was in the meeting, I didn’t know what he was talking about at the time, and he said “no, I mean in the lab.” And he wanted me in the lab, and that was great.

He tells this story in context to how his interest grew in biology. Consequently, it’s clear that SS responds to connections with people to get excited about his work. Finding identification targets in his advisors enables him to feel a strong connection to his M-EID identity. Again, the important link here is that this student historically prefers to feel a personal connection to the people he works around, and the fact that he finds this in the M-EID program likely plays a strong role in how attached he feels to the M-EID program. Thus, preferential frames of identification hold potential for understanding the likelihood of building strong attachment to M-EID identities, which may optimize the chance of success in the program.

Having examined two potentially important factors that may influence degrees of attachment to disciplinary or interdisciplinary identities, I now move on to the final results section. In the following section, I detail two accomplishments of the M-EID program that seem to benefit students regardless of identity attachment.

### Systemic Benefits of the M-EID Experience

The final noteworthy results involve two beneficial aspects of the M-EID program that all students acknowledged positively, independent of the strength of their attachment to their interdisciplinary identities. Those two benefits involve practical skills that all students recognize they will carry with them into the future. Those benefits are the ability to interact with a cross-disciplinary cohort, and the ability to build a “scaffolding” network of knowledge that connects disciplines. Both of these benefits seem to result from the intentional structure of the M-EID program: putting together a cross-disciplinary cohort that interacts often, and having them present research to each other through programs such as “journal club.”

Cross-disciplinary cohort – The most immediate difference in the experience of an M-EID student from traditional students are the near-daily interactions with a cohort from disciplines outside of their own. The M-EID program occupies space in a computer lab and in a lounge area where students were asked to maintain a presence. Consequently, the students offer each other feedback, information, and support that are cross-disciplinary in nature, and that may become useful at a later point. One student

characterizes the potential benefit of this information-swapping with his cohort:

Mostly I have to say what I've learned from my fellow trainees has been discussing the common mathematical problems, like statistical problems with them... working out things together that are in the courses. But I guess on reflection... well, now that I think about it... for instance, Jane [a Biology student]... uh, Jane and I have talked about issues with pathogens and stuff that have been relevant to both of our research, in fact, increasingly. I think I'm gonna keep close tabs on her, because she's going to be doing, I think, some sequencing of these uh, tick relapsing fever bugs that are gonna employ the same sorts of analyses that I'll be getting into, so that'll be good.

Almost offering a stream of consciousness answer, this student, who is a computer scientist, thinks of interactions he's had with students from two separate disciplines, who have helped him broaden his understanding of statistics and biology. The conversation he relates second here, with "Jane" has potential connection with work he may do in his career, and so he intends to keep tabs on her work. More than one student expressed this type of appreciation for the types of discussions that resulted from shared time in the M-EID computer lab and lounge.

Exposure to cross-disciplinary theory – "Scaffolding of Knowledge" - A second important difference in the experiences of M-EID trainees and traditional students comes in the way that M-EID students are regularly exposed to current research and theory outside of their home discipline. M-EID's weekly "Journal Club" meeting is set up to focus on one or two journal articles that students take turns choosing. The assigned student for the week will choose a research article from his or her own discipline, distribute it to other students during one Journal Club meeting, and present it for discussion the following week, after the other students have had a chance to read it. In this way,

students are exposed to new theories, but are also provided the opportunity to potentially discover connections between disciplines. In the following interaction, one student elaborates on the benefit that Journal Club has provided for him:

NB: Actually, that does make me wonder if it... if these seemingly peripheral discussions about... not pointedly that you embark upon in order to learn about your research, but if they... if these happenstance discussions at journal club about something that you didn't think was related, potentially does influence your research...

MT: Absolutely...

NB: ... in ways that you may not realize, but later on, you're like "ahh, that idea, that theory, that...way of looking at it, that might apply to this situation..."

MT: Exactly right. That's how I feel about it. I'm amazed at the way ideas come from unexpected places... places that seem irrelevant...you know, physics. What could physics have to do with it?... Well, there are problems that people have used, like Graham Auckland is gonna give a seminar next week. Well out of physics and statistical mechanics comes all these really interesting ideas about modeling from biological/ecological systems. So, I mean, I almost say, "shoot, you know, we should have physicists around, too. I mean, keeping in mind the danger is you just, spend too much time thinking about too many things..."

This last quote suggests an awakening to the potential ways that outside disciplines could unexpectedly provide ideas, approaches, or theories that are relevant to this student's research. In this way, he expresses a value for Journal Club discussions, even ones that he feels are boring at the time, and how they could eventually pay off in unforeseen ways. Not all students expressed this value, yet the point remains: insofar as students attend meetings, classes, seminars, and lectures involving outside disciplines, their exposure to those new ways of thinking may become relevant to them, the same way that this student anticipates how physics may influence biological/ecological

systems.

### Summary of Results

In summary, Chapter Three explored answers to my four research questions. I first established the common identity demands generally experienced by all postgraduate science students in this study. Secondly, I highlighted some ways that M-EID students felt supplemental identity demands resulting from the interdisciplinary aspect of their program, which distinguished them from traditional students, but also which at times created competing tensions between two identities: interdisciplinary versus traditional. Next, I reported how students responded to those tensions in ways that highlighted stronger or weaker attachment to their M-EID identities, and examined potential important factors that may influence the development of that attachment. Finally, I identified particular benefits of the M-EID program that seemed to transcend identity attachment, which appear to be the effects of the strategic structuring of the M-EID program. In the next and final chapter, I will examine and discuss the practical and theoretical implications of this study.

## CHAPTER FOUR: DISCUSSION AND IMPLICATIONS

In Chapter Three I presented the findings of this research study and answered the following research questions:

**RQ1:** What are the primary identity-related challenges that the M-EID students are confronted with, particularly regarding interdisciplinary work?

**RQ2:** From which discursive sources do the M-EID students draw upon when constructing and explaining their academic identities?

**RQ3:** What degree of coherence exists among identity-construction of the M-EID students as a group?

**RQ4:** What, if any, are the differences between M-EID students and single-discipline students, in how they construct their identities, especially with regard to interdisciplinary collaboration?

In this chapter, I discuss practical implications of this study, as well as the theoretical contributions it makes to the organizational communication literature. Specifically, this study contributes to communication theory in two areas. First, it further articulates and develops identity research and theory, especially regarding the subjectivity and insecurity inherent in identity development and maintenance (Collinson, 2003). Second, this study introduces the potential importance of “preferential frames” of identification that may influence the likelihood of attachment occurring within organizations. On the practical level, this study provides insight into the actual obstacles that stand in the way of students succeeding at interdisciplinary research. The first hand examination of those obstacles provides potentially valuable guidelines for structuring and implementing a program that aids students in overcoming those obstacles. In the following sections, I’ll elaborate on both the theoretical

implications of this study, and the practical contributions to the practice of interdisciplinary science.

### Theoretical Implications

This study extends communication research and theory focused on identity as it is embedded in the discourses that inform it. Collinson (2003) uses a post-structuralist viewpoint to argue that identity is a subjective production of discourses that operate within social institutions and culture. He further suggests that, as conscious persons who can view ourselves in different potential lights, we often make identity choices under the weight of, and in response to, the insecurities felt due to the defining power of discourse. That is, we choose our identities as a result of the insecurities we feel within discourses we perceive as relevant. This study provides a salient example of how the insecurities of identity work are negotiated by individuals who are subject to multiple, ambiguously aligned discourses. The students in this study were subject to two particularly important discourses – those of traditional science and of interdisciplinary science – and how they respond to their situation speaks prominently of their perception of insecurity within each discourse. For instance, those students who chose to develop their traditional science identities cited credibility as the reason behind their choice. They tended to respond to the felt insecurity of traditional science more principally than that of interdisciplinary collaboration, because they worried *how they would be seen* by traditional scientists at large. Collinson (2003) asserts, Insecurities in organizations can take many different, sometimes overlapping forms. It may, for example, be existential, social, economic and/or psychological.

These multiple insecurities can intersect and operate simultaneously, thus reinforcing their impact on the construction of workplace selves and the reproduction of organizational power relations” (529-30).

In this study, Collinson’s quote proves to be accurate. Students who chose to emphasize and invest in their traditional identities often did so at the expense of their interdisciplinary identities. Such a choice reproduces the power relations within science culture, and hinders the development of interdisciplinary science. The students want to be seen as “good scientists,” and to do so means to honor the traditional practices of science. No student could escape the question of credibility; they could only fulfill it while creatively balancing their interdisciplinary identities.

Importantly, the historical prevalence of traditional science is the existing power structure that students inherit. It has in fact defined them in their academic careers before coming to the M-EID program, as they established themselves in their disciplines. In this regard, choosing to develop an interdisciplinary identity is a noteworthy resistance to that traditional discourse. Again, Collinson’s (2003) emphasis on consciousness is key to understanding how individuals negotiate that tension. Those students who embody their interdisciplinary identities do so in awareness of traditional science’s reluctance to account for the newly emerging interdisciplinary credibility. They recognize the contradiction in their situation, and yet still choose to invest their time in developing an identity that traditional science may not reward, and even may view with skepticism.

A second important emerging implication of this study is the potential importance of preferential frames of identification that students seemed to exhibit. During interviews, students related their academic histories, dating back to the choice of their undergraduate major(s), up to their current situation. In explanation of those developing histories, students tended to demonstrate consistent tendencies to rely on preferred frames of identification targets for their decision-making, especially for important decisions, such as choosing a major, whether to attend graduate school, and which schools and programs to attend. Those three preferential frames of identification are Social-Relational, Occupation-oriented, and Research Problem-oriented. These preferential frames require further investigation and substantiation, but if they're as prominent as the data from this study suggests, then they could provide important insight into the likelihood of identification occurring for individuals within particular organizations.

### Practical Implications

The results of this study have immediate relevance for the training of interdisciplinary scientists. The M-EID program's failures and successes provide an insight into the factors that influence successful collaboration. Specifically, this examination of the M-EID program identifies some important steps to "set the stage" for effective interdisciplinary collaboration. The M-EID program demonstrates the need for: 1) integrative research labs, where numerous potential research projects are

available; 2) student-led interdisciplinary research seminars; and 3) shared office and computer space for students.

First, a primary determinant of success in the M-EID program was whether or not a student found research opportunities that suited their own interests, but also matched up with the research interests of other students. The place where this happened most frequently was research labs, where one or more faculty has multiple ongoing research projects in process. Importantly, these labs need to be relevant to the aims and goals of the program itself. In the case of the M-EID program, some students reported that a foundational problem confronting the program was the lack of labs where infectious disease research was taking place. These very students are those who developed low identification and attachment to the M-EID program. It stands to reason that the more labs available, the higher the likelihood of students finding a suitable research project, and therefore, the number of students who fail to apply themselves into a project would be reduced. Ultimately, this need for labs is an extension of a more elemental aspect of graduate programs in general: that students are dependent on faculty for the provision of potential research projects. When a student perceives no match of personal research interests with faculty research interests, then it's unlikely that the students is going to feel a sense of belonging in the program. This study of the M-EID program demonstrates the need for maximal opportunities for overlapping student/faculty research areas. In the case of the biological sciences, those overlapping interests are likely to be found in research labs.

Second, the M-EID program demonstrates success in broadening students' awareness of other disciplines through the implementation of student-led research seminars (referred to as "journal club"). These weekly meetings, wherein one student presented research articles from his/her own discipline, offered casual opportunities for students to become aware of the research going on in other disciplines. This introduction of "other discipline" research has the potential of immediately impacting the current research projects or ideas of students, but the more important impact are the long-term effects of continual exposure to new, interdisciplinary perspectives and practices. Learning about "other discipline" research effectively accumulated into a scaffolding of interdisciplinary knowledge that students could reflect upon when brainstorming for solutions to their current research problems or obstacles. The logical thought processes and approaches of other disciplines often can provide sparks of insight that break stale molds of thinking for single-discipline scientists. The M-EID program's "journal clubs" offered the opportunity for students to learn approaches and perspectives into research, and whether or not the students immediately recognized it, those new approaches and perspectives have the potential of influencing how those students approach and practice their research in later years. Ultimately, this is the goal of interdisciplinary collaboration: to broaden disciplinary horizons, and to "borrow" the ideas of other disciplines to aid in solving the current problems facing one's own discipline. These student-led interdisciplinary research seminars effectively set the seeds of this happening down the road for M-EID students.

Third, the M-EID program was successful in encouraging student interaction and collaboration largely due to the physical layout of the student space. The program provided a computer lab with a student lounge next door. Administrators encouraged students to spend time there, and to take advantage of the equipment and facilities. Students reported this set up as the primary reason why interdisciplinary interactions were numerous and fruitful. In short, fellow students were typically their own first resource. Given that some students did not pursue other disciplines to the point of expertise, the physical layout of the student space provided opportunities to consult students from needed disciplines for support, as often as they needed. Consequently, no matter the level of support that one student depended on other students for, that level of collaboration was easily accessible on a weekly or daily basis. Student's support of each other ranged from quick reference questions or equations, to collaborative problem-solving. The working space provided for M-EID students became an area where they felt free to ask for support, but were not forced. This opportunity helped set the stage for collaboration and interdisciplinary reliance.

The M-EID program thus provides a useful framework for understanding the importance of practical program implementation. Other interdisciplinary programs stand to benefit from the demonstrated lessons of 1) providing as many research labs opportunities as possible; 2) creating regular student-led interdisciplinary research seminars; and 3) providing student space that naturally encourages interaction and reciprocal student support.

### Selection

Finally, this study provides potential insight into the selection process for interdisciplinary science programs. This study has established that students demonstrated three distinct preferential frames of identification: social-relational, occupation-oriented, and problem-focused. Importantly, one of those preferential frames, problem-focused, consistently indicated strong student attachment and success in the M-EID program. This study also established that those preferential frames were demonstrated before the students began the M-EID program. Consequently, it may be possible to use the frames as a useful tool for the selection process into the program. Interdisciplinary programs may increase the likelihood of students completing and thriving within the program if they select those students who demonstrate problem-oriented identification frame. In entrance interviews during the selection process, programs potentially could ask for narratives about student's decision-making and overall academic histories, wherein the students would likely indicate their tendencies for making important decisions based on either people, career goals, or intellectual curiosity. This information may be very useful for predicting retention and contentment for individual students – important goals for any academic program.

However, this potential outcome of this study – as a useful tool in the selection process – also leads to further questions that require additional consideration and research. If preferential frames of identification are relatively stable and therefore useful in helping to predict student success, then it may be the case that they reflect attributes of student's interpersonal skills and/or temperament. This study only finds that these frames are observable, and reliable for understanding a student's experience

in an interdisciplinary academic program. This study cannot infer whether these frames are truly static throughout a student's academic career, nor does it identify why students come to rely on one frame more than the others. Contextualizing the factors why students rely on a particular frame of identification for decision-making may rest in the domain of understanding those students' interpersonal communication skill, or even in the domain of personality attributes, such as temperament. Understanding preferred frames of identification in a deeper, contextualized way may be necessary in order to predict with certainty why a particular student may succeed or fail in an academic program. With a student's potential academic career at stake, such factors should be considered carefully.

### Conclusion

In conclusion, my underlying goal in this study was to better understand the factors that influence individual scientists' capacity for participating in interdisciplinary research. I asked to what degree it is possible to train a scientist to be interdisciplinary instead of single-discipline focused. While I do believe this study has shed considerable light towards answering this question, a degree of uncertainty remains. This study has provided important insights into controllable factors that influence whether a student scientist will thrive in an interdisciplinary setting. It has provided a close examination of some of the primary obstacles that confront interdisciplinary collaboration, and it has offered poignant observations for how to construct an inviting interdisciplinary environment.

Ultimately, I found that students' capacity to participate in interdisciplinary research is embedded in the complex interplay of personal, occupational, and academic discourses. How students see scientific inquiry, and how they see themselves in context to that inquiry, is a dynamic product of how those discourses are uniquely prioritized for each student, even as they shift and therefore change the identity construction of the students themselves.

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## APPENDIX A: INFORMED CONSENT FORM

**Purpose:** You are being asked to take part in a research study examining student attitudes and opinions toward participation in interdisciplinary science research. This study also attempts to identify potential sources of those attitudes within students' experiences in postgraduate science programs.

You have been chosen because you are a Ph.D. student in Mathematics, Biology, Ecology, or Computer Science.

**Procedures:** If you agree to take part in this research study you will be asked to participate in an interview with me, the project director, at a time and location convenient for you. Ideal locations are public places, such as the library, a coffee shop, or an empty meeting room on campus.

Interviews will generally last between 30 minutes to one hour. Questions will focus on your overall experience within your current graduate program. You will be asked to reflect on particular aspects of your experience, and to provide descriptions and explanations for group projects or research undertaken while in this program. With your permission, interviews will be recorded for the purpose of transcribing your responses for later review and analysis.

You may also be asked for a second, follow-up interview. Not all interviewees will be asked for a second interview. I might request this if the first interview is cut short, or if I identify follow-up questions that were not originally asked. This potential follow-up interview would again take place at a location and time which is convenient for you, and would only take approximately an additional twenty to thirty minutes. Once again, with your permission, this second interview would be audio-recorded for later transcription.

**Risks/Discomforts:**

Since you will be asked to reflect on various aspects of your experience in your graduate program, this could prompt you to consider unpleasant experiences that may cause you to feel sad or upset. Should this occur, your willingness to participate in this study is fully your choice, and further, you may choose not to answer any particular questions asked during the interview.

**Benefits:** Participating in this study provides the potential opportunity to influence administrators and/or faculty as they organize the graduate program which you current attend. Although changes may be implemented after your departure, your feedback may be valuable for administrators to consider the general experiences of graduate students in this program.

**Confidentiality:**

A number of measures will be taken to assure that your identity is protected, and that your remarks and comments remain anonymous. If the interview is recorded, the audiotape will be transcribed without any information that could identify you. The tape will then be erased. If the results of this study are written in a scientific journal or presented at a scientific meeting, your name will not be used. Your signed consent form will be stored in a cabinet separate from the data, to prevent any possible connection of your identity with your responses.

**Compensation for Injury**

Although we do not foresee any risk in taking part in this study, the following liability statement is required in all University of Montana consent forms:

In the event that you are injured as a result of this research you should individually seek appropriate medical treatment. If the injury is caused by the negligence of the University or any of its employees, you may be entitled to reimbursement or compensation pursuant to the Comprehensive State Insurance Plan established by the Department of Administration under the authority of M.C.A., Title2, Chapter 9. In the event of a claim for such injury, further information may be obtained from the University's Claims representative or University Legal Counsel.

(Reviewed by University Legal Counsel, July 6, 1993)

**Voluntary Participation/Withdrawal:**

You may refuse to take part in or you may withdraw from the study at any time. If you decide to withdraw, any data collected will not be used for the study.

**Subject's Statement of Consent:**

I have read the above description of this research study. I have been informed of the risks and benefits involved, and all my questions have been answered to my satisfaction. Furthermore, I have been assured that any future questions I may have will also be answered by a member of the research team. I voluntarily agree to take part or to have my child take part in this study. I understand I will receive a copy of this consent form.

\_\_\_\_\_  
Printed (Typed) Name of Subject

\_\_\_\_\_  
Subject's Signature

\_\_\_\_\_  
Date

## APPENDIX B: INTERVIEW GUIDE

1. I'd first like to hear about your (graduate) program. What is the overall purpose of your program?
  - a. How did you choose it?
  - b. What does the program require of you?
  - c. What are the primary challenges that confront you in this program?
  - d. How well will this program prepare you for the future?
2. Tell me a little about your research.
  - a. Why does it interest you?
3. Can you choose one specific research project that you've worked on, and tell me about how that project developed?
  - a. What were some key decisions you had make for that project, and how did you make those decisions?
4. In what ways has your research been influenced by your advisor?
  - a. What do you think is his/her attitude towards your research? Toward interdisciplinary work?
5. In what ways has your research been influenced by other faculty?
  - a. Faculty from your discipline?
  - b. Faculty from other disciplines?
6. Tell me about your cohorts in the program – what is your relationship like with them?
  - a. In what ways has your research been influenced by your cohort, particularly when you've worked in teams for group projects?
  - b. How have you negotiated project-related decisions among your peers?
7. Do you think interdisciplinary students are “true” scientists?
  - a. Why or why not?